Final Report

University of Reading

CGIAR Research Program on Grain Legumes

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Acronyms, Abbreviations and Glossary

A4NH	CGIAR Research Program Agriculture for Nutrition and Health
AATF	African Agricultural Technology Foundation
ARR	Average Rate of Return
BMGF	Bill & Melinda Gates Foundation
Bt	*Bacillus thuringiensis*
CATIE	Tropical Agricultural Research and Training Center, Costa Rica,
CB	Consortium Board
CBO	Community-based Organisation
CC	Cross-cutting area
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CCEE	CRP Commissioned External Evaluation
CEG	Center for Excellence in Genomics
CIAT	Centro Internacional de Agricultura Tropical
CGIAR	Consultative Group of International Agricultural Research
CO	Consortium Board Office
CROR	Cumulative Rate of Return
CRP	CGIAR Research Program
CRSP	Collaborative Research Support Project
CWANA	Central and West Africa and North Africa
EIAR	Ethiopian Institute of Agricultural Research
EMBRAPA	Brazilian National Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária
FC	Funding Council
FP	Flagship Project
FTE	Full -time Equivalent
GCP	Generation Challenge Programme
GDAR	General Directorate of Agricultural Research (Turkey)
GLVA	Grain Legumes Value Alliance
Grain Legumes	CGIAR Research Program on Grain Legumes (Grain legumes are legume crops where the seed is consumed for food notwithstanding their alternative uses)
GxE	Genotype x Environment Interaction
ha	Hectare(s)
HT	Heat Tolerant/Tolerance
IAC	Independent Advisory Committee

ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in Dry Areas
ICRISAT	International Centre for Agricultural Research in the Semi-Arid Tropics
IDO	Intermediate Development Outcome
IEA	Independent Evaluation Arrangement
IF	Impact Factor
IITA	International Institute of Tropical Agriculture
IMOD	Inclusive Market Oriented Development
IP	Intellectual Property
ISC	CRP Independent Steering Committee
ISPC	Independent Science and Partnership Council
KARI	Kenya Agricultural Research Institute
LAC	Latin America and the Caribbean
LIFDC	Low-Income, Food-Deficit Countries
LIL	USAID Feed the Future Legume Innovation Lab
MABC	Marker-Assisted Backcrossing
MAS	Marker Assisted Selection
M&E	Monitoring and Evaluation
MRR	Marginal Rate of Return
MU	Management Unit
N2AFRICA	Large-scale, science-based “research-in-development” BMGF- funded project focused on putting nitrogen fixation to work for smallholder farmers growing legume crops in Africa
NARS	National Agricultural Research Systems
NGO	Non-government Organisation
NVRS	National Vegetable Research Station
OC	Oversight Committee
OT	Output Target
PIA	Program Implementation Agreement
PIM	CGIAR Research Program on Policies, Institutions and Markets
PL	Product Line
PLC	Product Line Coordinator
PMC	Program Management Committee of the CRP
PMIL	USAID Feed the Future Peanut and Mycotoxin Innovation Lab
PMU	Program Management Unit of the CRP
POWB	Plan of Work and Budget

PPA	Participant Program Agreements
PVS	Participatory Varietal Selection
QDS	Quality Declared Seed
QTL	Quantitative Trait Locus/Loci
R&D	Research and Development
R4D	Research for Development
RGT	Rapid Generation Technology
RMC	Research Management Committee
RO	Regulatory Organisation
ROI	Return on Investment
ROR	Rate of Return
SC	Strategic Component
SLO	System Level Outcome
spp	Species
SRF	CGIAR Strategy and Results Framework
SRO	Self-regulatory Organisation
SSA	Sub-Saharan Africa
SSEA	South and Southeast Asia;
TL I	Tropical Legumes I
TL II	Tropical Legumes II
TL III	Tropical Legumes III
TOR	Terms of Reference
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VBSE	Village Based Seed Enterprises
W1	Window 1 (funding) unrestricted funding managed by the CGIAR Fund
W2	Window 2 (funding directed to a CRP by donors through the CGIAR Fund)
W3	Window 3 (funding directed by donors through the CGIAR Fund to a specific project managed by one or more center)

Glossary

CGIAR Consortium: The CGIAR Consortium is an international organization that, together with the CGIAR Fund, advances international agricultural research for a food secure future by integrating and coordinating the efforts of those who fund research and those who do the research.

CGIAR Fund: The CGIAR Fund is a multi-donor trust fund that finances CGIAR research guided by the Strategy and Results Framework. The CGIAR Fund is administered by the **World Bank**, as Trustee, and governed by the Fund Council, a representative body of Fund donors and other stakeholders. The Fund Council is the decision-making body of the CGIAR Fund.

CGIAR Independent Evaluation Arrangement: The CGIAR Strategy and Results Framework calls for results-based management. This sets out the results to be achieved, and systematically directs capacities and investments towards delivering them. Independent evaluation ensures that all parts of the CGIAR system are held accountable for their performance. The CGIAR Independent Evaluation Arrangement (IEA) is the totality of the provisions of the CGIAR Policy for Independent External Evaluation which was adopted by the Fund Council and became effective on 1 February 2012. The policy addresses the independent external evaluation of the CGIAR as a whole, and of its ongoing and completed policies, programs, and institutional entities, in particular the CGIAR Research Programs.

CGIAR Strategy and Results Framework (SRF): This defines CGIAR System-Level Outcomes or SLOs as high-level goals, and Intermediate Development Outcomes (IDOs), which are intended to measure contributions towards the SLOs.

The **Independent Science and Partnership Council** (ISPC): Advises Fund donors on major science issues. The ISPC is a panel of world-class scientific experts chosen by the Fund Council to provide independent advice.

CRP staff: Staff who, funded from the CRP by funds not allocated to a centre, are involved in a formal way with the conduct of the CRP (Director, CRP; Senior Program Manager, Gender Specialist, Product Line Coordinators, Flagship Project Coordinators, Researchers)

Oversight Committee: An Oversight Committee has been set-up to work with the CRP Management, evaluation manager to ensure good communication with, learning by, and appropriate accountability to primary evaluation clients and key stakeholders, while preserving the independence of evaluators.

EXECUTIVE SUMMARY

Background and context

The Grain Legumes CRP was established to bring all research and development work on grain legumes within the CGIAR system under one umbrella. It was set up to provide public goods outcomes to serve the needs of the sustainable production and consumption of grain legumes in the developing world, capitalising upon their properties that enhance the natural resource base upon which production so unequivocally depends. The choice of species and research foci were finalised following extensive consultation with all stakeholders (though perhaps fewer end users), and cover all disciplines that contribute to long-lasting solutions to the issues of developing country production and consumption. ICRISAT leads Grain Legumes and is partnered by the CGIAR centers ICARDA, IITA and CIAT and a number of other important partners, both public and private, and of course farmers in the developed and developing world.

Originally in mid-2012 Grain Legumes was structured around eight Product Lines (PL) (i.e. technological innovations) intersecting five Strategic Components (SC) (i.e. arranged as components along the value chain). However, in 2015, it was restructured along a more R4D output model leading to Intermediate Development Outcomes (IDOs). Thus five Flagship Projects (FP) more closely reflecting a systematic pipeline of progression from fundamental science, implementation of interventions and the development of capacity and partnerships to promote and adopt impactful outcomes: FP1) Managing Productivity through crop interactions with biotic and abiotic constraints; FP2) Determination of traits that address production constraints and opportunities; FP3) Trait Deployment of those traits through breeding; FP4) Seed Systems, post-harvest processing and nutrition; FP5) Capacity-Building and Partnerships. Another three cross-cutting FPs analyse the broader environment surrounding the adoption of outputs, the capitalising of investments in genomics research, and a focus on the Management and Governance of Grain Legumes: FP6) Knowledge, impacts, priorities and gender organisation; FP7) Tools and platforms for high throughput genotyping and bioinformatics; and FP8) Management and Governance. Five FPs focus on R4D; FPs 5 and 6 are considered cross-cutting; FP 7 has a technical focus and FP 8 has an overarching objective. Over the three year period since its inception in July 1012, Grain Legumes has had a total budget of $140 million, with $62M originally to come from W1/W2 and the remaining $78M to come from W3/bilateral. In actuality only $45M came from W1/W2 but $106M from W3/bilateral corresponding to 106% of expectation.

Purpose, scope and objectives of the external evaluation

Principally, the evaluation of Grain Legumes is to ensure that the program is progressing in an effective manner towards addressing the system-level outcomes of the CGIAR as they relate to grain legumes. In essence, the evaluation aims to provide essential evaluative information for decision-making by Program Management and its funders on issues such as extension, expansion and structuring of the program and adjustments in relevant parts of the program. Subsequent to the formal signing of the agreed terms of reference, the evaluation team was also invited to comment upon the mooted options for merging and/or disaggregating of Grain Legumes. The audiences are therefore manifold, from the CGIAR Fund Council and Consortium, the Boards of Trustees of the four component CGIAR centres, the Grain Legumes Steering, Management and Independent Advisory Committees, to the researchers and others involved in the delivery of R4D outcomes and their partner organisations.

The evaluation was not only summative in measuring results from Grain Legumes at arm's length; it was also formative in promoting learning and improvements, and developmental in nurturing adaption to transformational change with time. The evaluation report was written in a manner that allows for engagement of key partners and funders in a dialogue as to how to increase

ownership and a common understanding of how the goals are to be achieved. We reviewed research undertaken before the CRPs but leading to impacts during Grain Legumes, and research commenced over the past 2.5 years. For related activities pre- and post-commencement of Grain Legumes, we reviewed the relevance of activities and their relation to CGIAR and the Grain Legumes goals, whether they were likely to lead to the outcomes and impacts as documented in the Grain Legumes proposal, and the quality of the science underpinning the likelihood to deliver outcomes. Throughout, we were cognisant of the extent of the reach of CGIAR centres' activities, and those of stakeholders upon which the impact of CGIAR R4D depends.

Within our remit we evaluated the original and modified management and governance structures, and all the processes/responsibilities managed within those structures. Besides the evaluation of the technical and managerial issues of Grain Legumes, we addressed cross-cutting issues of gender sensitivity, capacity building and the creation and nurturing of partnerships. The evaluation also has the objective to provide information relating to the development of full proposals for the new CRP funding cycle.

The evaluation addressed six overarching questions developed from the TOR questions (listed in the Inception Report, 2015 [http://1drv.ms/1POQSZh] and others including cross-cutting issues, phrasing them within the context of traditional evaluation criteria:

1. **Relevance**: Global development, urbanisation and technological innovation are progressing rapidly, are the aims and focus of Grain Legumes coherent, robust, fit for purpose and relevant to the global community?
2. **Efficiency**: Is the structure and effectiveness of leadership across Grain Legumes developing efficient partnership management and project management across PLs?
3. **Quality of science**: Is Grain Legumes utilising a wide range of technologies in a way that will increase our fundamental understanding of the biology that underpins several PLs; and are collected data used in the most effective way?
4. **Effectiveness**: Are Product Lines strategic contributors to the overarching aims and vision for Grain Legumes?
5. **Impact**: Are the impact pathways that underlie each PL well defined, measureable and achievable; and are they sufficiently defined in terms of beneficiaries? Does progress towards achieving outputs and outcomes from the major research areas indicate a lasting benefit for CGIAR and the communities it serves?
6. **Sustainability**: Is Grain Legumes managing the increasing level of restricted funding in terms of program quality and effectiveness, including attracting and retaining quality staff?

Questions for the evaluation of governance and management focused on accountability, transparency, the effectiveness and success of program execution, change management processes and communication methods, taking account of the effects of CGIAR reform. The three crosscutting issues were considered as follows: i) gender balance in program delivery, e.g. whether each PL is able to contribute to the increased income, food security, nutrition, environmental and resource conservation for resource-poor women and men existing in rural livelihoods; ii) are internal and external capacity gaps identified/met, is capacity effectively developed within each product line, and are staff at all levels engaged in contributing ideas towards capacity building; and iii) is there effective involvement of partners in research and activity programming, what are the criteria for developing partnerships, how they are formalised and how is communication between partners and within Grain Legumes managed?

It was not in remit to search for output, outcomes or impact, however as highlighted later, much of our time was spent on searching for information to support claims of impact, since Grain Legumes had no effective dedicated M&E in place at the time of undertaking the review.

Approach and methodology

The evaluation was conducted when Grain Legumes had been operational for approximately 3 years. The approach and methodology followed that outlined in the Inception Report [http://1drv.ms/1POQSZh]. The CCEE Team based its findings, conclusions and recommendations on data collection from several sources:

- review of program documents, communications with the CO, minutes and presentations from all management and governance committee meetings
- review of previous assessments and evaluations
- sampling of Grain Legume projects in 7 countries[1]
- more than 66 face to face interviews, a further 133 persons in groups and 4 phone/Skype conversations: ICRISAT, ICARDA, CIAT and IITA staff, partners and stakeholders. Meetings with one Independent Science and Partnership Council (ISPC) member.
- meetings with over 100 people in 16 external groups, such as farmers' groups
- online survey completed by 126 (33.4%) scientists who contribute to Grain Legumes and a number of non-CGIAR partners and Management representatives
- bibliometric review of 10 publications within each PL to qualitatively assess the design, conduct, analysis and presentation of results
- quantitative and qualitative self-assessment of the contributions of each of the PLs to the six criteria and 3 cross-cutting issues of evaluation mentioned above completed by PLCs (see below).

We reviewed the Logical Framework that underpins the desired Goals, or Impacts of Grain Legumes, and the links between the outputs and inputs as they related to the organisational units of Grain Legumes. The logical framework approach to planning and management of Grain Legumes activities implies a linear process, leading from activities, outputs, outcomes, to impacts, but within such an approach there may be room for a more systems dynamics approach allowing for feedback at every step and within every step, in order to refine and improve upon the respective activities as new results, ideas, and directions come to light.

We then developed a matrix that summarised quantitatively and qualitatively the contributions of each of the PLs to the six criteria and 3 cross-cutting issues of evaluation mentioned above.

Main findings and conclusions

Grain legume production and consumption remain of great importance to the food security of not inconsiderable populations in the developing world, and merit sustained research investment. We conclude that Grain Legumes continues to contribute significant returns to research investments by the CGIAR, and such investment should continue. The global research community looks to the CGIAR for leadership in Grain legumes, but needs to be assured of value adding when bringing CGIAR centres under the expected umbrella of synergy.

However, there is considerable scope for improving the efficiency with which outcomes are achieved. We note that an absence of an effective M&E has hampered the assessment of the effectiveness of proposed impact pathways. Likewise progress has been hampered by the limited numbers of research partnerships with Advanced Institutes and by budgetary constraints (lamented for their stifling effects on continuation of ongoing exciting research). The unworkable management structure constrains the CRP Director's leadership role; responsibility without authority will never lead to effective outcomes. Good fortune is responsible for many of the successes of Grain Legumes, underpinned by a devoted work force across the participating CGIAR centres and partners. The quality of the science is not uniformly high, and we believe that

[1] Morocco, Benin, India, Ethiopia, Kenya, Rwanda and Malawi.

mentoring of scientists should be given priority where quality is poor. Simplified yet informative reporting is an imperative to this. World class science underpins the identification of, and molecular basis for, traits important for yield improvement and this expertise should be extended to all grain legume species, capitalising upon the germplasm collections.

The linking of Grain Legumes with regional research and development consortia has been very successful, with outcomes aligning with those of Grain Legumes. We see that with declining funding consolidation of research effort based on likely successes will be necessary, and welcome the move afoot to incorporate grain legumes into an agri-food system focused on successful value chains that deliver sustainable outcomes.

Relevance and Strategy

Grain Legumes has geographic and disciplinary relevance, addressing the major supply chain issues of variety development seed system and agronomy, with some attention to quality and postharvest marketing systems. The CRP has provided the opportunity to cut ongoing and to initiate new research. Research funded by the Gates Foundation (Anon, 2014) suggests that the need for improvement is greatest in Africa and advocates reducing the number of crop by country combinations when resources are sparse. The lesser research investment in Latin America, however, is not in line with the regions' dependency on legumes.

In spite of the fact that there is no evidence of strong inter-partner CGIAR centre or internal synergy, the program is still moving ahead on most fronts in line with the overall project logframe. This is in spite of continual pushing and pulling by in particular donors and the CO. However, to quantify real impact, we believe Grain Legumes must have access to reliable baseline data on production and consumption, and this is missing. Similarly, there is little evidence of the proposed 'Inclusive Market Oriented Development' (IMOD) framework being used to assist with priority setting.

The product lines, eight of which cover most of the historical programmes in place in the partner CGIAR centres at the commencement of the Grain Legumes, do not cover all the constraints for formal constraints analysis was not undertaken at the inception of the Grain Legumes, and some of this additionally identified research is undertaken under the umbrella of the FPs; this needs to be rationalised. We found the PLs to be isolated in activity, even with minimally-integrated activities within each PL, with little evidence of synergy between PLs. Even though the SCs should ensure a systems approach, as with the new FPs, we did not get a feel that this is so. The underplaying of agronomy, and production practices may be one reason for this. We believe that treating legume crops as if they were horticultural crops will increase farmer returns from investment. The choice of Flagship Projects makes sense, with the flow of activity firstly around crop management and agronomy followed by the logical sequence of trait discovery, incorporation into improved varieties, dissemination of those varieties through appropriate seed chains leading to market impacts, and the capacity building required at all steps. One obvious omission, however, is the lack of a central and strategic policy on the role of transgenics in Grain Legumes.

We found four notable comparative advantages for Grain Legumes: the access to germplasm of component species, the use of the phenotyping facility at ICRISAT, the approach for village level industry for IPM, and the emphasis on hybrid pigeonpea.

Efficiency

Each centre has strong control of, and emphasis on, their 'species' domains, and ownership of the same detracts from possible synergy. Without synergy or value add, the Grain Legumes brings with it no comparative advantage over each centre continuing their own pre-CRP research agendas. We found little evidence of integration of programmes between centres and almost no cross-centre authorship of publications, such as could have occurred with the integrated cross-

centre approaches to stress tolerance including crop modelling: the one publication (Gaur et al., 2015) on heat tolerance by ICRISAT, CIAT and ICARDA does not provide any keys to inter-centre collaboration.

The integration of each centre with NARS and university research programmes is good, but the cross-centre links with NARS are poor. A better coordinated integration with Grain Legumes, , rather than through the individual centres, may reduce transactions costs for NARS,

Monitoring and evaluation is, as noted throughout our report, one area of Grain Legumes research management that has not been given the attention it should have received. If it had have received proper attention, some of the issues of poor efficiency might have been nipped in the bud. A strong monitoring and evaluation system would have provided the baseline data and set the milestones that would have allowed both efficiency and effectiveness to be better appraised. We found no attempt to define comparative advantages of the CGIAR centres and their R4D activities, although practice showed the better grasp of CIAT in developing innovative seed distribution systems.

During field visits and interviews, the CCEE Team observed shortcomings in the communication processes within Grain Legumes and with the broader scientific community and the public. For example, the public face of the program on the internet is out of date. Survey findings, however, suggest that information is shared freely and routinely within the PL within which scientists work.

Some external issues, such as those with funding, low W1/W2 and poor sustainability of funding (especially if funding is top heavy with a few agencies), undermine research investment and confidence of partners in the system (e.g. as voiced by researchers working on crops and countries not included in TL III and the cessation of ongoing competitively-funded projects especially in India), but other issues attributable to the governance and management of the Grain Legumes, such as opaque integration of W3/bilaterals with W1/W2 funding require attention. Offsetting this, the existence of the Grain Legumes did mobilise additional funding [that it would not have if Grain Legumes did not exist]. We were concerned that Grain Legumes is simply not recognised outside of the CRP, with a limited www presence and centres promote themselves, rather than Grain Legumes (with exception in IITA). This is not a good move if one wishes to increase investment in the Grain Legumes.

Although funding agencies require cost:benefit ratios, for example for each PL we faced difficulty in determining comparative value for money between investment in different types of research, and in being able to clearly attribute research and development outcomes to financial investment. There was also a time CCEE frame issue too.

There is poor interaction with the private sector, notably in areas where they have a comparative financial advantage. We questioned in particular the apparent lack of interaction with the major agro-chemical companies, with respect to the development of herbicide tolerant (HT) grain legumes and the lack of evidence that the regulatory and trade aspects related to herbicide tolerant crops had been considered.

Quality of science

The quality of the science is highly variable across Grain Legumes, with pockets of real excellence that are linked to good levels of productivity, whereas other PLs are struggling to deliver quality publications, and outputs and outcomes that are based on these. There is much evidence of gradualism in terms of research output and outcomes, i.e. essentially the same activities that were ongoing at the time of the launch of Grain Legumes are still in place. However, there are examples of game changers including those from valuable investments in genomics, phenotyping, and bio-control. We were pleased to see large proportions of collaboration on publications with non-CGIAR centres, reflecting cooperation with partners in developed and developing countries. The value of collaboration when ensuring quality of science cannot be stressed highly enough

both within the CRP, and with other global and national partners. PLs should be given incentives to collaborate with other CRPs and external institutions. There is little cohesion between PLs and with other CRPs as evidenced by publications, although there are some exceptions. We suspect the reasons for this are driven by funding.

Productivity from the different PLs is also highly variable and it is not clear what other activities staff are engaged in since, in some PLs, they do not appear to lead to quality publications.

Effectiveness

Grain Legumes has been very effective in addressing component issues of research, but not the continuum from variety development to legumes on someone's dinner plate. Our overall assessment of the effectiveness of Grain Legumes in stimulating synergy, innovation and impact indicate that gradualism is more prevalent than innovation. It also shows, as do publications, that there is little integration of disciplines or a focus on 'systems'. The absence of socio-economists from research teams is evident in the general lack of an end user focus. However, research on genomics, plant breeding and seed systems have made great strides forward, on the brink of delivering impact. Agronomy has been a poor sister, but some of the competitive grants within Grain Legumes have unearthed some potential game changers, such as objective use of transplanting as an agronomic practice.

As mentioned earlier, the lack of effective M&E (however, this was part of some major projects such as TL II/TL III), and therefore the ability to monitor impact pathways and achievement of impact, implies no systematic management of data. This creates difficulty when attempting to evaluate the achievement of the Grain Legumes objectives.

One might have expected at least one attempt to try to develop publications between centres arguing for similar biologies/research approaches, bringing species together under one umbrella, but we did not find any evidence for this. It is most unfortunate that, due to budgetary cuts, the new 'schemes', e.g. competitive grants and scholarships, were cut off before gaining a foothold.

With 8 species addressed by Grain Legumes, it is not unexpected that there will be little evidence of shared protocols across centres/species. One rare example was that hosted by the United States Department of Agriculture (USDA) on shared methods for phenotyping of legume germplasm. Researchers from CIAT, IITA, ICRISAT and three USDA stations attended, focusing in simple canopy temperature and root morphology measurements.

It is our belief that as a set of research centres, the CGIAR centres should be focusing on the research for which they have a comparative advantage. While imposing the restructure to FPs, which is fine for development objectives and outcomes (funded through W3/bilateral), it is less so for a research institute, and the structure should not detract from the more basic work expected of an international CGIAR centre (or set of centres as in a CRP).

Impact

It is well known that research does not always lead to scientific breakthroughs. Also, activities such as plant breeding are long term; making impacts difficult to assess. We believe that sufficient progress with genomics and associated research has been made to warrant impact, but we are unable to quantify the levels of impact, or the timeframe for the same.

Work in Grain Legumes has enormous potential for real impact in scientific research, commercial, farming, smallholder and household communities, much of which is being realised. However, the PLs need to become more adept at providing convincing cases that are strongly evidenced for these impacts, as this is likely to be a key factor in leveraging future funding. Claimed gains must be referenced against baseline data, and these are not always readily available. The CCEE Team realises that such impact evaluation represents a significant drain on resources, and Grain Legumes should determine whether the balance of costs to benefits favours such investment.

Interviews conducted by the CCEE during site visits showed that PLs are quantifying the area of adoption of varieties, but in most cases they are not measuring the impact on environment, health/nutrition. Since the health and nutritional benefits and the environmental gains from growing legumes are major arguments for supporting grain legume research, the community is currently missing substantial opportunities to strengthen its own case for continued support.

Whilst there are some impressive examples of considering the whole value chain, e.g. white beans from production through to export; in the main, the pipeline to end user is somewhat piece-meal, with no clear definition of the end user nor differential responsibility of Grain Legumes and of partners.

The lack of robust time-defined impact pathways is highlighted in Section 7.4, and even though developed for PL5, timeframes are essential for measuring progress against prediction.

Sustainability

In summary, there is general acknowledgement that future funding is likely to become more limited, specifically in W1&2 and there is understandable concern over the support for the staff and basic infrastructure that underpin the Grain Legumes programme. For example, it is reported that staffing in parts of CIAT has been dependent on W1&2 and that this is too unstable to re-establish a critical mass.

The present system whereby W3 and bilateral projects do not pay a realistic level of overheads means that such projects are being effectively subsidised by W1&2. This position is not sustainable in the long term as there will be a progressive but definite loss of basic skills and resources in the core centres. The only obvious options to prevent this outcome include a severe reduction in the fixed costs of the centres and/or a refusal to accept W3 and bilateral funding with an inadequate overhead component. In the latter case, there is an obvious danger that funders will move their resources away from the CGIAR system towards other, perhaps less expensive, suppliers of research, and possibly more relevant development expertise. This issue must be addressed.

As the Grain Legumes moves into the future, and if sustainable funding cannot be assured, decisions must be made concerning a reduction in activities, keeping some caretaker breeding maintenance, and focus (as has TL III) on fewer species and a reduced geographic focus.

Cross cutting issues: Gender, capacity building and partnerships

Gender is not mainstreamed, but there is some evidence that this is improving, especially with dedicated gender specialists and the slow integration of gender across CRPs. There is a need to approach gender through the vision of agriculture as a social practice, with recognition of what changes will be acceptable culturally and what not, and capitalising upon the perceived and actual features of production and processing that grain legumes are primarily women-based crops.

Gender awareness may be high among Scientists, but it appears to be a predominantly passive attribute with few proactively seeking opportunities for gender equity. It is, however, a sound sensitivity base on which to build. Nevertheless, examples of notable gender initiatives were identified during field visits. For example, in Benin, the development of biocontrol technologies has enthusiastically integrated diversity, engaging with women farmers' and youths while maintaining cultural norms. Women are gathering and processing, youths are taking the product to market. The implication is that several groups benefit, rather than domination by the majority group. In Malawi, innovative approaches have been developed to improving nutrition for children, such as incorporating nutrient enriched bean flour products into snacks. In India, scientists collaborating with gender scientists and socio-economists are identifying the impact of mechanical harvesting on agricultural labour and the potential displacement of female labourers. In Kenya, a novel initiative is improving the accessibility of certified seed for new varieties. Seed

suppliers have introduced small packs of grain legume seed at low unit cost, which are being purchased by young people and women.

Capacity building efforts for external partners are not clearly aligned with the research mandate and delivery of Grain Legumes. However, there are a number of training activities that are being undertaken by Grain Legumes, largely through the W3/bilateral project. Gender balance never reaches parity, but it appears that efforts are made to include female participants. Within the evaluation timeframe it was not possible to conduct external surveys to further validate or review external capacity building efforts in Grain Legumes.

Training of scientists is significant, with >40 benefiting. Postgraduate training is varied across PLs, and there is some opportunity to increase the numbers being supervised. We consider that support for postgraduates at ICRISAT could be better coordinated, satisfying more of the students' needs. It is important, however, to follow up investments in capacity building by monitoring effectiveness, career progressions and so on.

Training activities appear to be rather centre-specific, not following a coordinated programme managed by, nor at the level of, the Grain Legumes. Numbers of persons trained and their gender are important, but a measure of the effectiveness of the training is more important.

Although optimism is expressed by the great majority of Research Managers that partnerships were working well to leverage knowledge and research capacities, scientists have a less favourable view, particularly in terms of their incentives to participate. It seems likely that the activities taking place within Grain Legumes were, in the most part, continuations of previous collaborations. This is not surprising in light of the reduction in the emphasis on partnerships as Grain Legumes evolved to a funded project, and the consequent lack of opportunity and ambition for establishing novel partnerships. Where they exist, partnerships are good on the whole, especially with US. They could be expanded where comparative advantages exist (for example with Canada and Australia for machine harvestable legumes), but some earlier identified partnerships, e.g. with Turkey, have not been capitalised upon. Others experience problems of variety access (the embargo on exports of some sources of materials from India), yet others do have relevance e.g. imported Brazilian varieties in pre-release in Ethiopia (even though two of the three are from CIAT materials).

Governance and Management

The standard format of committee structure and responsibilities is common to other CRPs, as are the attendant problems. One of the major problems is that the Grain Legumes Director has responsibility but no authority; hence, even with the support of the RMC, the Director is unable to 'direct' in the literal sense of the work the activities of Grain Legumes. We also see the same sense of helplessness with the role of the PLCs. They have responsibility but no authority in managing the affairs of their PL, and they have no access to funds with which to promote intellectual collaboration and cooperation. Minutes from governance and management meetings do not reflect the compromised weak position of the Director and the associated difficulties in the management of Grain Legumes. Nor do the minutes reflect concerns about the amount of time spent by scientists in meetings for planning, integration, evaluation and reporting. Many scientists reported significant opportunity costs in participating in the ongoing imposed [by the CO] evolution of Grain Legumes and CRPs in general.

The changes brought in by the CO have not helped promote any greater authority and capacity of the Grain Legumes Director to direct. Likewise, they do not address any of the issues with the conflict of interest in having the Lead Centre chair the Steering Committee. Indeed, we believe that the combining of the Steering Committee with the Independent Advisory Committee, besides becoming unwieldy in number, annuls any sense of independence in advice offered to the Grain Legumes management.

We have concerns with the declining proportion of W1/W2 funds (as expressed in the section on Sustainability), and believe that when basic financial planning takes place, integration of W1/W2 and W3/bilateral sources must occur, and be linked to anticipated outcomes and impacts. This will ensure a close alignment of collaborators' and partners' objectives and contributions to that of the Grain Legumes. We also queried the process for, and the formality, or lack of, surrounding, the approval of annual budgets, and the level of priority setting when budgets are cut.

Recommendations for Grain Legumes

The CCEE Team makes the following recommendations, critical issues are highlighted in **bold,** and those that require action by an entity other than the Grain Legumes Research Management Committee or Project Management united are identified in a footnote.

Relevance and Strategy

Recommendation 1: A period of consistency is necessary to raise confidence, morale and trust across scientists, managers and partners to foster the assembly of enduring Grain Legumes outcomes[2].

- **There needs to be a concerted effort to undertake baseline studies and to implement a robust M&E activity during this period.** Without these data the foundation for integrated research in grain legumes is jeopardised.
- **There is a strong need to link more closely with the private sector, especially where there are financial and other comparative advantages to do so.**

Recommendation 2: The agronomic and physiological trait targets of Grain Legumes (tolerance to changing climate patterns, to the pests and diseases of today and of the future, incorporation of quality traits and adaptations to intensive production systems [machine-harvestability and herbicide tolerance], and short season high yielding characters) are all worthy of continued investment when selecting for improved varieties.

- There needs to be **a common strategy, implemented across centres and species, as to how to address these trait targets through conventional and modern breeding** approaches, but only if adequate funding is assured and secured and if a consistency and unity of purpose can be achieved across a large-scale. This should take the form of cross-species coordinated research programmes to address these breeding targets that cooperate across centres and make efficient use of facilities and other resources.
- The CRP should **undertake a detailed strategic review of the role of transgenics** across the range of targets in the mandate crops.

Efficiency

Recommendation 3: The lack of an effective M&E process is a significant omission, not least in terms of more efficient use of resources and the lack of baseline data with which to measure impact, and must be rectified.

- **Reinforcing Recommendation 1, an effective M&E system initially directed towards baseline studies must be implemented**.
- Transaction costs may be reduced through bilateral projects, which are seen as more cost effective than W1/W2 where transaction costs are disproportionately higher.

Recommendation 4: To improve communication and coordination within the CRP, and with a broader audience:

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[2] This can be achieved only by the coordinated action of the Consortium Board/Office and Fund Council.

- There is a priority need for a **central database** containing, names of staff associated with Grain Legumes and their time commitments, their responsibilities, and involvement in CRP activities, their progress and achievements, their publications, plans of training, travel, and other opportunities for interaction.
- Regular global meetings of staff involved in managing PLs, the entire CRP management staff and the IAC are essential for effective coordination of all activity within Grain Legumes.
- **The website must be given a complete overhaul** and improvement and then regular maintenance must be provided to keep it current.

Quality of Science

Recommendation 5: It is essential to continue investment in good science and to institute a change from gradualism in research output and outcomes to an expectation of innovative and concrete achievements that can be attributed clearly to people, centres and core facilities.

- **A cost:benefit analysis and subsequent strategic planning must be undertaken to justify further investment in the genomics and phenotyping facilities at ICRISAT especially as such technologies advance rapidly. Strategic planning and coordination must also be implemented for capitalising on the investment in crop simulation modelling.** (The phenotyping facility of ICRISAT needs to focus on delivering some outcomes, not only outputs.)
- **PLs should be given incentives to collaborate with other CRPs and external institutions.** The CCEE recommends special recognition of high quality collaborative papers, thereby encouraging increased quality of the research programmes and widening the penetration of research impacts.
- **More importance should be placed on the quality of publication, rather than quantity of outputs and there should be recognition of other types of outputs from Grain Legumes.** The CRP Director must be party to this.
- If staff are engaged in activities that relate more to impact than publication then this needs to be monitored and recorded and a clearer understanding developed of what constitutes a pathway to impact and how success of such activities can be evaluated. **A system must be devised and incorporated into the M&E to enable recognition of other types of outputs (non- publication based) from Grain Legumes, e.g. varieties for breeders.**

Effectiveness

Recommendation 6: To develop greater synergy, Grain Legumes should review management processes and the direction of research activities. In particular**, far more extensive integration of research and knowledge exchange should take place across both African and Asian continents** so that the best aspects of both can be shared. A multidisciplinary approach is recommended that considers processing solutions, as well as breeding solutions, to capitalise upon the nutritional benefits of the grain legume crops. We recommend:

- **A better collaboration with social scientists at the design stage of experiments** in order to improve the utility of the work carried out and to understand its reach.
- **Supporting[3] the adoption of best practice electronic data collection, central storage and open access, particularly of genomic data, for public use.**

[3] While the support can come from the CRP, the action must be taken by the lead and participating centres.

- Given the focus on the link between phenotyping and genotyping, we note that **there is a lack of congruence between the populations that are being phenotyped and those being genotyped, and therefore these could be better aligned within each species.**
- **Concentrating investment external to Grain Legumes on scaling up production of varieties with the most promising trait profiles to meet the basic seed requirement.**
- **Developing a more holistic approach that coordinates an understanding of the disease pathology and epidemiology, and of new chemicals before they become commercially available, together with agronomic practice such that recommendations can be made for growers.** Continuing work to establish whether agronomic factors hold true in different environments and to assess GxE effects within breeding programmes. Such rigorous trial practices should be used to inform the evaluation of breeding lines and to provide phenotype data to associate with markers for traits such as heat, drought and herbicide tolerance.
- **Considering grain legumes as if they were vegetable crops in terms of the strategy for intensification of production, both from the management perspective and for seed systems, will be a useful development objective into the future.** This will bring about more rapid intensification and is likely to increase farmer returns from investment.

Recommendation 7: **The CGIAR centres should focus in on the research for which they have a comparative advantage.** While imposing the restructure to FPs, which is fine for development objectives and outcomes (funded through W3/bilateral) it is less so for a research institute, and should not detract from the more basic work expected of an international CGIAR centre (or set of centres in a CRP).

- **Collaborative approaches should be explored within Grain Legumes**, e.g. similar biologies/research approaches, bringing species together under one umbrella. Similarly better alignment is needed to address the lack of congruence between the populations that are being phenotyped and those being genotyped.
- Despite positive impacts from research in genomics, plant breeding and seed systems, the lack of an effective M&E, already mentioned elsewhere, has reduced the ability to monitor impact pathways. This must be addressed.
- The absence of socio-economists from research teams is evident in the general lack of an end user focus. **Responsibilities of the different actors in the whole value chain must be considered and identified when developing impact targets, and the pathway leading to them, for individual projects. People with socio-economist skills must be part of the team from project inception so that appropriate frameworks are incorporated for measuring and influencing sociological and economic changes brought about by Grain Legumes research.**

Impact

Recommendation 8: PLs need to become more adept at providing convincing cases in which impact is strongly evidenced, as this is likely to be a key factor in leveraging future funding.

- **Claimed gains must be referenced against baseline data,** and these are not always readily available. The CCEE Team realises that such impact evaluation represents a significant drain on resources, and Grain Legumes should determine whether the balance of costs to benefits favours such investment.
- **It is essential that Grain Legumes provides training to staff on what constitutes impact** and how it can be recorded.
- Specific, rather than generalised, **potential impacts arising from activity within Grain Legumes should be defined at the time of justifying the programme of work** and a pathway to impact should form part of the documentation prepared ahead of a piece of

research commencing. . In other words, centres should submit work plans to Grain Legumes before they are undertaken using W1/W2 funds

Recommendation 9: The reporting activity must be streamlined to a single (brief) format that can be used to report to Grain Legumes, Centres and to donors for special project activities[4].

Sustainability

Recommendation 10: **As Grain Legumes moves into the future, and if sustainable funding cannot be assured, decisions must be made concerning a reduction in activities,** keeping some caretaker breeding maintenance, and focus (as has TL III) on fewer species and a reduced geographic focus. Zeigler (Director General of IRRI) states "*…time and effort would be better spent … making tough decisions about which programs deserve the precious support."*

- The present system whereby W3 and bilateral projects do not pay a realistic level of overheads means that such projects are being effectively subsidised by W1&2 and there will be a progressive but definite loss of basic skills and resources in the core centres. **To prevent this outcome it is necessary to significantly reduce the fixed costs of the centres and/or refuse to accept W3 and bilateral funding without an adequate overhead component.**
- **In the absence of long term certainty, the scale of the budget allocated to each of the new CRPs should be very conservative,** a feature that can only be achieved by restricting/reducing the scope, probably quite significantly.

Cross cutting issues: Gender, capacity building and partnerships

Recommendation 11: The challenge for Grain Legumes is to achieve pro-active gender mainstreaming, which facilitates opportunities for gender diversity within all activities, from employment processes through research to end users.

- **Strategic measurable gender indicators need to be embedded in research design**, for instance, through specific IDOs for each of the flagships projects. Accurate baseline data are also required to facilitate M&E reviews of progress.
- **Implementation of the Gender Strategy is the responsibility of everyone**, not solely the Gender Team**.** Thus, **ownership could be encouraged by setting personal development for key personnel objectives with specific outcomes**, e.g. employment practices or research outcomes.
- Recognising the positive gender initiatives in progress or planned, feedback must be communicated and integrated into broader research planning to share opportunities, methods and outcomes.
- In addition to promoting gender equity in research, **Grain Legumes also needs to ensure that working environments are gender sensitive and that recruitment processes, including promotion opportunities are equitable**. Gender imbalance in management should be actively examined to identify further opportunities for developing female leadership.

Recommendation 12: **It is recommended that a training plan be devised** to ensure that capacity building efforts are more clearly aligned with the research mandate, delivery and timeframe of Grain Legumes. Moreover, we recommend that ICRISAT develop a strategy to treat their new cohort of researchers more equitably in the future.

[4] While this can be led by the RMC/PMU it requires the agreement of the lead and participating centers with respect to W3 or Bilaterally funded projects that are 'mapped' to the CRP.

Recommendation 13: **To develop a more coherent strategic programme designed to eliminate overlap and promote synergy between programmes with common aims, Grain Legumes should hold a meeting with a range of partners.**

Governance

Recommendation 14: Governance processes should be re-assessed and the structure altered to ensure that the Grain Legumes Director has the authority and budget control to drive the execution of strategy.

- **The ISC should be truly independent and given the power to influence strategic decisions before they become final**. We also recommend that PLCs are provided with the authority to manage the direction and finances of their PL; and that **ring-fenced funds are provided for the promotion of collaboration, coordination and staff training**[5].

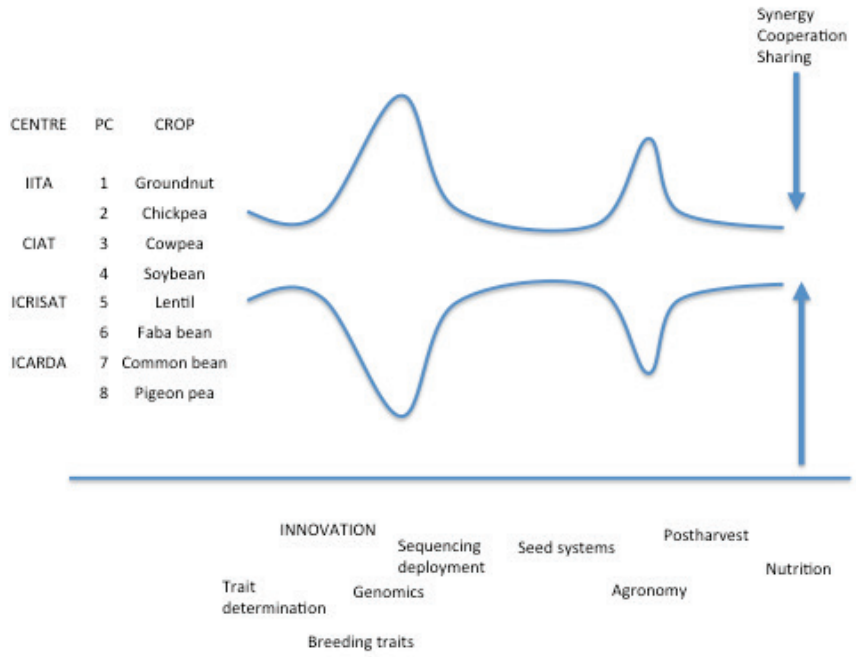
The way ahead

In our view, having seen the ineffectiveness of much of the attempts [or lack of attempts] to harness synergies between multiple centres, and of the strength in few or sole centre partnerships, **we believe that there is little to justify a full retention of the 8 legume species and 4 CGIAR centres in a CRP**. TL I and II and PABRA have shown to be reasonably good cross-centre and single centre integrated programmes, but even they suffer from incomplete value chain approaches to increasing rural incomes while increasing food and nutritional security; they both need multi-faceted solutions which are not immediately forthcoming from Grain Legumes. **It is important to embed Grain Legumes research within the agri-food systems these crops serve**.

Figure ES1 broadly shows the perceived current and potential degrees of synergy between centres, PLs and species, and is discussed more in the text. It is clear that the value chains for individual species from trait determination to nutritional impact have more cohesion than do the individual activities (e.g. trait deployment) across species. For this reason we believe that the future for research in Grain Legumes is best addressed by focusing on each of the species separately, and within an ecosystem framework; any synergy for research across species can be effected through communication and not necessarily through obligatory cooperative research. The ecosystem framework will allow for strengthening of agronomy type systems research, the arguments for benefits of inclusion of grain legumes in cropping systems, which is notable by its absence in much of what Grain Legumes currently undertakes.

[5] This requires action by the lead center and the agreement of the lead and participating centers: ultimately this is the responsibility of the lead center Governing Board.

Figure ES1. Current and potential degrees of synergy between centres, PLs and crop species



We therefore agree with the innovation in agri-food systems approach of the CG, and believe that Grain Legumes rightly belongs in the Dryland Cereals and Legumes Agri-food Systems.

We believe that the option of combining the crops of dryland cereals and legumes in the cereal-legume-livestock systems of subsistence farming communities for whole-farm productivity is closest to the best way forward. Indeed the inclusion of grain legumes may not warrant even a CRP alone, rather the legume components should fit in with the major crops that determine the production systems. Legumes will always be subservient to the major cereals, as necessary adjuncts to the whole production system, providing both nutritional diversity and environmental services, neither achievable from cereals alone.

Figure ES2. Most suitable option for integration of Grain Legumes and Dryland Cereals into an Agri-Food Systems CRP

Agri-Food Systems		Priority Setting & Impact (Enabling Environments?)	Crop Improvement & seed production	Seed Systems & Input Services	Integrated & Water Productivity	Livestock & Livelihoods	Postharvest Value & Output Markets
Grain Legumes and Dryland Cereals		Sorghum, Millet, Barley, Pigeonpea, Groundnut, Chickpea (90%), Cowpea (50%), Soybean (20%)					
Maize							
Rice							
Wheat							
RTB							
FTA							
Livestock							
Fish							

Most suitable option for integration of Grain Legumes and Dryland Cereals into an Agri-Food Systems CRP, which

- Incorporates ex-Dryland Systems, Dryland Cereals, Grain Legumes, some HumidTropics, some ex-Livestock &Fisheries into a new CRP

- Will cover full agri-food system VC for all 8 legumes in all ecologies, but must interact (dock) with the relevant AFS-CRPs for the dominant cereal in the relevant ecology
- Hence, will need to negotiate with other Agrifood Systems-CRPs on who does what for legumes
- In addition, responsible for sorghum and millet in the mixed dryland crop-livestock agro-ecologies

For major game changers to be effected, we believe that the game has to change, and there is little evidence of this. The direction of CRPs is the correct route, but the journey has not yet come to its destination. A major change of game [such as the adoption of a Flagship Project approach as exemplified by the Australian CSIRO – where flagships contract services from centres of research excellence] would be painful to implant.

The CGIAR system is going down the right pathway but it has not gone far enough.

Table of Contents

ACKNOWLEDGEMENTS ii

Acronyms, Abbreviations and Glossary iii

EXECUTIVE SUMMARY 1

Background and context 1

Purpose, scope and objectives of the external evaluation 1

Approach and methodology 3

Main findings and conclusions 3

Relevance and Strategy *4*

Efficiency *4*

Quality of science *5*

Effectiveness *6*

Impact *6*

Sustainability *7*

Cross cutting issues: Gender, capacity building and partnerships *7*

Governance and Management *8*

Recommendations for Grain Legumes 9

Relevance and Strategy *9*

Efficiency *9*

Quality of Science *10*

Effectiveness *10*

Impact *11*

Sustainability *12*

Cross cutting issues: Gender, capacity building and partnerships *12*

Governance *13*

The way ahead 13

Table of Contents 16

Index of Figures 21

Index of Tables 25

1. Introduction 27

1.1. Purpose and audience 27

1.2. The evolving CGIAR context 27

1.3. Evaluation methodology and timelines 28

1.3.1. Methodology outline *30*

1.4 Analysis framework 32

1.5. Deviation from inception report 32

1.6. Limitations to the evaluation 32

1.7. Structure of the report 33

2. Grain Legumes Background 33

2.1. Economic and environmental value of Grain Legumes 33

2.2. Background and objectives for the Grain Legumes Collaborative Research Programme 34

2.3. Roles and Responsibilities 35

2.4. Program objectives 35

2.5. Structure of the Grain Legumes Collaborative Research Programme 37

2.6. Framework and management of the CRP Grain Legumes 40

2.7. Grain Legumes Finance: funding and expenditure 41

2.8. Previous reviews of Grain Legumes 45

3. Relevance 47
3.1 Coherence and program design 47
3.1.1 Relevance across the entire CRP 47
3.1.2. Programme design of the overall CRP 47
3.1.3 Research Strategies 48
3.2. Comparative advantage conferred by the overall CRP 50
3.3. Conclusions and recommendations 51

4. Efficiency 52
4.1. Management of resources 53
4.2. Monitoring and evaluation 53
4.3. Communications 54
4.4. Structural change 55
4.5. Interaction with the private sector 56
4.6. Value for money 56
4.7. Conclusions and recommendations 56

5. Quality of science 58
5.1. Research investment 58
5.1.1. Scientific quality arising from investment in facilities 58
5.1.2. Scientific outcomes arising from modest investment in special projects 58
5.2. Internal processes and conditions including research staff and leadership quality 59
5.2.1. Quality arising from collaboration 59
5.3. Outputs 59
5.3.1. Publications 59
5.3.2. Other outputs/outcomes 61
5.4. Conclusions and recommendations 61

6. Effectiveness 64
6.1 Overview 64
6.2. Progress towards output targets 64
6.3. Effective use of resources 65
6.4. Effectiveness of outputs 65
6.4.1. Plant Breeding and Variety Identification 65
6.4.2. Seed Systems 67
6.4.3. Agronomy 68
6.5 Integration and synergy and other topics influencing effectiveness 69
6.6. Conclusions and recommendations 71

7. Impact 73
7.1. Efforts to document outcomes and impact from past research 73
7.2. Findings from the on-line survey 76
7.3. Constraints to impact 78
7.4. Conclusions and recommendations 78

8. Sustainability 79
8.1. Commentary 80
8.2. Conclusions and recommendations 81

9. Cross-cutting issues 83
9.1. Gender 83
9.1.1 Introduction 83
9.1.2. Implementation of the gender strategy 85
9.1.3. Outputs and outcomes 86

9.1.4. Diversity within Grain Legumes 86
9.1.5. Conclusions and recommendations 87
9.2. Capacity building 90
9.2.1. External: partners and beneficiaries 90
9.2.2. Internal: Grain Legumes staff 90
9.2.3. Conclusions and recommendations 92
9.3. Partnerships 92
9.3.1. The context for effective partnership involvement in research 92
9.3.2. Criteria for developing partnerships 93
9.3.3. Maintaining and managing relationships with partners 94
9.3.4 Outputs/outcomes demonstrating positive synergy among the various partners 94
9.3.5. Conclusions and recommendations 95

10. Broad overview of governance and management 96
10.1. Introduction 96
10.2. The cost of Grain Legumes 97
10.3. In support of continuing Grain Legumes 98
10.4. CGIAR reforms 99
10.5. The Director's compromised role 100
10.6. The budget 102
10.7. Sense of belonging to Grain Legumes among staff 104
10.8. Conclusions and recommendations 104

11. Conclusions and the future outlook for Grain Legumes 105
11.1. Conclusions 105
11.2. The way forward 105

References 108

Appendices 109
A.1. Evaluation of Product Lines 109
A.1.1. Product Line 1: Drought and low P tolerant beans, cowpeas and soybeans 109
A.1.1.1 Relevance 109
A.1.1.2. Efficiency 109
A.1.1.3. Quality of science 109
A.1.1.4. Effectiveness 111
A.1.1.5. Impact 113
A.1.1.6. Sustainability 114
A.1.1.7. Gender 114
A.1.1.8. Capacity building 115
A.1.1.9. Partnerships 115
A.1.1.10. Overall score 115
A.1.1.11. Conclusions and recommendations 116
A.1.2. Product Line 2: Heat-tolerant chickpea, common bean, faba bean and lentil 116
A.1.2.1. Relevance 116
A.1.2.2. Efficiency 116
A.1.2.3. Quality of science 116
A.1.2.4. Effectiveness 118
A.1.2.5. Impact 119
A.1.2.6. Sustainability 120
A.1.2.7. Gender 120
A.1.2.8. Capacity building 121
A.1.2.9. Partnerships 121

A.1.2.10. Overall score *121*
A.1.2.11. Conclusions and recommendations *121*
A.1.3. Product Line 3: Short-duration, drought tolerant and aflatoxin-free groundnut 122
A.1.3.1. Relevance *122*
A.1.3.2. Efficiency *122*
A.1.3.3. Quality of science *122*
A.1.3.4. Effectiveness *123*
A.1.3.5. Impact *124*
A.1.3.6. Sustainability *125*
A.1.3.7. Gender *126*
A.1.3.8. Capacity building *126*
A.1.3.9. Partnerships *126*
A.1.3.10. Overall score *126*
A.1.3.11. Conclusions and recommendations *126*
A.1.4. Product Line 4: High nitrogen-fixing chickpea, common bean, faba bean and soybean .. 127
A.1.4.1. Relevance *127*
A.1.4.2. Efficiency *128*
A.1.4.3. Quality of science *128*
A.1.4.4. Effectiveness *130*
A.1.4.5. Impact *130*
A.1.4.6. Sustainability *131*
A.1.4.7. Gender *131*
A.1.4.8. Capacity building *131*
A.1.4.9. Partnerships *132*
A.1.4.10. Overall score *133*
A.1.4.11. Conclusions and recommendations *133*
A.1.5. Product Line 5: Insect-smart chickpea, cowpea, and Pigeonpea production systems 133
A.1.5.1. Relevance *133*
A.1.5.2. Efficiency *134*
A.1.5.3. Quality of science *134*
A.1.5.4. Effectiveness *136*
A.1.5.5. Impact *136*
A.1.5.6. Sustainability *136*
A.1.5.7. Gender *137*
A.1.5.8. Capacity building *137*
A.1.5.9. Partnerships *137*
A.1.5.10. Overall score *138*
A.1.5.11. Conclusions and recommendations *138*
A.1.6. Product Line 6: Extra-early chickpea and lentil varieties 139
A.1.6.1. Relevance *139*
A.1.6.2. Efficiency *139*
A.1.6.3. Scientific quality *139*
A.1.6.4. Effectiveness *141*
A.1.6.5. Impact *143*
A.1.6.6. Sustainability *143*
A.1.6.7. Gender *144*
A.1.6.8. Capacity building *144*
A.1.6.9. Partnerships *144*
A.1.6.10. Overall score *145*
A.1.6.11. Conclusions and recommendations *145*

A.1.7. Product Line 7: Herbicide-tolerant, machine-harvestable chickpea, faba bean and lentil varieties 145
A.1.7.1. Relevance *145*
A.7.2. Efficiency *146*
A.1.7.3. Scientific quality *146*
A.1.7.4. Effectiveness *147*
A.1.7.5. Impact *149*
A.1.7.6. Sustainability *149*
A.1.7.7. Gender *150*
A.1.7.8. Capacity building *150*
A.1.7.9. Partnerships *150*
A.1.7.10. Overall score *150*
A.1.7.11. Conclusions and recommendations *150*
A.1.8. Product Line 8: Pigeonpea hybrid and management practices 151
A.1.8.1. Relevance *151*
A.1.8.2. Efficiency *151*
A.1.8.3. Quality of science *151*
A.1.8.4. Effectiveness *153*
A.1.8.5. Impact *153*
A.1.8.6. Sustainability *153*
A.1.8.7. Gender *154*
A.1.8.8. Capacity building *154*
A.1.8.9. Partnerships *154*
A.1.8.10. Overall score *154*
A.1.8.11. Conclusions and recommendations *155*
A.2. Final scoring of Product Line Self Assessment 155
A.3. Team member profiles and specific evaluation responsibilities 158
A.4. Self-nominated outputs by PL 161
A.5. Online survey data, respondents host organisations, and e-survey 171
A.6. Persons consulted 202

Index of Figures

Figure ES1. Current and potential degrees of synergy between centres, PLs and crop species 14

Most suitable option for integration of Grain Legumes and Dryland Cereals into an Agri-Food Systems CRP, which..... 14

Figure 2.4.1. The links between the CGIAR SLOs and the Grain Legumes IDOs. 36

Figure 2.5.1. Illustration of links between PLs and SCs. 38

Figure 2.5.2. Comparison of the allocation of funds by product line and strategic component. 38

Figure 2.5.3. How the former PLs and SCs align with FPs. 39

Figure 2.5.4. The Output Targets from Product Lines though to Strategic Components. . 40

Figure 2.7.1. The basis of the 2015 and 2016 budget estimates (W1 and W2) 44

Figure 5.3.1. Impact Factors of the publications from different Product Lines where the information was supplied. 61

Figure 6.5.1. Activities within product lines are 'donor driven' (Research Manager) 70

Figure 6.5.2. Product lines are real 'game changers' (Research Manager) 71

Figure 8.1. Have steps been put in place to ensure sustainable funding? (Research Manager) 80

Table 8.2. Growth and Distribution of CGIAR Funding ($million) by Year, pre and post CGIAR Fund 82

Figure 9.1.1. The Gender Strategy Impact Pathway 85

Figure 9.1.2. Does Grain Legumes have a gender strategy? (Scientist) 86

Figure 9.2.2. I am mentored effectively (Scientist) 90

Figure 10.2.1. Within Grain Legumes, I perceive transaction costs to be high (Scientist) 97

Figure 10.2.2. Structures are in place to minimise general management costs/processes (Research Manager) 98

Figure 10.3.1. CRP activities have enhanced synergy in research and development (Research Manager) 98

Figure 10.4.1. Has value been added by the programme's design and implementation, management and commissioning processes? (Research Manager)..... 100

Figure 10.5.1. Opportunity exists for radical modification of research direction following findings from M&E (Research Manager) 101

Figure 10.5.2. Should the Grain Legumes Director have budgetary control over all W1/W2 expenditure? (Research Manager) 102

Figure 10.7.1. Do you feel an integral part of the CRP? (Scientist) 104

Figure 10.7.2. I fully understand the CRP organisational structure in which I work (Scientist) 104

Figure 11.2.1. Stylised viewpoint for synergy, or lack of it, between CGIAR centres in the R&D supply chain. 106

Figure A1.1. Publications from PL1 ranked by impact factor of the journals they were published in 110

Figure A1.4. Publications from PL4 ranked by impact factor of the journals they were published in. 128

Figure A1.5. Publications from PL5 ranked by impact factor of the journals they were published in. 134

Figure A5.1. Employer organisation of respondents working within Grain Legumes......171

Figure A5.3. Proportion of time spent working on legumes. 172

Figure A5.4. Is the CRP considered a global leader in grain legume research and development? (Research Manager) 173

Figure A5.5.There is a comparative advantage in combining all grain legume research under one CRP (Research Manager). 173

Figure A5.6. An eco/production/systems approach would be superior to the product line approach in delivering impact.....174

Figure A5.7. Lessons learned from research conducted prior to the CRP have influenced my choice of current research (Scientists).....175

Figure A5.8. Opportunity exists for me to follow-up on good ideas with research (Scientist) 175

Figure A5.9. Do you feel an integral part of the CRP? (Scientist).....175

Figure A5.10. I fully understand the CRP organisational structure in which I work (Scientist) 176

Figure A5.11. CRP activities have enhanced synergy in research and development (Research Manager).....176

Figure A5.12. Has value been added by the programme's design and implementation, management and commissioning processes? (Research Manager).....177

Figure A5.13. Have the reformed CGIAR organisational structures and processes increased (or decreased) efficiency and successful program implementation? (Research Manager) 177

Figure A5.14. Opportunity exists for radical modification of research direction following findings from M&E (Research Manager) 177

Figure A5.15. Within my PL, information is shared freely and routinely (Scientist) 178

Figure A5.16. Between my PL and other PLs, information is shared freely and routinely (Scientist).....178

Figure A5.17. Between my CRP and other CRPs, information is shared freely and routinely (Scientist).....178

Figure A5.18. There is sufficient clarity for outsiders on needs in the CRP (Research Manager).....179

Figure A5.19. There is sufficient clarity for outsiders on priorities in the CRP (Research Manager).....179

Figure A5.20. I have access to all the equipment required for my research (Scientist) ..179

Figure A5.21. I have access to all the training I need for my research (Scientist).....180

Figure A5.22. Have you heard of the CRP in Grain legumes? (non CRP Respondent).....180

Figure A5.23. What is the primary reason you are not involved? (non CRP Respondent) 180

Figure A5.24. Have you heard of the Tropical Legumes Programmes? (non CRP Respondent) 181

Figure A5.25. GL CRP has achieved its Intermediate Development Outcomes (Research Manager).....181

Figure A5.26. GL CRP has achieved its CGIAR System-Level Outcomes (Research Manager) 181

Figure A5.27. Product lines are real 'game changers' (Research Manager).....182

Figure A5.28. Activities within product lines are 'donor driven' (Research Manager) ...182

Figure A5.29. My research has led to increased production, sales or consumption of GL (Scientist).....183

Figure A5.30. My research has led to reduced poverty, hunger, or malnutrition of small-holder farmers (Scientist) 183

Figure A5.31. My research has led to improved sustainability of farming systems (Scientist) 184

Figure A5.32. From your knowledge of the CRP, is there evidence of improved crops, or enhanced finances of smallholder farmers and the agricultural system from the ability of grain legumes to fix nitrogen in soils? (Scientist).....184

Figure A5.33. Are you able to directly link an output to a CRP funded activity? (Scientist) 184

Figure A5.34. Sufficient efforts have been made to document outcomes and impact from pre-CRP research, with reasonable coverage over research areas. (Research Manager) 185

Figure A5.35. Are you aware that publications are important pathways for impact? (Scientist).....185

Figure A5.36. Do you expect the benefits of the CRP's activities to be sustained when the CRP ends? (Research Manager) 186

Figure A5.37. Have steps been put in place to ensure sustainable funding? (Research Manager).....186

Figure A5.38. Does the CRP have a gender strategy? (Scientist) 187

Figure A5.39. Have you benefitted directly from association with the CRP? (Scientist).187

Figure A5.40. Have you benefitted indirectly from association with the CRP? (Scientist) 188

Figure A5.41. Have you directly benefitted from capacity building in the past three years? (Scientist) 188

Figure A5.42. I am mentored effectively (Scientist) 188

Figure A5.43. Please indicate how satisfied you are with support from CRP in the following areas: (Scientist) 189

Figure A5.44. Has the CRP supported your partnership with other organisations? 190

Figure A5.45. There is no benefit in researchers on legumes to get together formally (non Grain Legumes Respondent) 190

Figure A5.46. NARS and other partners are sufficiently well represented in the structures of the CRP (Research Manager) 191

Figure A5.47. I belong to another network that supports research synergy (non Grain Legumes Respondent) 191

Figure A5.48. CRP partners are effectively leveraging their knowledge and research capacities, enabling them to coordinate strategies with diverse public and private organisations (Research Manager) 192

Figure A5.49. Are end users viewpoints and needs incorporated into your research agenda? (Scientist) 192

Figure A5.50. There is an integrated approach to the governance and management of the CRP (Research Manager) 193

Figure A5.51. Structures are in place to minimise general management costs/processes (Research Manager) 194

Figure A5.52. Within the CRP, I perceive transaction costs to be high (Scientist) 194

Figure A5.53. Should the Grain Legumes Director have budgetary control over all W1/W2 expenditure? (Research Manager) 194

Index of Tables

Table 1.3.1. Timeline of CCEE evaluation 31

Table 2.2.1. Grain legumes production areas and regional poverty matrix (priority legumes in bold) 35

Table 2.5.1. Product Lines (PLs) and Strategic Components (SCs) 37

Table 2.7.1. Grain Legumes Funding Budget (US$ '000s) 42

Table 2.7.2. Budget by Product Line (US$ '000s) 42

Table 2.7.3. Total Three-Year CRP Research Budget by Product Line and Strategic Component (US$ '000s). 43

Table 2.7.4. Budget by Partner (US$ '000s) 43

Table 2.7.5. Gender Research & Analysis Budget (US$ '000s) 43

Table 2.7.6. CRP Management Budget (US$ '000s) 44

Table 2.7.7. Planned key activities for 2015 to produce IDOs and outputs, with associated planning budgets. 45

Table 5.3.1. Summary of Quantity and Quality of Output Data from all Product Lines [Raw data from self assessments]. 63

Table 9.1.1. Gender Research & Analysis Budget 2012-2015 (US$ '000s) 84

Table 9.1.2. Gender Actuals and Budget Table 2012-2015 (US$ '000s) 84

Table 9.1.4. Scoring of gender balance and sensitivity in each Product Line from PL survey. 89

Table 9.2.2. Summary of PhD and MSc students per Product Line [Raw data from self assessments]. 91

Table A1.1. Quality assessment of nominated papers from PL1. 111

Table A1.1.6. Funding sources for PLs in Grain Legumes 114

Table A1.1.10 summary of PL1 scores. 115

Table A1.2. Quality assessment of nominated papers from PL2. 117

Table A1.2.10 summary of PL2 scores. 121

Table A1.3. Quality assessment of nominated papers from PL3. 123

Table A1.3.10 summary of PL3 scores. 126

Table A1.4. Quality assessment of nominated papers from PL4. 129

Table A1.4.10 summary of PL4 scores. 133

Table A1.5. Quality assessment of nominated papers from PL5. 135

Table A1.5.10 summary of PL5 scores. 138

Table A1.6. Quality assessment of nominated papers from PL6. 140

Table A1.6.10 summary of PL6 scores. 145

Table A1.7. Quality assessment of nominated papers from PL7. 146

Table A1.7.10 summary of PL7 scores. 150

Table A1.8. Quality assessment of nominated papers from PL8. 152

Table A1.8.10 summary of PL8 scores. 154

Table A2.1. Environment, coordination and capacity building per Product Line [Raw data from self assessments]. 156

Table A2.2. Summary of scores derived from the self assessment for each Product Line [Information from self assessments]. 157

Figure A5.2. Scientific Discipline of Respondents 172

Table A5.1. Respondents' host organisations other than the four main CGIAR Centres 195

1. Introduction

1.1. Purpose and audience

The purpose of the CRP (CGIAR Research Program) Commissioned External Evaluation (CCEE) of Grain Legumes is to provide essential evaluative information for decision-making by Program Management and the CRP funders on issues such as extension, expansion and structuring of the program and adjustments in relevant parts of the program.

This evaluation provides an independent assessment of Grain Legumes, which will feed into decisions on the next phase of CRPs, to start in 2017. Pre-proposals are due to be submitted by all CRPs in August 2015 (CGIAR Consortium Office, 2014b) – an important consideration in our timing and underlying the urgency in completing this evaluation.

Evaluation of CRPs is the remit of the IEA, but the evaluation and financing of Grain Legumes (and four others) has been delegated to the respective lead centres.

The evaluation team was also invited to comment upon the proposed options for merging and/or disaggregating of Grain Legumes. The audiences for this report are, therefore, manifold, from the CGIAR Fund Council and Consortium, the Boards of Trustees of the four component CGIAR centres, the Grain Legumes Steering, Management and Independent Advisory Committees, to the researchers and others involved in the delivery of R4D outcomes and their partner organisations. The evaluation was conducted in line with the Terms of Reference, as outlined in the Inception report [http://1drv.ms/1POQSZh]. The Evaluation Team members' profiles are summarised in Appendix 3.

1.2. The evolving CGIAR context

The CGIAR is a global agricultural research partnership that has evolved from a group of four research Centres in 1971 to 15 today, together with other entities such as the CO, FC, IEA and ISPC, with a presence in many countries.

The CGIAR started a major reform process in 2009, moving away from Centre-focussed programs and activities, culminating in the establishment of new structures: a central CGIAR Fund, a CGIAR Consortium, and a Global Conference on Agricultural Research for Development. These were established to promote effective, targeted investment and to build partnership, capacities and mutual accountabilities at all levels of the agricultural system so as to ensure that today's agricultural research will meet the needs of the resource-poor end user. The reform process helps to refine regional and global agricultural research priorities, as identified by different stakeholder groups and representatives in each region in an inclusive manner. One outcome of the reform is the CGIAR Strategy and Results Framework (SRF), which defines CGIAR System-Level Outcomes or SLOs as high-level goals, and Intermediate Development Outcomes (IDOs) which are intended to measure Centre contributions towards the SLOs. The current four SLOs are:

1. Reducing rural poverty (SLO1)
2. Improving food security (SLO2)
3. Improving nutrition and health (SLO3)
4. Sustainable management of natural resources (SLO4)

In parallel was an introduction of cross-CGIAR Research Programs (CRPs), which now cover most of the CGIAR research portfolio. There are currently 15 CRPs, each led by a single CGIAR Centre. CRPs typically contain a mixture of activities, some which represent continuations of previous work ('legacy activities') and others which are new although still incorporating on-going research so as to not lose likely returns to past CGIAR investment.

These CRPs are funded as follows:

- W1 (Window 1) through unrestricted funding managed by the Fund
- W2 (Window 2) funding directed by donors through the Fund to a specific CRP
- W3 (Window 3) funding directed by donors through the Fund managed by a specific Centre
- Bilateral donor projects, with defined objectives and timeframes; other contributions, for example cash or in-kind contributions from partner countries to Centres.

One of the CGIAR Research Programs is Grain Legumes, led by ICRISAT, which combines and coordinates research-for-development activities of eleven principal partners: four CGIAR centres (ICRISAT-lead centre, CIAT, ICARDA and IITA), a CGIAR Challenge Program (Generation), four major national agricultural research systems (EIAR, Ethiopia; EMBRAPA-Brazil, GDAR-Turkey and ICAR-India) and the two USAID-supported legume Cooperative Research Support Programs, all of whom are leaders in grain legume research and development. Other NARS, public and private sector institutes in target and developed countries are also participants of Grain Legumes. Their involvement, and that of local development and community-promoting organisations, is absolutely critical if Grain Legumes is to be able to realise positive impact for beneficiaries (i.e. rural household producers, and consumers), in developing countries. CRP-funded activities cannot be expected to encompass this scale.

Although represented by a diversity of species, the crops of interest to Grain Legumes are all from the same botanical family, and there is much similarity in their genetic constitution, their adaption to various farming systems and their role in nutrition. Therefore, there is an argument for synergy between research organisations and their research products in terms of adoption in similar geographical environments globally. We explore whether such synergy takes place and indeed whether it is necessary.

1.3. Evaluation methodology and timelines

Questions set out in the TOR were phrased within the context of traditional evaluation criteria and developed into six overarching questions (as listed in the Inception Report, 2015 [http://1drv.ms/1POQSZh]:

1. **Relevance**: Global development, urbanisation and technological innovation are progressing rapidly, are the aims and focus of Grain Legumes coherent, robust, fit for purpose and relevant to the global community?
2. **Efficiency**: Is the structure and effectiveness of leadership across Grain Legumes developing efficient partnership management and project management across PLs? The review team examined the structure and effectiveness of leadership across Grain Legumes, including governance structures, financial management and engagement with the Independent Advisory Committee.
3. **Quality of science**: Grain Legumes has access to a wide range of technologies; are they are being utilised in a way that will increase our fundamental understanding of the biology that underpins several PLs. Are data collected in response to hypothesis driven research and are they used in the most effective way to inform and deliver, at the contributing organisation or CRP level? The degree of cooperation and research synergy and of sharing of resources between CGIAR centres themselves and with NARS was quantified.
4. **Effectiveness**: Are PLs strategic contributors to the overarching aims and vision for Grain Legumes?
5. **Impact**: Are the impact pathways that underlie each PL well defined, measureable and achievable; and are they sufficiently defined in terms of beneficiaries? Does progress towards achieving outputs and outcomes from the major research areas indicate a lasting benefit for CGIAR and the communities it serves? Impact of CRP investment in ongoing R&D at the time that Grain Legumes commenced was also evaluated.

6. **Sustainability**: Sustainability of each product line is closely linked to impact and the review team will assess whether the programme of work completed and proposed will generate a lasting benefit for CGIAR and the communities it serves. Is Grain Legumes managing the increasing level of restricted funding in terms of program quality and effectiveness, including attracting and retaining quality staff?

The evaluation also addresses three cross-cutting issues, gender, capacity development and partnerships, and finally governance and management:

7. **Gender:** Gender is a crosscutting area of assessment in the proposed review and is a key area for Grain Legumes, particularly because legumes are often considered as crops of secondary importance (compared to maize and wheat), which are therefore cultivated primarily by women. Gender barriers, such as access to resources and technologies, were recognised in the CRP program description, and the review will assess to what extent such barriers are overcome by implementation of the research strategy. The review team searched for data that describe how each product line is able to contribute to the increased income, food security, nutrition, environmental and resource conservation for resource-poor women and men existing in rural livelihoods. The team investigated to what extent gender balance is achieved in delivering each program, through providing demonstration or test farms, participating in varietal selection and managing production, as set out in the CRP proposal (Table 21 in Original Proposal).
8. **Capacity building:** The evaluation analysed the way in which Grain Legumes has identified and met internal and external capacity gaps. The CGIAR Capacity Development Community of Practice has developed a number of tools and frameworks to inform Centers and these were used, along with other appropriate frameworks, to guide the evaluation. The review assessed the effectiveness of capacity development, considering stakeholders to include internal and Grain Legumes staff, external partners, governments, policy makers and the private sector. The team assessed the extent to which there are methods for implementing capacity building within each product line, and how well staff at all levels feel they can contribute ideas towards capacity building.
9. **Partnerships:** The CCEE team is aware of how significant and important external partnering with organisations, projects and individuals can be to the success of a research programme. The team will examine to what extent there is effective involvement of partners in research and activity programming, what the criteria are for developing partnerships, how they are contracted and how communication between partners and within Grain Legumes are managed.
10. **Governance and Management:** Questions for the evaluation of governance and management explored the effects of the CGIAR reform on the effectiveness and success of program execution, and lessons from changes, and proposed changes, to the structure of Grain Legumes. The team was informed by the section on partnering to evaluate the effectiveness of partnership management, of project management across PLs and how IP is managed across multiple partners inside and outside the grain legumes program. Lines of communication that work effectively are essential at many different levels, and transparency is essential. The review examined the formal reporting framework and whether it is successful in a practical sense between scientists, managers and advisory partners within a product line, between product lines and between Grain Legumes and other CGIAR programs. The team also examined how effective the grain legume program is at communicating its findings with the outside world through peer-reviewed publications, trade and grey literature and other forms of media that engage the stakeholder community. The findings were informed by documented evidence plus interviews to examine the structure and effectiveness of leadership across Grain Legumes.

1.3.1. Methodology outline

The evaluation methodology is presented in detail in the Inception Report. Using a combination of qualitative and quantitative methods, the CCEE Team:

- Reviewed as many Grain Legumes documents as time permitted; these included the original proposal, detailed annual reports, submissions to the CO and responses (including for the extension phase), committee minutes, and other working documents of the CO.
- Visited the following countries, representative of the range of R4D within Grain Legumes, to capture information and perceptions as to the quality and effectiveness of field and other trials, the integration between CGIAR centres and with national partners, the links with beneficiaries, overall management of the research focus, and other relevant information through meetings either one-on-one or in groups:

May 11-15: Morocco	Dunwell, Midmore
May 27-June 1: Benin	Dunwell, Midmore, Smith
June: ISPC France	Dunwell
June 13-20: India	Dunwell, Midmore, Smith
June 29-July 9: Kenya, Ethiopia, Malawi	Dunwell, Smith
June 29-July 9: Kenya, Ethiopia, Rwanda	Midmore

- Focusing on aspects of Grain Legumes relevant to their respective roles, interviewed for the summative evaluation, in a semi-structured manner through virtual or face to face means, a representative selection of donors, partners, peers and external stakeholders and other individuals knowledgeable of the CGIAR, Grain Legumes and global Grain Legumes research in the agricultural development context. Over 300 people in total: 203 persons - 66 face to face, 133 in groups, and phone/Skype conversations with 4; and over 100 people in 16 external groups, such as farmers' groups, whose names were not recorded. Those consulted are listed in Annex A4.
- Invited 377 persons to complete an online survey targeted at ICRISAT, ICARDA, CIAT and IITA researchers or managers contributing to Grain Legumes and a number of non-CGIAR partners and Management representatives. Response rate was 33.4%: 126 completed responses from 377 invitees[6]. The survey was designed with two distinct routes: i) those engaged in (90 respondents), and ii) those outside Grain Legumes (36 respondents). Within the former, four paths were constructed: i) Research Manager, i.e. Manager within a Partner Institution, member of the Steering Committee/Independent Advisory Committee/Research Management Committee; ii) Active Researcher (hereafter referred to as Scientist) ; iii) Extension Specialist/Development Agent; and iv) Student. Response numbers were adequate for Research Managers (51), Active Researchers (33) and non CRP participants (36). Few Extension Specialists/Development Agents or Students responded (2 and 4 respectively); thus, their responses are not included in the body of the report and their views are not adequately represented in issues covered by the survey. In a few instances, respondents were routed past certain questions in the survey; thus percentages originating from survey responses are always based on the actual number of responses to each question, not the total number of respondents within a particular path. All responses were provided on the basis of anonymity, any attributable quotes have been inserted with permission. The survey was

[6] Personal invitations to complete the survey were sent to 436 individuals. To account for invalid email addresses, duplicate invites and long-term absence, such as maternity leave, 377 is a more accurate reflection of invitees.

open from 2nd to 14th and 20th to 22nd July 2015 using an independent platform, Bristol Online Surveys (BOS).

- Undertook, for the formative evaluation, group self and peer evaluations, with the involvement of Grain Legumes staff and stakeholders, to determine the degree of integration, feedback, and way forward within Grain Legumes.
- Analysed a narrative, which allowed for quantitative and narrative responses, prepared by each Coordinator of each PL on publications, other nominated outputs, outcomes, impacts, gender integration and student activities; and contributions of staff to the outcomes and impact within their PL.
- Reviewed all of the activities in each of the PLs, taken to represent 'case studies'; and within each PL, concentrated on one activity, analysing formally in depth the range of criteria outlined in the Inception Report.
- Quality of science was evaluated (by one team member, crossed referenced by the others) using traditional bibliometric criteria for the 'quality' journal used for publication, proportional contributions of Grain Legumes and non-Grain Legumes authors, and proximities of relevance to the objectives for Grain Legumes. Ten publications were reviewed within each PL to qualitatively assess the design, conduct, analysis and presentation of results, their integration between centres and with partners, as well as their impact factors.

Team members were assigned responsibility for each of the Product Lines (the engine-house for R&D, see later), each assisted by the Research Associate and these are indicated in the Table in Appendix 3, together with Team Members' backgrounds. Analyses of each PL were written up according to the criteria outlined in the section on data collection, in a form that allows for cross-case analysis, searching for both objective and serendipitous outcomes. Given the diversity of backgrounds between team Members, the collations reflect differing emphases. The same was so for the 10 Evaluation Criteria (Section 1.3), and responsibilities are indicated in Appendix 3.

The team began the evaluation officially on 1st May 2015, and followed the timelines given in Table 1.3.1.

Table 1.3.1. Timeline of CCEE evaluation

Timeline for CCEE Phase	Period	Main Outputs	Responsibility
Inception Phase	April 2015	Inception Report	CCEE Team
Inquiry Phase	May – July 2015 July 2-22 2015	Various reports and analysis products as defined in inception report On-line survey	CCEE Team
Reporting Phase			
Drafting of Report	Late-July 2015	Draft CCEE Report	CCEE Team
Presentation of Preliminary findings	Early-August 2015	Presentation of preliminary findings Feedback from main stakeholders	CCEE Team
Final CCEE Report	September 2015	Final CCEE Report	CCEE Team

1.4 Analysis framework

Data gatherings and analyses as outlined above initially focused on each of the PLs separately (Appendix A1), and subsequently these analyses were integrated into narratives on each of the six overarching questions. The adoption of the flagship approach to project management, which would have made for a clearer analysis using a conceptual tool of discovery to deployment, was in place for only a short time in the CRP. The team therefore used a number of approaches and interlinked tools for data analyses within and across the PLs. These took the form of both quantitative and qualitative analyses, according to the type of data collected. For example, the quality of science was evaluated using standard metrics, whereas relevance was more qualitative and gender analysis used both quantitative and qualitative approaches. The survey was administered close to the end of the review in order to be able to include questions that were relevant either because data had not been collected earlier in face to face and site visits (such as questions about use of former constraints analysis and ex post studies of research as guiding ongoing and future research), or because there were some issues that were raised by a few interviewees that we believed merited airing by others (such as those related to transaction costs).

We reviewed the balance between investments across the CRP portfolio, both from a disciplinary and funding perspective, and interpreted outputs and outcomes given the short organisation timeline for the CRP. We also searched for evidence of the adoption of a theory of change philosophy that would underpin impact pathway goals, hoping to achieve this through review of monitoring and evaluation activities (but unfortunately these were only rudimentarily adopted).

1.5. Deviation from inception report

The team did not review specific projects, since it was not possible to identify clearly the assignment of funds throughout the duration of Grain Legumes to individual activities at a meaningful level. Instead we evaluated the eight Product Lines, addressing them from the points of view of each of the evaluation criteria where relevant. Thus, the 'in-depth case studies' within each product line proposed in the inception report are now represented by an evaluation of the PLs themselves.

Activities using the PL by SC matrix were not evaluated, since most activity is reported as PL.

1.6. Limitations to the evaluation

Notably, the evaluation was conducted at a time when the future direction and position of Grain Legumes was being reviewed. The evaluation team was invited, therefore, to expand their remit to comment upon the proposed options for merging and/or disaggregating the Grain Legumes.
The size, complexity and numbers of crops in Grain Legumes all mitigate against a clear cut outcome from the evaluation. A major limitation in the evaluation is that the ultimate impact, i.e. that measurable on the ground, is outside the direct influence of Grain Legumes. The CRP, as opposed to the research outputs from its component parts, appears to have very little influence at the level of farmers, and growers. Indeed, the outcomes in terms of increased production might in fact augur against adoption of some recommendations/technologies if increased production simply leads to lower unit prices and therefore neutral or negative impacts on farmers' net revenue.

A further shortcoming was that the team had no support from the IEA (indeed, the CCEE was a financial burden on the MU of Grain Legumes) and did not have access to an IEA Evaluation Analyst. The team also had to spend time to coordinate and execute all travel arrangements,

working within the confines of time limitations and competing demands on all CGIAR staff availabilities.

Much team-time was spent chasing contacts, documents and other sources of information which, had an effective Monitoring and Evaluation database been in place, could have otherwise allowed for greater team-time in analysis and reflection. Consolidated details of contacts within Grain Legumes, of external partners, of meetings and other events suitable for capturing multiple actors/stakeholders for interview were not available from the Management Entity (ME). Finally, the attention given to this Evaluation by members of Grain Legumes has justifiably been constrained due to the ongoing re-organisation/merging of CRPs, by the inordinate demands on time by other external reviews, although the reluctance by some to submit requested information may reflect their disengagement with the Grain Legumes as an entity.

The evaluation benefitted considerably from a survey targeted at ICRISAT, ICARDA, CIAT and IITA researchers who contribute their time to Grain Legumes and a number of non-CGIAR partners. Response numbers were adequate for Research Managers, Active Researchers and non CRP participants. Few Extensionist/Development Agents or Students responded (2 and 4 respectively); thus, their responses are not adequately represented in issues covered by the survey.

1.7. Structure of the report

The report outline is based on the TOR for the evaluation. Chapter 2 provides an overview of Grain Legumes. Chapter 3 considers the relevance of the program and its comparative advantages. Chapter 4 looks at the program's efficiency in terms of management unit processes and budget management. Chapter 5 analyses the quality of science related to research design, processes, outputs and infrastructure. Chapter 6 analyses effectiveness through the degree to which Grain Legumes has achieved its projected outputs. Chapter 7 discusses impact, outputs and outcomes. Chapter 8 reviews sustainability, Chapter 9 provides a summary of the cross-cutting issues. Chapter 10 summarises issues around governance and management, and Chapter 11 provides a summary of the CCEE Team's conclusions and view of the way forward.

2. Grain Legumes Background

2.1. Economic and environmental value of Grain Legumes

Grain legumes are a desirable commodity independent of whether they are viewed as a cost-effective option for improving the diets of low-income consumers who cannot easily afford meat, dairy products and fish. They are also sought by those who choose not to eat meat for ethical or religious reasons. They are a source of dietary protein with a low environmental impact. Grain legumes also generate substantial benefits to the well-being of smallholder farm families. Often a crop cultivated by women, harvests may be consumed at home or sold to generate family income.

In addition, grain legumes provide on-farm agronomic benefits. By complementing cereals, roots and tubers in farming systems of smallholder farmers, legumes can help intensify *and* diversify systems. Grain Legumes focuses on the poorest sectors of society in order to generate a range of economic, social and environmental benefits. However, the major question as to whether a family will be able to lift itself out of poverty with one hectare of grain legumes, for example, is a moot point, one that has to be asked in the context of the whole lifescape within which agricultural interventions take place.

Nevertheless, previous investments in R4D have not satisfactorily addressed four serious production and consumption challenges:

- Legume cultivation has shifted to less productive environments, as a consequence of other staple crops receiving favourable policy support, while other inputs and associated yields of legumes have not increased at a similar rate.
- Inadequate seed production systems and the lack of access to seed by distant smallholder producers are particular bottlenecks to the adoption of improved varieties.
- In some regions the *per capita* demand for legumes is decreasing.
- Grain legumes, as with many crops, are susceptible to climate change, both drought and heat.

These challenges form much of the substance of Grain Legumes, with focus on a number of more important grain legume species. They also form the substance of this evaluation, to determine to what extent Grain Legumes has delivered on these challenges.

2.2. Background and objectives for the Grain Legumes Collaborative Research Programme

The CGIAR Research Program on Grain Legumes was envisaged as a collaborative ten-year research program that focuses on improving eight priority grain legumes crops, chickpea, cowpea, common bean, faba bean, groundnut, lentil, pigeonpea and soybean grown by poor smallholder families and it works in four target regions to combat poverty, hunger, malnutrition and environmental degradation. The research program is underpinned through strategic partnerships as indicated above, along with several public and private institutes and organizations, governments, and farmers worldwide.

Despite many grain legume species offering opportunity for intensification and diversification of cropping systems, eight species were chosen out of 14 candidate species considered at a meeting in Dubai in March 2011. This choice followed extensive literature reviews, and considerations of the known and potential contributions of different species to alleviate poverty, hunger and malnutrition using the number of poor living on less than US$2 per day as an index. The latter are presented in Table 2.2.1 with respect to the target regions in which grain legumes are important commodities.

Table 2.2.1. Grain legumes production areas and regional poverty matrix (priority legumes in bold)

Area	Number of Poor (<US$2 per day)				Total Area (M hectares)
	HIGH (>750million)	MEDIUM (250-750 million)	LOW (<250 million)		
	SSEA (1.3 billion)	SSA (539million)	CWANA (64 million)	LAC (55 million)	
HIGH (>0.5M hectares)	Soybean, oil (11.4) **Chickpea (9.0)** **Groundnut (7.9)** Mung bean (5.0) **Pigeonpea (4.2)** **Lentil (1.7)** Pea (0.78)	**Groundnut (10.8)** **Cowpea (10.4)** **Bean, common (5.8)** **Soybean (1.4)** **Faba bean (0.50)** **Pigeonpea (0.50)**	**Chickpea (1.2)** **Lentil (0.6)**	Soybean, oil (4.4) **Bean, common (2.7)**	**Groundnut (19.02)** **Chickpea (10.71)** **Cowpea (10.62)** **Bean, common (8.75)** Mung bean (5.00) **Pigeonpea (4.74)** **Lentil (2.43)** **Soybean (1.58)** Pea (1.47) **Faba bean (1.04)**
LOW (<0.5M hectares)	Cowpea (0.17)	Pea (0.45) Chickpea (0.42) Bambara nut (0.12) Lentil (0.11) Pea (0.04)	Faba bean (0.4) Bean, common (0.25) Soybean (0.18) Groundnut (0.13) Pea (0.13) Cowpea (<0.01)	Groundnut (0.19) Faba bean (0.14) Chickpea (0.09) Pea (0.07) Cowpea (0.04) Pigeonpea (0.04) Lentil (0.02)	

Notes: SSEA: South and Southeast Asia; SSA: Sub-Saharan Africa; CWANA: Central and West Africa and North Africa; LAC: Latin America and the Caribbean; Figures in parentheses for each crop are area of production (in million ha)

Sources: Area of production for three-year average 2007-2009, FAOSTAT; Number of Poor (>$2 per day) – World Bank, http://research.worldbank.org/PovcalNet/index.httm. The table is taken from the Grain Legumes proposal document.

2.3. Roles and Responsibilities

The Lead Centre (ICRISAT) signed a Program Implementation Agreement (PIA) with the Consortium of Agricultural Research Centres for implementation of Grain Legumes on 1st January 2013, though the start date was 1st July 2012. It was determined that the lead centre, represented by its Director General and Governing Board, would be responsible for the overall performance of Grain Legumes by providing a clear vision, direction, priorities and focus through an inclusive, consultative and transparent partnership process. Participant Program Agreements (PPAs) were signed in January 2013 with all key participants according to Consortium procedures and policies.

The Governing Board of ICRISAT has the fiduciary and legal responsibility and accountability for the implementation of Grain Legumes. Through the Director General, it will monitor management and implementation, including the performance of the Grain Legumes Director, Independent Advisory Committee, Steering Committee and Research Management Committee. The governance and management entities of the other partners will be expected to provide similar oversight of their respective institute's involvement in Grain Legumes. This would include ensuring that their institutional policies, vision and mission are in agreement with Grain Legumes, that Grain Legumes is appropriately reflected in their strategic plans and that their institution assumes fiduciary and legal responsibilities and accountabilities for implementing the agreed research agenda of Grain Legumes.

2.4. Program objectives

The broad objectives addressed by Grain Legumes are to increase production, sales, consumption and the beneficial contribution of grain legumes to agricultural systems and so to reduce poverty,

hunger, malnutrition of smallholder farmers and their households, while improving the health of both the urban and rural population, which will increasingly depend on these foods.

The five Intermediate Development Outcomes[7] of the Grain Legumes CGIAR Research Program are:

- *IDO1 Food Security*: Improved and stable access to grain legumes by urban and rural poor;
- *IDO2 Income*: Increased and more equitable income from grain legumes by low income value chain actors, especially women;
- *IDO3 Nutrition & Health*: Increased consumption of healthy grain legumes and products by the poor for a more balanced and nutritious diet, especially among nutritionally vulnerable women and children;
- *IDO4 Productivity*: Improved productivity of farming systems, especially among smallholder farmers; and
- *IDO5 Environment*: Minimised adverse environmental effects of increased production and intensification of grain legumes.

Figure 2.4.1 illustrates the relationship between these five CRP Intermediate Development Outcomes and the four CGIAR-wide System Level Outcomes.

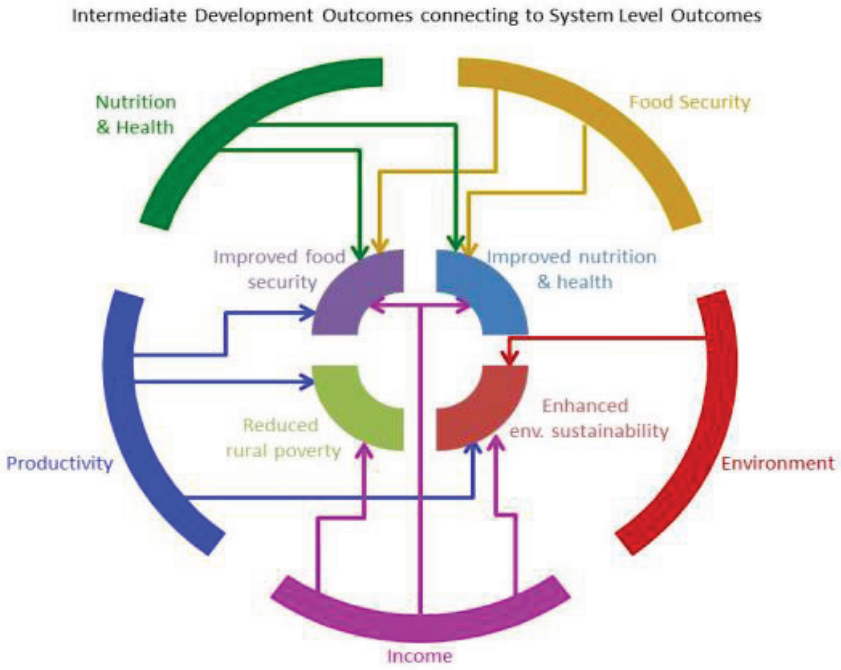


Figure 2.4.1. The links between the CGIAR SLOs and the Grain Legumes IDOs.

Source: CRP Grain Legumes Extension Proposal, 2014.

The success of the program is to be characterised in three ways: i) approximately 20% of crop area as legumes and concomitantly reduced demand for inputs in the target areas for Grain Legumes;

[7] These were proposed in September 2013.

ii) balanced nutrition for consumers from the combination of legumes & cereals, including vegetable legumes; and iii) that these together will provide stable income to smallholders.

The high nutritional value and low cost of legumes as food makes them especially attractive for low-income households. This has tended to stigmatise the consumption of legumes in non-vegetarian cultures, although there is a growing awareness of their dietary and nutritional value among those for whom meat-eating is not seen as a necessary correlate of status.

2.5. Structure of the Grain Legumes Collaborative Research Programme

The original research management structure was based upon eight Product Lines (PLs - determined at one of a few meetings in Dubai prior to the submission of the accepted proposal), and 5 cross-cutting Strategic Components (SCs). This choice was based on Consortium Board comments on the GLVA (Grain Legumes Value Alliance, the title of the proposal that time) in June 2011: only 8 primary legume crops were selected for Grain Legumes. The PLs are ordered around species and output oriented research objectives. The SCs contribute to advancing Grain Legumes objectives of improving the production, sales, and consumption of grain legumes. Both are indicated in Table 2.5.1. Targets for SCs within each product line align according to IDOs, which were accepted after the start of Grain Legumes and established in 2013.

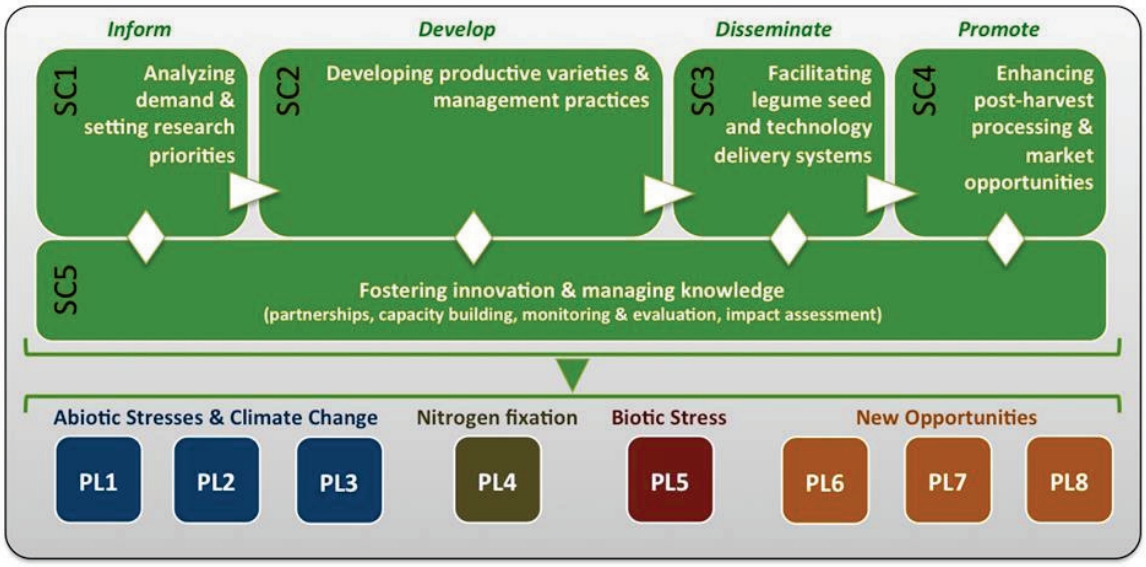
Table 2.5.1. Product Lines (PLs) and Strategic Components (SCs)

Product Line	Focus of activity
PL1	Drought & low-P tolerant common bean, cowpea & soybean
PL2	Heat tolerant chickpea, common bean, faba bean and lentil
PL3	Short-duration, drought tolerant & aflatoxin-free groundnut
PL4	High nitrogen-fixing chickpea, common bean, faba bean and soybean
PL5	Insect-smart chickpea, cowpea, and pigeonpea production systems
PL6	Extra-early maturing chickpea and lentil varieties
PL7	Herbicide tolerant machine-harvestable chickpea, faba bean and lentil varieties
PL8	Pigeonpea hybrid and management practices

SC 1	Analyzing demand and setting research priorities	Identify priority research and development needs ranging from farmers, seed sellers, processors, and marketers to consumers and policymakers.
SC 2	Developing productive varieties and management practices	Accelerate the development of more productive and nutritious legumes varieties and crop and pest management practices for resilient cropping systems of smallholder farmers.
SC 3	Facilitating legume seed and technology delivery systems	Develop and facilitate efficient legume seed production and technology delivery systems for smallholder farmers.
SC 4	Enhancing post-harvest processing and market opportunities	Enhance grain legumes value additions, and social and environmental benefits captured by the poor worldwide, especially women.
SC 5	Fostering innovation and managing knowledge	Partnerships, capacities, and knowledge sharing to enhance grain legume R4D impacts

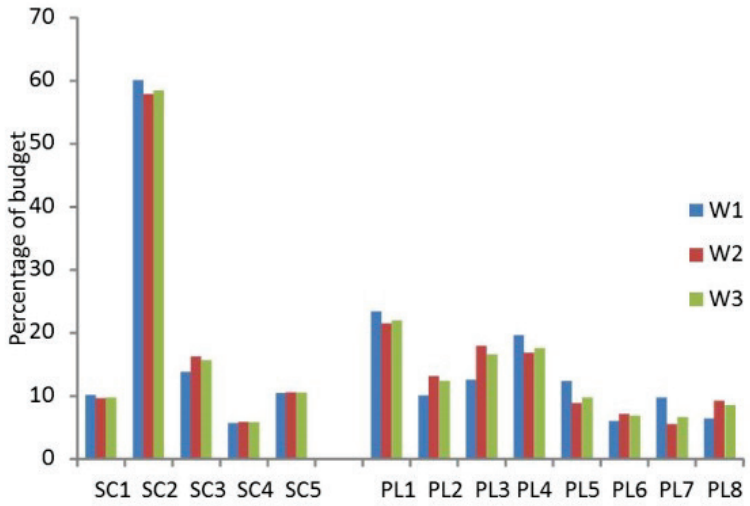
This delivery structure, with minor amendments was maintained until the end of 2014 and remains imbedded within the structure developed for the extension phase (2015-2016). Within each PL five Activity Clusters were nominated, within each with activities. A pictorial representation of the links between PLs and SCs is given in Figure 2.5.1, and the allocation of funds by PL and SC is in Figure 2.5.2.

Figure 2.5.1. Illustration of links between PLs and SCs.



Source: CRP Grain Legumes Proposal dated 15 Aug 2012.

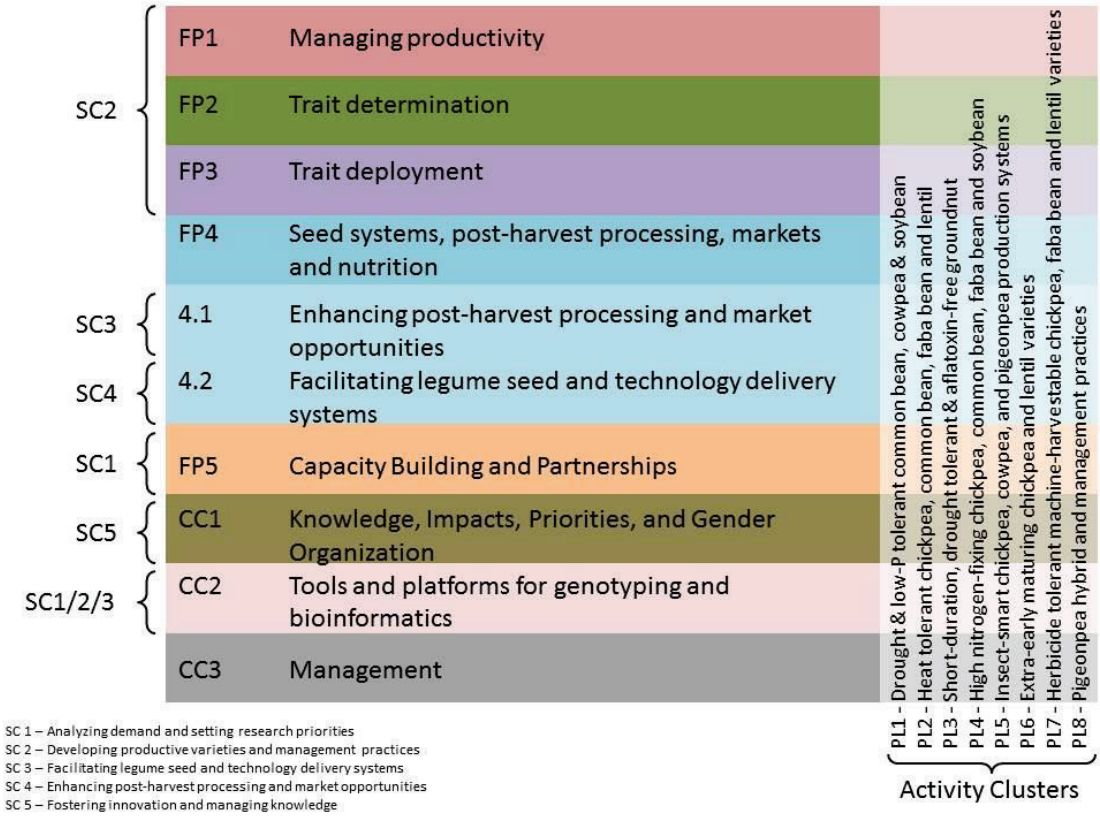
Figure 2.5.2. Comparison of the allocation of funds by product line and strategic component.



Source: CRP response to comments on the 2014 POWB.

Following directives by the CO, voiced through CO and ISPC comments on the 2014 POWB, a new structure was developed, with effect from 2015 using the Flagship Project Approach. (FPs i.e. that relate to the "**o**ne **c**orporate **s**ystem" description of CRPs). Eight FPs were set up, five with their most important outputs in the context of the R4D process leading to IDOs, two as cross-cutting activities (Called FP 6 and 7), and one for Management (FP 8). Nominal relationships between PLs, SCs and FPs are presented in Figure 2.5.3.

Figure 2.5.3. How the former PLs and SCs align with FPs.



Note CC 1, C2 and CC3 are later called FP 6, FP 7 and FP 8 in response to the CO/ISPC comments, and note that Activity Clusters are within each PL and FP.

Source: CRP Grain Legumes Extension Proposal, 2014.

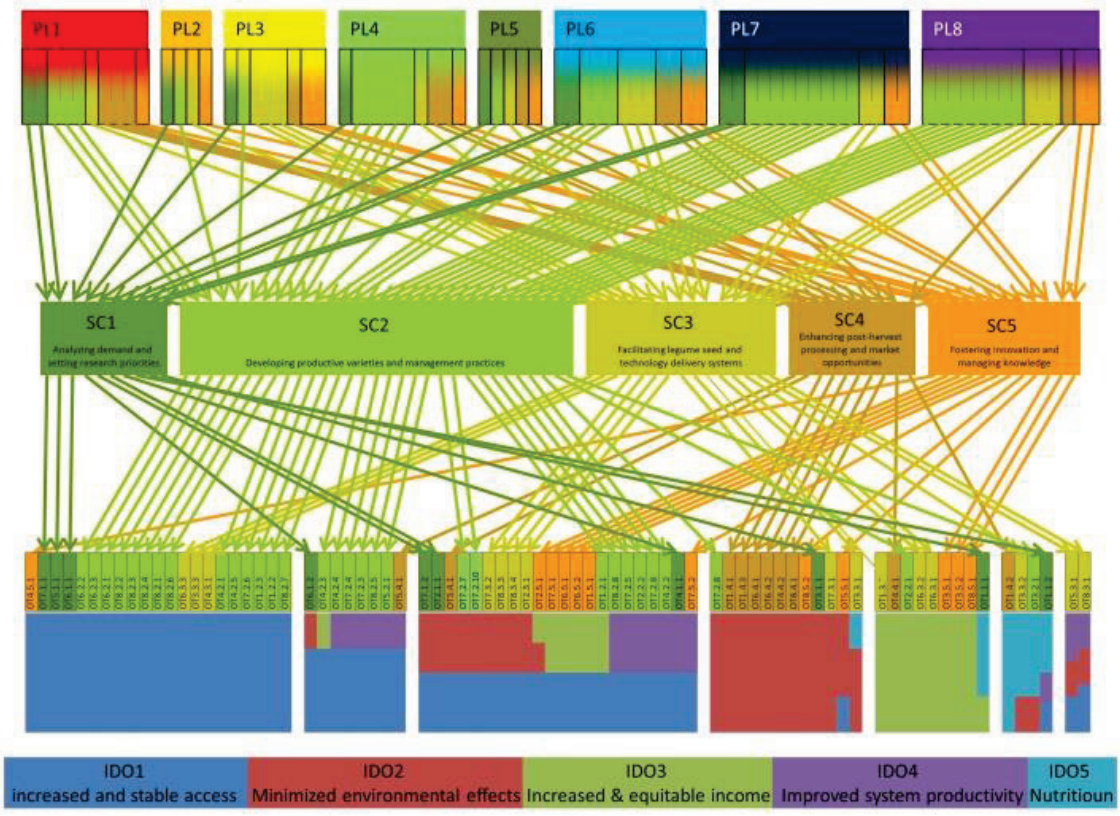
This overall reorganisation required some modifications to the descriptors of Output Targets. The former SC2 (*Developing productive varieties and management practices*) was divided into three more manageable Flagship Projects, since it comprised 60% of Grain Legumes activities/resources/budget.

This realignment of Grain Legumes according to Flagships rather than Product Lines places the most important outputs of Grain Legumes into the context of the R4D process leading to IDOs, rather than emphasising the specific technical innovations. Product Lines remain intact, and run through the FPs providing the outcome focus in this process perspective. The Flagship Projects 1 to 5 identify the crop interactions with biotic and abiotic constraints (FP1), the trait discovery and deployment pipeline (FP2 and FP3), the seed systems required for their adoption, and markets that produce income (FP4), and capacity building and partnerships (FP5). The cross-cutting assessment of impact, the redefining of priorities and assessing gender components of priorities

and activities is undertaken in CC1) (FP6). Another new cross-cutting area, CC2 (FP7), intends to develop high throughput genotyping and associated bioinformatics, and CC3 (also called FP 8) includes the Project Management Unit and the various governance and oversight committees.

The concurrence of PLs and SCs with IDOs is presented Figure 2.5.4.

Figure 2.5.4. The Output Targets from Product Lines though to Strategic Components.



Source: Response to CRP Grain Legumes POWB 2014.

The Output targets in Figure 2.5.4 are organised according to their percentage contribution to each IDO. Each output target is directed to one or more IDO, with a rough estimation of the proportion; these are clustered at the bottom of the figure according to the type of outcome anticipated.

2.6. Framework and management of the CRP Grain Legumes

The framework and management of Grain Legumes is based on the principles outlined in the CGIAR Strategy and Results Framework. In 2013 the structure of Grain Legumes was implemented, with the appointment of the Director, the Research Management Committee and the Independent Advisory Committee. Prior to this, the Steering Committee and Lead Centre Governing Board had exercised oversight through an interim structure. The year saw major upheavals in terms of projected budget as well as the timing and nature of future plans. These were consequently rather more difficult to deal with than it would have been had these structures been long established.

The management structures are set up to provide effective governance and oversight by the Lead Centre, strategic oversight by key partners, research management by key contributing partners and independent evaluation and input by outside experts. With time, these are being refined with evolution of Grain Legumes.

Integration of the program is a continuing process and the formation of the Research Management Committee with representatives from the four CGIAR Centres and one partner organisation was a major step towards coordinated decision-making that builds on the original planning of the project. The diversity of specific projects (bilaterally and W3 funded) creates a complex structure, but the USAID funded projects, for example, help to sustain linkages between Grain Legumes and partner organisations. The Bill and Melinda Gates funded project Tropical Legumes is a major component of Grain Legumes of comparable scale to the W1/W2 funding and with closely aligned objectives, but more restricted in the scope of crops and target areas; N2Africa is a similarly large BMGF project which also serves to connect CRP Grain Legumes with the CRP Humid Tropics.

2.7. Grain Legumes Finance: funding and expenditure

The planned funding budget across Centres for Grain Legumes as of the proposal is set out in Table 2.7.1, where Year 1 is 2012, year 2 is 2013 and year 3 is 2014. The same total allocation is apportioned to PLs in Table 2.7.2 and by PL and SC in Table 2.7.3. Tables 2.7.4, 2.7.5 and 2.7.6 indicate the proposed budget according to Partner (and management), gender and CRP Management entity allocations.

Table 2.7.1. Grain Legumes Funding Budget (US$ '000s)

Funding Source	Year 1	Year 2	Year 3	Total	
CIAT					
CGIAR Window 1 & 2: Research	3,600	3,780	3,969	**11,349**	**33%**
Bilateral Funding (secured)*	4,663	2,511	2,364	**9,538**	**28%**
Funding Gap	-	5,878	7,661	**13,539**	**39%**
Totals	**8,263**	**12,169**	**13,994**	**34,426**	**100%**
* includes Other Center Income					
ICARDA					
CGIAR Window 1 & 2: Research	3,330	3,496	3,671	**10,497**	**65%**
Bilateral Funding (secured)*	1,081	570	550	**2,201**	**14%**
Funding Gap	1,059	1,112	1,168	**3,339**	**21%**
Totals	**5,470**	**5,178**	**5,389**	**16,037**	**100%**
* includes Other Center Income					
ICRISAT					
CGIAR Window 1 & 2: Research	4,422	4,643	4,875	**13,940**	**28%**
Bilateral Funding (secured)*	8,429	6,920	3,843	**19,192**	**39%**
Funding Gap	-	5,873	10,792	**16,665**	**33%**
Totals	**12,851**	**17,436**	**19,510**	**49,797**	**100%**
* includes Other Center Income					
IITA					
CGIAR Window 1 & 2: Research	6,342	7,051	7,806	**21,199**	**67%**
Bilateral Funding (secured)*	3,433	3,598	3,260	**10,291**	**33%**
Funding Gap	-	-	-	-	-
Totals	**9,775**	**10,649**	**11,066**	**31,490**	**100%**
* includes Other Center Income					
Generation Challenge Program					
CGIAR Window 1 & 2: Research	-	-	-	-	
Bilateral Funding (secured)*	1,020	1,029	691	**2,740**	**100%**
Funding Gap	-	-	-	-	
Totals	**1,020**	**1,029**	**691**	**2,740**	**100%**
* includes Other Center Income					
TOTAL					
CGIAR Window 1 & 2: Research	17,694	18,970	20,321	**56,985**	**41%**
CGIAR Window 1 & 2: CRP Management	1,474	1,547	1,625	**4,646**	**3%**
Total CGIAR Window 1 & 2	**19,168**	**20,517**	**21,946**	**61,631**	**44%**
Bilateral Funding (secured)*	**18,626**	**14,628**	**10,708**	**43,962**	**32%**
Funding Gap	**1,059**	**12,863**	**19,620**	**33,542**	**24%**
Totals	**38,853**	**48,008**	**52,274**	**139,135**	**100%**
* includes Other Center Income					

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

Table 2.7.2. Budget by Product Line (US$ '000s)

	Year 1	Year 2	Year 3	Total	
Product Lines					
PL1 Drought & low-P common bean, cowpea & soybean	9,436	12,137	13,105	**34,678**	25%
PL2 Heat tolerant chickpea, faba bean, lentil & common bean	3,984	4,649	5,227	**13,860**	10%
PL3 Short-duration & aflatoxin-free groundnut	4,535	6,084	6,721	**17,340**	12%
PL4 High nitrogen-fixing common bean, chickpea, faba bean & soybean	4,236	5,658	6,388	**16,282**	12%
PL5 Insect-smart cowpea, chickpea & pigeonpea	6,529	7,417	7,762	**21,708**	16%
PL6 Extra-early maturity lentil & chickpea	2,081	2,482	2,679	**7,242**	5%
PL7 Herbicide tolerant chickpea, faba bean & lentil	2,834	3,187	3,448	**9,469**	7%
PL8 Hybrid pigeonpea	2,232	3,029	3,389	**8,650**	6%
Total Product Lines	**35,867**	**44,643**	**48,719**	**129,229**	93%
Gender Research & Analysis	1,512	1,818	1,930	**5,260**	4%
CRP Management	1,474	1,547	1,625	**4,646**	3%
Total Budget	**38,853**	**48,008**	**52,274**	**139,135**	100%

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

Table 2.7.3. Total Three-Year CRP Research Budget by Product Line and Strategic Component (US$ '000s).

	PL1	PL2	PL3	PL4	PL5	PL6	PL7	PL8	Total	
Strategic Components										
SC1 Better targeting of opportunities	2,266	1,597	1,598	1,093	1,819	999	1,413	961	**11,746**	8%
SC2 Cultivars and crop management	21,098	8,656	9,871	7,550	11,816	4,113	5,512	3,844	**72,461**	52%
SC3 Effective seed delivery	5,311	1,542	2,883	2,394	2,495	1,117	1,272	1,922	**18,936**	14%
SC4 Post-harvest value and markets	1,324	636	1,442	2,804	1,976	481	636	961	**10,260**	7%
SC5 Knowledge sharing and training	4,679	1,428	1,546	2,441	3,602	533	636	961	**15,826**	11%
Total Strategic Components	**34,679**	**13,859**	**17,340**	**16,283**	**21,708**	**7,242**	**9,469**	**8,650**	**129,230**	93%
Gender Research & Analysis	1,412	564	706	663	884	295	385	352	**5,260**	4%
CRP Management	1,246	498	623	585	780	260	340	311	**4,645**	3%
Totals	**37,337**	**14,922**	**18,669**	**17,531**	**23,372**	**7,797**	**10,195**	**9,313**	**139,135**	100%
	27%	11%	13%	13%	17%	6%	7%	7%	100%	

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

Table 2.7.4. Budget by Partner (US$ '000s)

Partner	Year 1	Year 2	Year 3	Total	
CIAT	6,499	10,229	11,860	**28,588**	**21%**
ICARDA	5,055	4,786	4,980	**14,821**	**11%**
ICRISAT	11,145	15,122	16,920	**43,187**	**31%**
IITA	8,411	9,163	9,522	**27,096**	**19%**
GCP Partners	1,020	1,029	691	**2,740**	**2%**
Center Partners	5,249	6,132	6,676	**18,057**	**13%**
CRP Management	1,474	1,547	1,625	**4,646**	**3%**
Total Budget	**38,853**	**48,008**	**52,274**	**139,135**	**100%**

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

Table 2.7.5. Gender Research & Analysis Budget (US$ '000s)

Partner	Year 1	Year 2	Year 3	Total
CIAT	367	460	488	**1,315**
ICARDA	156	164	172	**492**
ICRISAT	449	611	682	**1,742**
IITA	489	532	553	**1,574**
GCP	51	51	35	**137**
Total Gender Research Budget	**1,512**	**1,818**	**1,930**	**5,260**

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

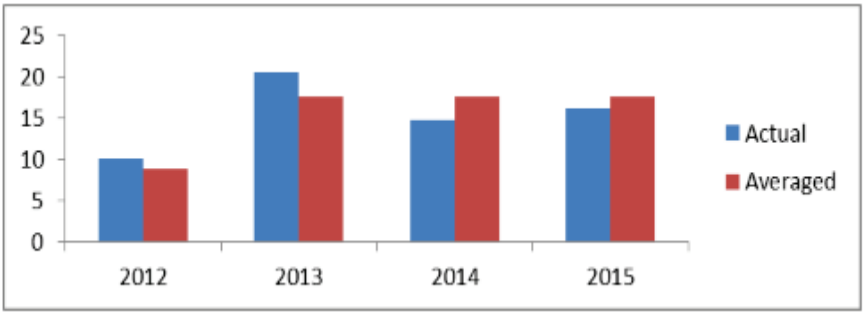
Table 2.7.6. CRP Management Budget (US$ '000s)

Category	Year 1	Year 2	Year 3	Total	
CRP Director (salary, travel, operations)	280	294	309	**883**	**19%**
Product Line Coordinators (salaries, travel, operations)	768	806	847	**2,421**	**52%**
Program Management Unit (salaries, operations)	208	218	229	**655**	**14%**
Research Management Committee (travel, operations)	128	134	141	**403**	**9%**
Independent Advisory Committee (honorarium, travel, operations)	90	95	99	**284**	**6%**
Total CRP Management Budget	**1,474**	**1,547**	**1,625**	**4,646**	**100%**

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

An unusually high W1+W2 budget allocation in 2013 was 'rectified' by a considerable reduction in 2014 and 2015 (Figure 2.7.1). This has created difficulties with projections into the future for funding of Grain Legumes.

Figure 2.7.1. The basis of the 2015 and 2016 budget estimates (W1 and W2)



Source: CGIAR Extension Proposal 2015-16, p14.

For purpose of comparison, the proposed budget for 2015 on a flagship basis is presented in Table 2.7.7.

Table 2.7.7. Planned key activities for 2015 to produce IDOs and outputs, with associated planning budgets.

FOR REFERENCE ONLY Level as described by OCS	Level of organisation within the CRP	Description of planned key activities at each level of internal organisation	Expected results of planned key activities	Planned budget ($ 000s)
Level 3: Theme, and Level 4: outcomes	Level n-1: Flagship Project	*Provide a list of all the Flagship Projects (level n-1) which constitute the full CRP (level n). Indicate, where relevant, the geographical areas where the Flagship is implemented. Number Flagships from 1 to x*	*Expected progress toward the CRP IDOs, and indicators of this progress*	*Budget per Flagship Project W1W2 & W3-bilateral*
Flagship Project 1 Managing productivity		All target areas		7,265
Flagship Project 2 Trait determination		All target areas		2,043
Flagship Project 3 Trait deployment		All target areas		8,925
Flagship Project 4 Seed systems, post-harvest processing, markets and nutrition		All target areas		14,482
Flagship Project 5 Capacity Building and Partnerships		All target areas		3,865
Flagship Project 6 Knowledge, Impacts, Priorities, and Gender Organisation		All target areas		1,857
Flagship Project 7 Tools and platforms for genotyping and bioinformatics		This will have a high degree of focus on chickpea so will be mainly relevant to South Asia and Ethiopia		743
Management				1,044
			Total	40,223

Source: CRP Grain Legumes POWB 2015.

The program costs were US$61.631 million for 3 years for Windows 1&2, and $43.962 million secured for W3 and bilateral, with a further $33.542 million, giving a total budget of $139.135 million, as discussed later. The Funding Gap refers to anticipated W3/bilateral funding. It was assumed that, at the time this was written, the distinction between W3 and bilateral funding was not acknowledged.

2.8. Previous reviews of Grain Legumes

Over the past year a number of reviews of CGIAR grain legume research have been published. One by Pachico (2015) focuses on 6 of the 8 species included in Grain Legumes, on the adoption of improved varieties and their impact on productivity, profitability, poverty, food security, gender and management of natural resources. Another by Robinson (2015) addresses the role of CIAT in bean research in Africa, one by Anon (2014) reviews progress in the Gates Foundation TL II from a perspective of programme effectiveness and efficiency, and two others include grain legumes with other crops (Walker et al., 2014 – all eight Grain Legumes crops in sub-Saharan Africa with a focus on diffusion of improved varieties; and Sachdeva et al., 2014, - beans, groundnuts, cowpeas, chickpeas in the Global Challenge Programme reviewing particularly impact of genetic products and of capacity building).

Pachico (2015) reviewed 30 adoption studies, providing evidence for adoption of improved varieties particularly bean varieties in sub-Saharan Africa, cowpea in West Africa, and chickpea in southern India and smaller scale adoption of chickpea in the Horn of Africa. Groundnut adoption is more localised, in East Africa, as is that of lentil, in Bangladesh and Ethiopia. With seed system playing a key role in adoption of new varieties, Pachico recommends identification of best practices in grain legume seed systems to guide implementation. Although, once adopted, the impact of the new varieties on CGIAR system-level outcomes is far less evident, there being little empirical evidence for direct benefits of improved varieties on nutrition and health. Likewise, there is little to no evidence of beneficial impacts of new varieties on the farm-level natural

resource base. Of interest, Pachico finds that adoption of improvements in production practices, other than those attributable to new varieties, has not taken place.

With a focus on beans and CIAT's contribution to improvement in West, Central, Eastern and Southern Africa (a total of 30 nations, in a consortium called PABRA), Robinson (2015) highlights the central overseeing role that CIAT has had with PABRA, underpinning the technical activities and adding catalytic weight to sourcing of funds and resources. He does not provide data on value for money, but refers to earlier studies showing returns of $200 million on investments of $16 million spent over 17 years, plus unaccounted for spill-over effects.

Research in grain legumes funded by the Gates Foundation (Anon, 2014) led to increased aggregate availability per capita of grain legumes in target countries (Nigeria was an exception) and a generated 10:1 direct benefit. It was concluded that the project has made significant progress in achieving the goal of moving improved genetics from the research station to the farm and to the marketplace. However, the follow-up phase III has reduced both the number of crops and the target countries (the main focus is now Africa where the need for improvement is greatest), to reduce the number of crop by country combinations when allocating sparse resources. A greater proportion of fund allocation to NARS and an increased focus on gender-differentiated activities and outcomes are planned, the latter to address equitable inclusion of women along the entire value chain.

Using historic data on varietal release and expert-panel and nationally representative surveys on cultivar-specific levels of adoption in sub-Saharan Africa, and cross-sectional data on the strength of human resources in agricultural research systems, Walker et al. (2014) find that cowpea has one of the lowest output intensities, very few varieties having been recently released. Just over one half of the released varieties are CG-related, compared to over 80% for pigeonpea and lentil and over 95% for chickpea. Less than one half of the new varieties in other legume species have origins in CGIAR germplasm. The lower than average value for beans reflects the varietal input from other programmes such as the Bean CRSP, CATIE and the NVRS in the UK. Pigeonpea and soybean have an estimated adoption performance superior to the overall average of 20 species. Soybean as a newly introduced, market led, crop also tops the list of areas planted to modern varieties. In terms of allocation of FTE per crop, soybean, pigeonpea, chickpea and lentil have more staff than based on a normative allocation (based on value of crop production and scientist costs of $115,000 pa), whereas the other four species, faba bean, cowpea, bean and especially groundnut are underinvested. Lentil, chickpea, soybean and bean are the four topmost crops with highest numbers of staff per hectare planted area (89-43 FTE /1 million ha). Groundnut is the lowest with 4 FTE /1 million ha, dropping to an even lower position if based on crop value.

As found by Pachico (2015), Walker et al. (2014) argue that the large-scale diffusion of modern varieties in Africa is without much intensification of accompanying inputs. Sachdeva et al. (2014), in reviewing the Generation Challenge Programme (GCP) which included bean, chickpea, groundnut and cowpea in both phases and lentil and pigeonpea in Phase I, commended the investment in these minor crops for which genetic and genomic resources would not have been developed so quickly without the intervention of GCP. Through the support by the GCP, genomic tools and data have been used effectively to develop molecular markers and to translate them into practical assays for target legume species for applied breeding use. The GCP supported through a large collaborative effort the development of the first-ever draft genome sequence map for a kabuli chickpea variety, as well as a similar draft sequence for pigeon pea. SSR molecular markers and marker sets for specific traits such as drought tolerance in all legumes, and other genomic resources that enable molecular breeding are now available. Breeding programmes in

each legume are now well positioned to use molecular breeding routinely in crop improvement, and a drought tolerant bean variety using marker technology has been released in Nicaragua. In evaluating progress, the team rated as highly satisfactory bean, cowpea and chickpea, and groundnut as satisfactory.

All emphatically agree that returns on investment are positive (but none actually make *ex ante* predictions as to likely returns) and that investments in R&D for grain legumes, especially varietal development and seed production, should continue.

3. Relevance

3.1 Coherence and program design

This section reviews the coherence of Grain Legumes and the consistency of program design with the objectives of the CGIAR. One of the major issues to point out from the outset is that with the division of labours across the PLs; there is little interaction between the various disciplines and partners. Even with the SC structure, since reporting is not based on SCs, the integration of activities along value chains is lacking. The implementation of FPs to some extent will resolve this issue, but as discussed in section 6 on Effectiveness, detracts from the upstream science and merges it with downstream adoption.

3.1.1 Relevance across the entire CRP

The bringing together of four CGIAR centres and eight different crops into one CRP is likely to be tortuous and fraught with issues relating to leadership and power, competition for resources to sustain ongoing activities, and protection of historical interests and boundaries between institutions. Therefore, from the outset, the CRP would either draw out the best or the worst in individuals, with forced marriages between centres and scientists, forced to work together on issues of common interest at times, and, at other times, opposing.

Nevertheless, given the role of grain legumes as sources of protein for poorer sectors of society, and for those with cultural aversions to some or all meats, the activities within Grain Legumes contribute directly to the SLOs as presented in the CGIAR Strategy and Results Framework, and represent an important link in the chain that upholds global access to nutritious and healthy food. The links between the SLOs and the Grain Legumes IDOs are succinctly illustrated in Figure 2.4.1.

The geographic focus and choice of species are highly relevant, and even though there is minimal evidence of strong synergy, as indicated throughout this report, the research is still moving ahead on most fronts in line within the overall logframe. During interviews and from the survey, a large majority of Scientists agreed that the initial selection of eight legumes was generally considered as appropriate, particularly for the semi-arid tropics. A few suggested that others are key and worthy of inclusion, e.g. mung bean, grass pea (*Lathyrus sativus*), and dry pea. The lesser research investment in Latin America is not in line with the regions' dependency on legumes, but varietal improvements in beans in Africa, including associations with N fixing bacteria, will have a spill-over effect into Latin America.

3.1.2. Programme design of the overall CRP

There is normally little opportunity to cut ongoing research and to initiate new research. The CRP gave this opportunity and a large majority of Scientists surveyed (84%) agree that lessons learnt from research conducted prior to CRP have influenced their choice of current research. Much of this thinking was woven into the final approved CRP document. Survey comments complement interview discussions, indicating that the research agenda and the Grain Legumes objectives are heavily influenced by previous research projects. For example: *"Prior to CRP, the research was*

material oriented. However, it gave insights into the specific problems addressed. With CRP, the programmes got focused into 'Product oriented' which is very important for tangible results". Two thirds of comments from Research Managers surveyed indicate that constraint analyses and lessons from *ex post* studies have informed program design for enhancing the likelihood of impact, although several suggest that further analyses are needed or learning is yet to be incorporated. For example: *"I believe that CRPs have been over evaluated but learning has not been efficiently translated into redesign give the rigidity of CRP design and activities."* Conversely, *"There has been little formal quantitative constraint analysis. Most is based on expert opinion".*

Therefore, since its inception, the structure of Grain Legumes focuses on Product Lines (PLs) as avenues for outputs, leading to outcomes and impacts. These product lines can be traced back to much ongoing research being conducted by the four CGIAR centres. As the engines of change we have focused on evaluation of the Product Lines, as drivers of outputs. The creation of a matrix that has Strategic Components (SCs) running across Product Lines (Figure 2.5.1) made sense in that the SCs represented a continuum from decision making, to product development to dissemination and marketing, with capacity building included at each step. The decision by the CO that required CRPs to re-orientate along the lines of Flagship Projects, besides consuming valuable research time in its conceptualisation and implementation, has created a further level of complexity in the management of the already complex CRP for Grain Legumes, and has increased the size of committees. In spite of this, the Management of Grain Legumes and staff have to be commended on their ability to align Activity Clusters from the original PLs to the R4D focus of the FPs and the IDOs. The choice of Flagship Projects makes sense, with the flow of activity firstly around crop management and agronomy followed by the logical sequence of trait discovery, incorporation into improved varieties, dissemination of those varieties through appropriate seed chains leading to market impacts, and the capacity building required at all steps. However, we believe that the use of the Flagship term as specified by the CO for the crosscutting activities, impact assessment, gender analysis, informatics, and project management is misplaced, and prefer the term Cross Cutting Activity which infers holistic integration of the issues within Flagship Projects.

The focus on impact assessment must be accompanied by concerted efforts to undertake baseline studies as mentioned above and to implement a robust M&E activity. Some of the materials brought to light by this evaluation should find their place in the M&E files. The M&E facility and impact assessment will be of immediate use when updating research priorities in line with resource availability and ongoing partner needs. There is little documented evidence that the proposed 'Inclusive Market Oriented Development' or IMOD, has been used as a framework for priority setting.

3.1.3 Research Strategies

Transgenics

One of the obvious omissions found during our varied discussions across the range of mandate crops was that there was no central and strategic policy on the place of transgenics in Grain Legumes. Pre-Grain Legumes research has taken place on the use of transgenics, e.g. resistance to the Indian peanut clump virus, for drought tolerance in groundnut and chickpea, for enhanced content of pro-vitamin A in groundnut and pigeonpea, and the chitinase gene from rice that is effective in reducing pre-harvest infection of *A. flavus*. However, these do not figure in the research or development of Grain Legumes.

We heard mention of the Bt cowpea and how it might have a role in the development of insect resistant lines. However, the material developed via the AATF (African Agricultural Technology Foundation), is not adapted to all regions of need, and there seemed to be little discussion about how to overcome this deficiency. Perhaps some of the reluctance actively to pursue a GM approach lies in the attitude that this technology will never be adopted, so why should research and management time be devoted to this area? Such an attitude is based on concerns that are widely expressed but it is not founded on an objective analysis of the most effective long-term options.

A similar diversity of views was found within the groundnut community, where many people were trying to tackle the aflatoxin issue, but only a few were prepared to include a GM approach in their thinking. Candidate (transgenic) lines which have low accumulation of aflatoxin have been achieved and PL3 is making good use of collaborations with Louisiana State University and the Danforth Plant Science Centre, both in the USA. High quality science is certainly in progress, but evidence is needed to show how this will be translated into a resource that can be used in the local breeding and farming communities.

There seemed throughout to be a feeling that this approach with transgenic research was too controversial an area, so should be avoided, or perhaps allowed to exist but without giving it any real investment.

Likewise, there were extensive demonstrations of diverse approaches to the development of herbicide tolerant crops either via selection of existing genetic variants, or by application of mutagenic techniques. These approaches have shown varied degrees of success in terms of achieving adequate levels of field resistance, without effects on yield, to appropriate herbicides. However, there was no evidence that any comprehensive SWAT analysis had ever been conducted to compare the GM and non-GM options.

This absence of clear and reasoned thinking is despite the presence of an expensive, though underutilised facility at ICRISAT, the Platform for Translational Research of Transgenic Crops.

Plant breeding and varietal identification, seed systems and agronomy

The three main levels of enquiry, that is plant breeding and varietal identification, seed systems and agronomy are as relevant today for all eight species as when Grain Legumes commenced. Using information from the proposal, 14% ($18.9 million) was allocated to seed systems, but separation of expenditure on agronomy and varietal development across centres was not possible, hence evaluation of coherence is limited. With the limited time available and without an analyst assigned to the team, we were not able to drill down all research activities to determine the proportion and total amounts of funding allocated to each.

New varieties, as much as they embody traits desirable to growers, will always be the first focus of demand by growers. Tolerance to changing climate patterns, to the pests and diseases of today and of the future, incorporation of quality traits and adaptations to intensive production systems (machine-harvestablity and herbicide tolerance), and short season high yielding characters are all worthy of investment when selecting for improved varieties. A common and coherent strategy is needed, if one could be implemented across centres and species, as to how to address these through conventional and modern breeding approaches. However, even once new varieties are made available through cooperative work with NARS, given the self-pollination nature of the grain legumes and their large seeded-low multiplication rates (ranging from 1:10 for groundnut to 1:100 for pigeonpea, compared to 1:100-200 for most cereals) they are inherently less attractive from

a commercial seed-production standpoint. The exception is the use of hybrid seed being commercialised with pigeonpea in India.

However, there does not appear to be complete coherence among some of the research activities in Grain Legumes. For example, the separate inclusion of breeding for drought tolerance (in addition to tolerance to heat) in chickpea, faba bean, lentil and common bean in PL2 and PL1 implies that parallel efforts are underway in different groups of species (and different CGIAR centres), undermining the opportunity to cooperate and make efficient use of facilities and other resources. Likewise, in the PL3 proposal for groundnut there is explicit reference to research and development efforts on drought. The proposal speaks of identification of genomic regions governing drought tolerance serving to improve cross-species tolerance, but we did not find evidence for this. Likewise, stated research on effects of low P on nitrogen fixation in PL1 do not link to PL4 with its focus on N_2 fixation. We conclude that there are many examples of isolated and minimally-integrated activities within each PL, with little evidence of synergy between PLs. But even though there is no evidence of strong synergy, neither between PLs nor centres, research activities and outputs are still moving ahead on most fronts in line with the overall logframe.

In spite of these drawbacks, a large majority of Research Managers and Scientists, in both interviews and the survey, believed that there was advantage in combining all research on grain legumes under one CRP. In the survey, one Research Manager stated *"If grain legumes are split up they will become less visible to the development community and donors*" and another "*From a science perspective, constraints within the seed system are similar, BNF research on rhizobium-plant interactions, genomics-synteny, nutritional analysis, gender considerations".*

3.2. Comparative advantage conferred by the overall CRP

Four areas stand out in terms of there being comparative advantages of Grain Legumes in delivering international public goods relative to other international initiatives and research efforts, including the private sector. In the first of these, the four centres hold the global collections for the 8 target grain legume crops, with arrangements in place for facilitation of germplasm exchange. However, due to restrictions on the export of germplasm incorporating specifically Indian material, this is not so effective for export from ICRISAT. This embargo has to be resolved for the global good in as short a time as possible. It could be argued that there is a comparative advantage for all breeding work in the grain legumes to be supported by Grain Legumes, since the private sector is unlikely to invest in varietal development, as indicated in the earlier discussion of seed multiplication, when the market is not conducive to significant returns on the sale of seeds.

The second is that of genome sequencing and the attendant publically available sequence data, and other aspects of molecular breeding undertaken by the Center of Excellence in Genomics facility at ICRISAT (www.ceg.icrisat.org). These simply would not have received the same level of investment were it not for Grain Legumes and its component W3/bilateral projects, and are underpinning some of the marker assisted selections underway in a number of crops, including but to a lesser extent, some of those outside of the ICRISAT remit (e.g. in groundnut and lentil). Given the availability of germplasm and of purpose assembled crosses, such research was deemed to be better placed to be undertaken within ICRISAT than outsourcing in institutions with perhaps more up-to-date equipment and better efficiencies. The availability of training facilities at ICRISAT further justify the focus at that centre as a means of instructing national scientists into the use of, for example, marker assisted selection (MAS) to improve selection efficiencies in their own

breeding programs. However, a cost:benefit analysis to justify further investment in the facility is necessary as the technology advances rapidly.

The third is in the area of integrated pest management (beyond that of varietal resistance), in particular for *Maruca* and *Helicoverpa*. The facility in Benin, formerly part of the ICIPE and the CMI/CABI, and a similar functioning facility managed by the Benin INRA, illustrate magnificently what can be achieved with concentrated and directed research efforts.

The fourth is the technology for development of hybrid pigeon pea, an investment unlikely to have been supported by the private sector, but one that is slowly being adopted by the private sector in India as that sector and growers see the benefits of hybrid seed. It should be noted that the initial work into this system was conducted at ICRISAT more than a decade ago, before the establishment of Grain Legumes. The loose link with public and private seed multipliers in India is vital for the technology to survive beyond the research input via Grain Legumes. Exploitation of this hybrid system in other regions, e.g. Kenya, is likely to be many years away, as the present germplasm is not adapted to that region.

In support of the above findings, in answering the survey question "Is a mega-program CRP better than the sum of its parts or could the same research have been done just as well or better if the four centres had worked independently?", more than two thirds of Research Managers supported the concept of Grain Legumes in terms of the power of synergy and collaboration. For example: *"The program has provided unique opportunity to share scientific knowledge including methodologies and ideas in more purposeful manner, which is of paramount importance to change world legumes research scenario".* Several cited TL programs as positive examples of comparative advantage: *"...three of the centres did work together through the TL projects (and in TL I that included many outside partners). The CRP is just another mechanism to achieve this".* However, a minority of Research Managers offered different opinions, noting that the CRP structure increases transaction costs and time spent planning. *"Transaction costs, politics of budget allocations, large number of reviews and planning meetings have reduced the time and resources available for research. We need to look at efficiencies to reduce these transaction costs as well as revise planning processes that are responsive to the needs of farmers and national government priorities."*

3.3. Conclusions and recommendations

Grain Legumes has geographic and disciplinary relevance, addressing the major supply chain issues of variety development seed system and agronomy, with some attention to quality and postharvest marketing systems. Program design was influenced by lessons learnt from research prior to the CRP. With diminishing funds, it would appear, following Gates Foundation initiative, that a focus on Africa will address greater needs and possibly increase likely returns to research investment. In spite of the fact that there is no evidence of strong synergy, Grain Legumes is still moving ahead on most fronts in line with the overall project logframe. However, to quantify real impact Grain Legumes must have access to reliable baseline data on production and consumption, and this is missing. Similarly, there is little evidence of the proposed IMOD framework being implemented in priority setting. The product lines, eight of which cover most of the historical programmes in place in the partner CGIAR centres at the commencement of the Grain Legumes, do not cover all the articulated constraints and some research is undertaken under the umbrella of the PLs. This needs to be rationalised. We found the PLs to be isolated in activity, even with minimally-integrated activities within each PL, with little evidence of synergy between PLs. Even though the SCs should ensure a systems approach, as with the new FPs, we did not get a feel that

this is so. The underplaying of agronomy, and production practices, may be one reason for this. Treating legume crops as if they were horticultural crops we believe will increase farmer returns from investment.

One notable omission is the lack of a central and strategic policy on the place of transgenics in Grain Legumes, despite the presence of the Platform for Translational Research of Transgenic Crops facility at ICRISAT.

We found four notable comparative advantages for the Grain Legumes; the access to germplasm of component species, the use of the phenotyping facility at ICRISAT, the approach for village level industry for IPM, and the emphasis on hybrid pigeonpea.

Recommendation 1: A period of consistency is necessary to raise confidence, morale and trust across scientists, managers and partners to foster the assembly of enduring Grain Legumes outcomes[8].

- **There needs to be a concerted effort to undertake baseline studies and to implement a robust M&E activity during this period.** Without these data the foundation for iintegrated research in grain legumes is jeopardised.
- **There is a strong need to link more closely with the private sector, especially where there are financial and other comparative advantages to do so.**

Recommendation 2: The agronomic and physiological trait targets of Grain Legumes (tolerance to changing climate patterns, to the pests and diseases of today and of the future, incorporation of quality traits and adaptations to intensive production systems [machine-harvestability and herbicide tolerance], and short season high yielding characters) are all worthy of continued investment when selecting for improved varieties.

- There needs to be **a common strategy, implemented across centres and species, as to how to address these trait targets through conventional and modern breeding** approaches, but only if adequate funding is assured and secured and if a consistency and unity of purpose can be achieved across a large-scale. This should take the form of cross-species coordinated research programmes to address these breeding targets that cooperate across centres and make efficient use of facilities and other resources.
- The CRP should **undertake a detailed strategic review of the role of transgenics** across the range of targets in the mandate crops.

4. Efficiency

Within this section we consider the efficiency with which Grain Legumes is working, at all levels below the MU Issues for the efficiency of the MU, of committee structures, of CGIAR reforms, and the overall governance and financial management are presented in Section 10, Broad Overview of Governance and Management.

Efficiency can be measured at a number of levels, of communal management of budgets and resources to achieve outputs, of programme implementation, of ability for outsiders to make contact with Grain Legumes, of value-adding to research partnerships (or choice of and creating such partnerships), and the like for the achievement of outputs.

[8] This can be achieved only by the coordinated action of the Consortium Board/Office and Fund Council.

4.1. Management of resources

In our opinion, there is little evidence for a greater efficiency of use of resources by the centres that can be attributable to the existence of Grain Legumes. Each centre has strong control of, and emphasis on, their 'species' domains, and ownership of the same detracts from possible synergy. The ownership of such domains stretch into the use of resources, of germplasm (there is little evidence of individual centres working on species that are not 'owned' by themselves) and even of national programme partners. This precludes the opportunity for integration of programmes between centres and collaboration between scientists; there are very few examples of cross-centre authorship of publications, such as should have occurred if resources, including staff, were shared between centres for the common objectives of Grain Legumes. Examples exist where integrated cross-centre approaches would have benefits for the greater good; these include genomic research, crop modelling, and stress tolerance. Even in the few cross-centre publications, for example on heat tolerance (Gaur et al., 2015) by ICRISAT, CIAT and ICARDA, each centre takes their own approach. But the survey showed that 88% of the research managers agreed (20% strongly) that Grain Legumes has enhanced synergy in research and development, stating that *"The CRP has brought together institutions that were not used to work together. This is noticeable at the country level."* And *"There have been some good outcomes (e.g. physiology across legumes, seed systems, applications of genomics)."* This was balanced by statements such as: *"It seems that on-going work of the Centers has been forced into a so-called "collaborative" research structure. Maybe some synergies that have developed but they are not readily apparent."* Similarly, *"Very little true interaction within the Product lines."* The program's design and implementation was responsible, according to two thirds of Research Managers, for added value within Grain Legumes; increased efficiencies being due to *"... utilising the shared facilities; individuals covering more than just one centres [sic] work and having common agendas. However, this may not be uniform across all CRPs projects and activities".* In addition, [Grain Legumes is] *"...more transparent than in the past".* And importantly and in line with the new focus of TL III, *"Resource allocation to NARs has improved".* We nevertheless believe that there is a need to define the comparative advantages of the CGIAR centres and their R4D activities, and that this has not been done. There is little sense in duplicating across centres those activities that individual centres do well (with the proviso that these are shared and integrated openly).

In contrast to the lack of efficiency at the cross-centre level, the integration of each centre with NARS and university research programmes is good, but again the cross-centre links with NARS are poor. One argument for Grain Legumes was that transactions costs for NARS would be reduced with a coordinated integration with Grain Legumes, rather than through the individual centres, but again there is little evidence of this taking place. Cross-CRP coordination is not evident within the documents or other evidence that we reviewed. Vehicles for improved efficiency through reduction of transaction costs include bilateral projects, which are seen as more cost effective than W1/W2 where transaction costs are disproportionately higher.

4.2. Monitoring and evaluation

One avenue to increase the efficiency of use of resources by Grain Legumes would be through an effective Monitoring and Evaluation Facility. With all partners appraised of plans, undertakings, research outputs and outcomes, there is greater opportunity for centres to use resources more efficiently. One statement about M&E on Grain Legumes website (http://grainlegumes.cgiar.org/how-we-do-it/monitoring-and-evaluation/) claims that "M&E will examine the effectiveness of the entire system, because this is essential for learning from both successes and shortcomings. Grain Legumes partners will also conduct their own internal M&E of agreed research activities." However, it is apparent that Grain Legumes lacks an effective M&E

entity. Notably, with the absence of routine M&E activities, many survey comments referred to this CCEE review: *"The current research direction is good and needs to be continued. What will a bunch of people with limited exposure to Grain Legumes be able to suggest compared to scientists who have 10 to 30 years of experience in legumes?"* Others are more accepting of change: *"Both research management and direction can be modified following the review." "More integration is expected in the GL CRP across all commodities after the findings of M&E."* Others commented on the function*: "M&E can not [sic] modify research direction. It helps in how improving the way work is conducted"* and *"If we need to reduce trasaction [sic] costs and need to be effective, it is imperative to improve the structure."*

Although the Annual (and Mid-Year) Reports do attempt to bridge somewhat the gap created by a lack of M&E, and to provide feedback from the MU to scientists, this is a cumbersome process, with scientists advising of the multiple demands for having to report to Grain Legumes, to their own Centre and to donors for special project activities. At times they are reporting the same activity in three different formats; thus, some uniformity of reporting is to be recommended. The POWBs for each year, which have evolved into reasonably detailed documents, also provide information on the relevance of research activities to addressing output targets. However, we were surprised that there was no central database containing, names of staff associated with Grain Legumes and their time commitments, their responsibilities, and involvement in CRP activities, their progress and achievements, their publications, plans of trainings, travel, and other opportunities for interaction, and so on.

4.3. Communications

In spite of our perceived shortcomings in the communication processes within Grain Legumes identified during field visits and interviews; in the survey, a large majority of scientists (78%) agreed that information is shared freely and routinely within the PL within which they work. However, responses ranged from '*never have scientific exchange in the PL*' to '*I always get quick response [to my problems]*', so quite evidently there is a range of management styles between PLs. Responses were less positive about inter-PL information sharing; 48% agreed, 14% disagreed and 37% were undecided. It is unclear whether information is freely and routinely shared between CRPs; 28% disagreed, 26% agreed and 47% were undecided.

The communication process should also enhance efficiency in the making known to the public, firstly of the existence of Grain Legumes, and secondly of its achievements. In the relevant section of Grain Legumes website it is stated that one major indicator to be used by Grain Legumes M&E is "Publication of peer reviewed research article, curated data sets and learning materials in easily-accessible channels". However, less than one third of research managers surveyed believe that the activities and needs of Grain Legumes are well communicated to outsiders, (although one contrasted that with communication from centres, which is strong and focused). Our search for publicity on the Grain Legumes website led to numerous dead-ends. For example, the link to research publications for 2014 (http://grainlegumes.cgiar.org/products/publications/research-publications/) has no content, and the publications for 2013 are only available for two PLs, namely PL3 and PL8. Likewise, in the "Impacts" section for the crop specific lists the main references cover a period from 1993 with only soybean having a single reference after 2011. One site, for Faba bean, is "still under construction" and only two crops groundnut and chickpea have "recent posts". Additionally, the databases section of "Products" is empty. Links to Grain Legumes on the CGIAR www site did not work [now they do], and with the exception of IITA there is no mention of centre staff alignment to the Grain Legumes. However, Grain Legumes has an improved presence on the www pages of the individual centres as we have progressed with this review,

although information on the ICRISAT www site as to whom to contact re Grain Legumes is out of date [by almost two years]. Such lack of care and attention in relation to effective publicity is in sharp contrast to the TL II programme which produced monthly bulletins, available on line (http://www.icrisat.org/tropicallegumesII/Bulletin-of-Tropical-Legumes.htm), from Jan 2011 to Jan 2014. The scientific coordination of individual PLs and across the PLs has not been effective. Specifically, there have been no global meetings, other than the one in Saskatoon in July 2014, and none for individual PLs that bring more than one centre together. This probably explains the overall lack of integration and the absence of any cross-centre communal spirit within any of the PLs. Technical interchanges have been rare, and one example cited was organised external to Grain Legumes, although bringing some cross-centre staff together. There is little opportunity for bottom up consulting or communication, the majority of scientist respondents indicated that top-down methods are more prevalent, and that these are *ad hoc*. From all available sources of information PLs that comprise single centres seem to be organised in a more coherent and efficient manner, and combine high quality science with a practical and effective link to the farming sector. The role of PL coordinator within single centre PLs was not compromised by inter-centre politics or competition, and provided contributors to those PLs with an opportunity to look into many scientific aspects underpinning the achievement of output targets. We did find evidence for dynamic and effective relationships between the various stakeholders in terms of achieving programme outcomes/objectives, but this was at the individual centre level with NARS and other stakeholders, and not across centres and their national stakeholders. Not so much related to efficiency, but we did find that non-CGIAR stakeholders, especially in India, found the link between the centre and themselves (not necessarily Grain Legumes and themselves) was beneficial in leveraging and mobilising additional funding for research on grain legumes. It is interesting to note that efficiency was not raised as a concern in reviews of the involvement of CIAT in PABRA (Robinson, 2015), nor in the management of TL I and II, in the former where only one centre was involved, and in the latter with three CGIAR centres.

4.4. Structural change

The change of structure from an 8 product line/5 strategic components structure to one of 8 flagship projects we believe has reduced efficiency in research outputs, with little gain in focus or cross-centre synergy. Having to report both at the PL and FP level adds to impositions on scientists and reduces time for research.

In terms of time spent by CGIAR centre staff in the execution of Grain Legumes, research managers, and indeed even the individual researchers from centres have been expected to contribute substantial amounts of time in addressing the constant changes brought about by the CO for iterations towards a markedly refined Results Framework template. This causes serious interruptions to the smooth and efficient conduct of research, diverting attention away from creative endeavours and often causing worry about securing funding for the very research they are conducting. Funding and, to a lesser but still important extent, time have restricted achievements by CRP staff. Additional meeting time to attend to CRP needs was cited by one scientist in the survey, but mentioned by many during face-to-face discussions. Survey of managers indicated that change management should be introduced systematically and rolled out in phases, rather than as in the current climate where abrupt changes have been introduced.

This leads to the question about the efficiency of scientists being involved in cross centre CRPs. A common theme in interviews and discussion is compounded by the survey; 50% of scientists involved in Grain Legumes believe that transaction costs are too high (40% were undecided and only 10% disagreed), and that scientists and managers spend too much time in governance and

management of Grain Legumes. However, we were not able to disaggregate the responses according to whether one, two or three centres were involved in the PL.

4.5. Interaction with the private sector

There are examples where interaction with the private sector has been exemplary, such as with the hybrid pigeonpea industry in India, and with seed production in Kenya (with the Dry Land Seed Company and Smart Logistics) but much opportunity exists for scope with other sectors in the supply chain. Conversely, there are some areas where the interaction with the private sector has been poor, especially in areas where they have a comparative financial advantage. Linking with the private sector in areas such as herbicide tolerance (HT), development of transgenic Bt *Maruca*-resistant cowpea, and all of the accompanying legalities of transgenic crops, of herbicide levels in exported herbicide tolerant genotypes, and so on, would improve efficiencies in terms of returns on financial investment. As an example, selection for tolerance to the suite of herbicide products with ALS inhibitors as active ingredients is of concern, for in parallel with the ease of identification of tolerance amongst selected populations is the ease with which weed populations will undergo the same or greater selection pressure and develop tolerance to the same suite of agrochemicals. New herbicide products are continually being developed, and Grain Legumes should align with these private companies and ensure that tolerance to such new suites of herbicides become available. In this context there was also little evidence of any systematic consideration of the regulatory aspects of future international trade in HT crops, for example from the perspective of allowable herbicide residues.

4.6. Value for money

There is difficulty in estimating cost:benefit ratios for each activity, cluster of activity, and each PL, and in comparing with rations for activities in other CRPs. As indicated in the section on Governance and Management (Section 10), although budgets using W1/W2 funds are provided to each centre according to allocations made at the RMC level, within each centre allocations are made according to the needs of that centre (Tom Hum, Pers. Comm.). There is great difficulty in determining comparative value for money between investment in different types of research, and in being able to clearly attribute research and development outcomes to financial investment. There is also a timeframe issue here; the investment of CRP has been in place for ca. 2.5 years, but this is a short timeframe within which to expect significant outputs, let alone outcomes and impact. We are unable to predict future returns on investments, although indications are that in the main the research is progressing as planned and outputs are likely.

We realise that efficiency has been compromised by the change in status and loss of the ICARDA facility in Syria, which may have affected performance but there is confidence that this will improve when the new facilities in Morocco and elsewhere are established.

4.7. Conclusions and recommendations

Each centre has strong control of, and emphasis on, their 'species' domains, and ownership of the same detracts from possible synergy. Without synergy or value add, the Grain Legumes brings with it no comparative advantage over each centre continuing their own pre-CRP research agendas. We found little evidence of integration of programmes between centres and almost no cross-centre authorship of publications, such as could have occurred with the integrated cross-centre approaches to stress tolerance including crop modelling: one publication on heat tolerance by ICRISAT, CIAT and ICARDA does not provide any keys to inter-centre collaboration.

The integration of each centre with NARS and university research programmes is good, but the

cross-centre links with NARS are poor. A better coordinated integration with Grain Legumes, rather than through the individual centres, may reduce transactions costs for NARS,

Monitoring and evaluation is, as noted throughout our report, one area of Grain Legumes research management that has not been given the attention it should have received. If it had have received proper attention, some of the issues of poor efficiency might have been nipped in the bud. A strong monitoring and evaluation system would have provided the baseline data and set the milestones that would have allowed both efficiency and effectiveness to be better appraised. We found no attempt to define comparative advantages of the CGIAR centres and their R4D activities, although practice showed the better grasp of CIAT in developing innovative seed distribution systems.

During field visits and interviews, the CCEE Team observed shortcomings in the communication processes within Grain Legumes and with the broader scientific community and the public. Survey findings, however, suggest that information is shared freely and routinely within the PL within which scientists work. Nevertheless, the public face of the program on the internet is out of date.

Some external issues, such as those with funding and low W1/W2 and poor sustainability of funding (especially if funding is top heavy with a few agencies), undermine research investment and confidence of partners in the system (e.g. the non TL III crops and countries, the cessation of ongoing competitively-funded projects), but other issues attributable to the governance and management of the Grain Legumes, such as opaque integration of W3/bilaterals with W1/W2 funding require attention. Offsetting this, the existence of the Grain Legumes did mobilise additional funding [that it would not have if Grain Legumes didn't exist]. We were concerned that Grain Legumes is simply not recognised outside of Grain Legumes, with a limited www presence and centres promote themselves, not Grain Legumes (with exception in IITA). This is not a good move if one wishes to increase investment in the Grain Legumes

Although funding agencies require cost:benefit ratios (for example for each PL indicate, we faced difficulty in determining comparative value for money between investment in different types of research, and in being able to clearly attribute research and development outcomes to financial investment. There was also a timeframe issue too.

There is poor interaction with the private sector, especially in areas especially where they have a comparative financial advantage. We questioned in particular the apparent lack of interaction with the major agro-chemical companies, with respect to the development of herbicide tolerant (HT) grain legumes and the lack of evidence that the regulatory and trade aspects related to herbicide tolerant crops had been considered.

Recommendation 3: The lack of an effective M&E process is a significant omission, not least in terms of more efficient use of resources and the lack of baseline data with which to measure impact, and must be rectified.

- **Reinforcing Recommendation 1, an effective M&E system initially directed towards baseline studies must be implemented**.
- Transaction costs may be reduced through bilateral projects, which are seen as more cost effective than W1/W2 where transaction costs are disproportionately higher.

Recommendation 4: To improve communication and coordination within the CRP, and with a broader audience:

- There is a priority need for a **central database** containing, names of staff associated with Grain Legumes and their time commitments, their responsibilities, and involvement in CRP activities, their progress and achievements, their publications, plans of training, travel, and other opportunities for interaction.
- Regular global meetings of staff involved in managing PLs, the entire CRP management staff and the IAC are essential for effective coordination of all activity within Grain Legumes.
- **The website must be given a complete overhaul** and improvement and then regular maintenance must be provided to keep it current.

5. Quality of science

This section reports the assessment of Quality of Science (QofS) as related to research design, processes, outputs and infrastructure. The methods used and the framework for assessing QofS are presented in the Methodology section 1.3.

Scientific quality is judged by peer review, as is most obvious through the medium of publications in international peer reviewed journals, and through other forms of peer review such as Centre Visiting Groups. The CCEE considered the information available on the Grain Legumes CRP to ask whether the research investment reflects high quality and up to date scientific thinking, state of the art knowledge and innovation across the areas of research. We also considered, although only superficially, if the internal processes and conditions, including research staff and leadership quality, are adequate for assuring science quality. Research outputs in the form of publications and other outputs, such as genetic material, were examined for quantity and quality relative to the number of staff working on the product line. We would have liked to establish whether negative, as well as positive, findings were documented and disseminated in order to prevent multiple people from following the same erroneous path. Unfortunately, human nature means that only progressive findings are reported and null or negative results were not evidenced from the documentation we were able to access. The quality of science is analysed at the PL level, not at the individual researcher level, although we were aware that the majority of scientists had PhDs and established careers in their areas of expertise.

5.1. Research investment

5.1.1. Scientific quality arising from investment in facilities

There are pockets of game changing activities and some valuable investments into facilities for genomics, phenotyping and bio-control. The introgression of drought QTL into JG11 and likely release of at least one line in India is solid support for the genomics facility (CEG). However, the phenotyping facility of ICRISAT (PL2) is not in our opinion delivering to its full potential; it needs to focus on delivering some outcomes, not only scientific outputs. More modest investment in Benin for novel biocontrol practices is also leading to significant scientific and practical outcomes, with the caveat that the latter are not well documented.

There is however much evidence of gradualism in terms of research practice, output and outcomes, essentially the same activities that were ongoing at the time of the launch of Grain Legumes are still in place. As an example, the field collection of data noted in a number of locations could be improved, transitioning from the pen and paper approach to electronic capture of data.

5.1.2. Scientific outcomes arising from modest investment in special projects

The only real impressionable story from our visit to Hyderabad of a technology change was that of transplanted pigeonpea. Admittedly it is combined with irrigation, but the possibility of

establishing a pigeonpea crop in shorter time than with seed drilling can give [according to Dr Sudakar Reddy] an impressive 3-fold increase in yield; terminal drought is avoided. The CCEE was also impressed by activity in Malawi, where an example of double population planting of groundnut within a row to increase yield was presented. Interestingly this was predicted through crop simulation modelling by SSM in PL2.

5.2. Internal processes and conditions including research staff and leadership quality

Staff engaged in the CRP were characterised as being enthusiastic, committed, productive, and in the main highly qualified scientists. However, we did sense a degree of divided allegiance to the CRP and to the host institution, not unexpected since salary and staff appraisal pertain to the host institution, yet deliverables are attributed to the CRP. This two masters' problem has been reported in other CRP evaluations, and may be circumvented if CRP duties are integrated into the HR procedures of host institutions. This is still not in place in this CRP.

Our site visits highlighted the strong leadership qualities in a number of the research groupings, with leadership extending across centres (e.g. within the CEG). The Director of the CRP showed excellent leadership quality, but was constrained in what he could effectively achieve through leadership, other than by example.

5.2.1. Quality arising from collaboration

A strong correlation is known to exist between collaboration/partnership with similar standing institutions and quality of science, but there is little cohesion between PLs and with other CRPs, with some exceptions that are driven by funding. Collaboration between different CGIAR centres was very poor in terms of developing shared publications. There was a single example of a three-way collaboration on a rather low key paper on heat tolerance across species and very few two-way collaborations. The seven papers in PL8 that were co-authored across two institutions is the output of groups in ICRISAT and although CIMMYT is indicated in affiliation of authors, it is because of the support from the Generation Challenge Programme hosted by CIMMYT. International collaborations are a proven way of increasing citations per article as researchers will often search on lead authors from both communities. Furthermore, special recognition of papers that are co-authored across CGIAR centres would promote and drive more collaborative activity, leading to increased quality of the research programmes and widening the penetration of research impacts.

5.3. Outputs

5.3.1. Publications

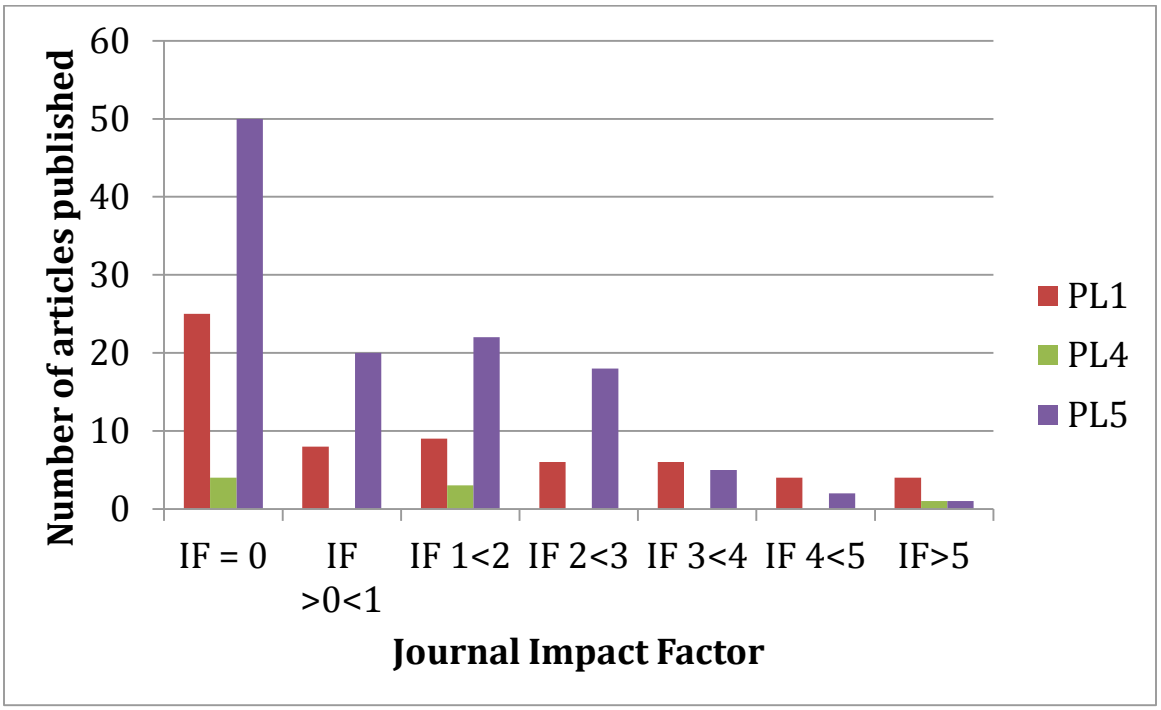
Good quality science is emerging from Grain Legumes with some quality publications at the level expected of an international centre of excellence. The work undertaken by PL1 (Drought and low P tolerant beans, cowpeas and soybeans) is routinely published in internationally renowned journals. The same is true for PL2 (Heat-tolerant chickpea, common bean, faba bean and lentil) in which 75% of all publications are peer reviewed (Table 5.3.1). There is good research on integrated pest and disease control in PL5 (Insect-smart chickpea, cowpea and pigeonpea systems). This Product Line has the highest productivity per FTE of any PL. Outputs are a mix of peer reviewed papers and otherwise, but good science is published in places where people will be able to see and access it. PLCs provided PDF files of the top ten published outputs regarded as key from the PL and the average of the scores for each output in Tables A1.1-8 was used to generate an overall Output Quality score in Table 5.3.1. PL2 and PL6 were extremely late in providing information to date on which articles they rank highest, PL3 returned a very incomplete self assessment document which was missing staff FTE scores and relevant information, e.g.

gender relating to research students. Each output was summarised by a single line comment and then a score awarded to reflect the quality of that output, based on the scientific quality and reach into the user community that the output was judged to have had.

The quantity and quality of published outputs, as assessed from data provided in the self assessment document, varied enormously (Table 5.3.1), and not always in line with the number of staff contributing to the PL. For example, PL5 has only 4.75 FTE of staff contributing, but it has the highest number of outputs (128). PL5 also had the best scores in terms of numbers of peer-reviewed papers (with and without an Impact Factor [IF]) per FTE. This PL was therefore given the maximum Output Quantity Score of 15. In contrast, PL4 was given the lowest Output Quantity score as, despite having 9 staff FTE, it only generated 8 peer reviewed outputs during the assessment period, of which only 4 were in journals with an impact factor. PL3 did not return a list of publications, hence we developed our own. PL7 produced work of the highest quality, as judged by the top ten outputs nominated from the PL and reviewed by the CCEE; that PL was productive in terms of overall outputs, although many are in publications without an impact factor, indicating that there are pockets of excellence and also a body of work that has not been published in a particularly rigorous environment. Impact factors range from 0.5 to 9; this is reviewed more thoroughly within each PL. In terms of absolute numbers PL5 had the most outputs in all categories of journals with an IF<3. Although PL1 had fewer publications it did manage to publish in the highest-ranking journals (Figure 5.3.1), and in one publication combined contributions from 6 CRPs. PL6 is to be commended in publishing the chickpea genome sequence in Nature Biotechnology as is PL8 for publishing the pigeonpea genome in the same journal. This work and the chickpea genome research published in 2013, reflect earlier investment, particularly of the Generation Challenge Programme, but are reported as outputs from within the timeframe of the Grain Legumes CRP. The CCEE notes that IF is not always the best or only way of judging the quality of published work and that articles published in low-IF journals may still reach an appropriate audience and aid dissemination of the research findings.

There is, however, a long tail of less good quality research that is published in grey literature, conference proceedings and non-peer reviewed or non-internationally recognised journals although if such outputs are more accessible to stakeholders and underpin practical outcomes, then they should continue to be supported. More importance should be placed on the quality of publication, rather than quantity of outputs. However, as noted in some PLs (e.g. PL1) up to two thirds of collaborative publications were with non-CGIAR centres, reflecting collaboration with other global and national research partners. This may encourage recognition of other types of outputs from Grain Legumes, e.g. varieties for breeders.

Figure 5.3.1. Impact Factors of the publications from different Product Lines where the information was supplied.



5.3.2. Other outputs/outcomes

In the analysis of each PL presented in the Appendix (A1), data are provided on the extent of adoption of improved varieties. These adoptions are based upon the implementation of good science and art in the identification of such varieties, but are too voluminous in some PLs and disparate between PLs to allow for critical evaluations. This links into the Impact section as many of the alternative outputs represent real impact from the translation of research, e.g. numbers of varieties, released and a better 'pathway to impact' should be implemented that records the extent and uptake of variety release and for example the presentation of scientific outputs at regional conferences and the like for 'down-stream' partners that aids communication and dissemination of results. The self-assessment outputs are recorded in Appendix A4.

Other technologies, such as integrated pest management, are also derived from good science and are mentioned in the relevant PLs in Appendix A4.

5.4. Conclusions and recommendations

The quality of the science is highly variable across Grain Legumes, with pockets of real excellence that are linked to good levels of productivity, and some valuable investments into facilities genomics, phenotyping and bio-control. However, in terms of research output and outcomes, gradualism (i.e. the continuation of steady step by step progress, often building on pre-CRP research) is more prominent than innovation; activities that were ongoing at the time of the launch of Grain Legumes are still in place.

The value of collaboration cannot be stated highly enough within the CGIAR, and with other global and national research partners. With institutions and scientists of similar standing this is known to lead to improved quality publications. There is, however, little cohesion between PLs within the CRP and with other CRPs, with some exceptions driven by funding. A prime example is that of

crop modelling, which should benefit from crops-centre synergies but apparently does not (based on published evidence).

Productivity from the different PLs is also highly variable and it was not always clear what other activities staff are engaged in since, in some PLs, they do not appear to lead to quality publications.

Recommendation 5: It is essential to continue investment in good science and to institute a change from gradualism in research output and outcomes to an expectation of innovative and concrete achievements that can be attributed clearly to people, centres and core facilities.

- **A cost:benefit analysis and subsequent strategic planning must be undertaken to justify further investment in the genomics and phenotyping facilities at ICRISAT especially as such technologies advance rapidly. Strategic planning and coordination must also be implemented for capitalising on the investment in crop simulation modelling.** (The phenotyping facility of ICRISAT needs to focus on delivering some outcomes, not only outputs.)
- **PLs should be given incentives to collaborate with other CRPs and external institutions.** The CCEE recommends special recognition of high quality collaborative papers, thereby encouraging increased quality of the research programmes and widening the penetration of research impacts.
- **More importance should be placed on the quality of publication, rather than quantity of outputs and there should be recognition of other types of outputs from Grain Legumes.** The CRP Director must be party to this.
- If staff are engaged in activities that relate more to impact than publication then this needs to be monitored and recorded and a clearer understanding developed of what constitutes a pathway to impact and how success of such activities can be evaluated. **A system must be devised and incorporated into the M&E to enable recognition of other types of outputs (non-publication based) from Grain Legumes, e.g. varieties for breeders.**

Table 5.3.1. Summary of Quantity and Quality of Output Data from all Product Lines [Raw data from self assessments].

PL	No. staff	Gender ratio (M/F)	FTE	Total no. outputs	No. outputs with authors from 2 CGIAR centres	No. outputs with authors from more than 2 CGIAR centres	Number of peer reviewed papers	Number of peer reviewed paper with IF	Output productivity (total outputs/ FTE)	Paper productivity (total peer reviewed papers/ FTE)	Paper + IF productivity (total peer reviewed papers with IF/FTE)	Quantity score[1] (Max 15)	Quality score[2] (Max 15)	**Final score for Output (Max 30)**
1	18	12/6	16.8	84	4	0	62	37	5.0	3.7	2.2	5	10	**15**
2	45	37/8	9.5	100	2	0	75	63	10.5	7.9	6.6	10	11	**21**
3	21	16/5	16.2	26	5	0	26	21	1.6	1.6	1.3	3	9	**12**
4	23	19/4	9	14	0	0	8	4	1.6	0.9	0.4	1	9	**10**
5	12	11/1	4.75	128	1	1	118	68	26.9	24.8	14.3	15	10	**25**
6	46	38/8	7.3[3]	101	1	0	85	62	13.8	11.6	8.5	10	11	**21**
7	39	32/7	6.7	87	0	0	69	40	13.0	10.3	6.0	10	12	**22**
8	36	26/10	6.7	91	7	0	80	41	13.6	11.9	6.1	10	10	**20**

[1]Quantity score is determined by the absolute number of outputs and weighted by FTE and then scaled so that the PL with the highest Output Productivity was given the maximum score of 15, the PL with the lowest given a score of 1 and the others proportionately in between.

[2]Quality score is determined for each PL for the top ten outputs nominated by the PLC. Each output was evaluated by the CCEE and given a score out of 15 based on the quality of the science and the significance of the findings for the target readership/farming community. The average of these scores (shown in Tables A1.1-1.8) was transferred to this table.

[3]Note, in PL6 some NARS staff time was included when data were submitted.

6. Effectiveness

6.1 Overview

Effectiveness refers to the degree to which Grain Legumes has achieved its projected outputs. Success is realised through a series of CRP interventions, amongst which may be cited (a) the management processes for (b) effective use of the resources (including staff), and (c) the funding scenario (selection of project and W1/W2 funding). Management processes are discussed in Section 10, resources to some extent in Section 6 and the project portfolio that underpins the outputs in the Appendix A1.1.-A1.8.

Our initial overall assessment of the effectiveness of Grain Legumes in stimulating synergy, innovation and impact indicates that, as mentioned in Relevance, gradualism is more prevalent than innovation. There are few publications that integrate disciplines, or focus on 'systems'. And inter-centre and inter-PL publications are rarities. There is no attempt to try to develop publications between centres arguing for similar biologies/research approaches, or the bringing species together under one R&D umbrella.

However, there are pockets of innovation, and these are indicated in Appendix A1.1-A1.8. Some major advances in the desired traits earliness, disease resistance and heat tolerance have been transferred to improved germplasm and inexpensive nitrogen fixation may help grain legume farmers improve productivity. What is clear is that there must be close integration of these technologies with knowledge of farmer decision-making.

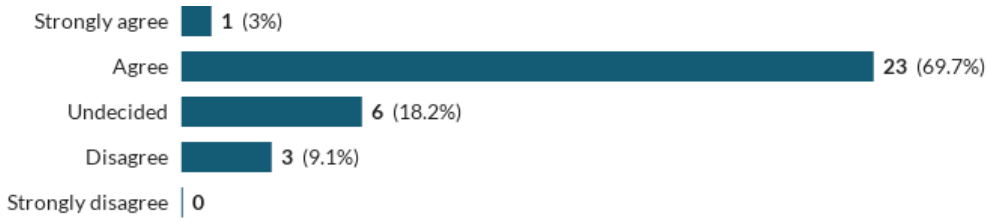
6.2. Progress towards output targets

Based on a reading of all the information presented in the 2012-2014 Annual Reports, and from information collected during interviews and the survey, over the first 2.5 years Grain Legumes has been on average effective in meeting 70-80% its output targets. This varies across the different product lines (as illustrated in Appendix A1.1-A1.8).

It is encouraging to report that, in the survey, the majority of Research Managers (Figure 6.1) agreed that Grain Legumes has achieved its Intermediate and CGIAR System Level Outcomes (73% and 51% respectively) (Question 7).[9] But this is tempered by the associated comments, which indicate less positive responses across a range of issues, such as coordination, funding and reporting processes: *"These are still a long way off. The important question is whether the CRP is headed in that direction. I think it is, but slowly and with some obstacles." "Yes if considering that it builds on the previous work." "Sustained efforts are required to achieve better coordination and transparency among partners on technical aspects." "While GL scientists have done their best to deliver, the funding support from Donors and Consortium itself has been dismal. In addition, scientists have to spend more time in preparing reports, extension proposal, new proposal, etc rather than doing actual research."*

[9] In a few instances, respondents were routed past less relevant questions in the survey; thus percentages originating from survey responses are always based on the

Figure 6.1. Grain Legumes has achieved its Intermediate Development Outcomes (Research managers)



Source: Grain Legumes Survey

6.3. Effective use of resources

Output targets are only one step towards achieving the more ambitious outcome and impact targets, such as achieving increased grain legume harvests by 7.1 million tons in Low-Income, Food-Deficit Countries (LIFDCs) in five regions with an estimated economic value of US$ 4.5 billion. Up to 10% of the economic impact will be due to increased N fixation. The means with which this impact is to be achieved are documented in the Proposal under the Grain Legumes Impact Pathways, subsequently refined as in the Extension Phase. The Grain Legumes Impact Pathways depended upon traditional top-down vertical dissemination of outputs, although there is evidence in some of the special projects where the approach is more participatory. The Extension Phase is projected to adopt an interactive model with feedback loops back and forth between farmers, traders, researchers, and seed producers. Output delivery pathways for each output target are not yet complete, and those that are (PL5 is one reported example of completeness) are not integrated with an M&E system. It is well known that there is a long lag between research investments and reaping the full benefits, and projection of the same should be exercised with caution. As indicated in other sections of the Evaluation, without a functioning M&E, and reliable baseline information, verification of this impact and attribution to the work of Grain Legumes will be challenging. The predicted achievement of impact depends not only on the technological improvements, but also on the socio-economic climate within which they are exposed, and Grain Legumes has not considered these to the full in the past. This makes the social profitability of research investments difficult to estimate. Indeed, informal cross-border trade (e.g. of beans in Eastern Africa) may distort statistics on grain legume availability, and on nutritional impacts for a country. For a country that, based upon production statistics is self-sufficient, may indeed be deficit once exports have been subtracted from production data. Convincing policy makers to make decisions that favour adoption of new technologies must rely upon good scientific and socio-economic evidence, and examples of this are to found in the section 6.4.2 on Seed Systems.

6.4. Effectiveness of outputs

It is sensible to separate the effectiveness of outputs according to the three main levels of enquiry; that is Plant Breeding and Varietal Identification, Seed Systems and Agronomy. All three converge to assist the producer of grain legumes in developing countries.

6.4.1. Plant Breeding and Variety Identification

With breeding programmes stretched across eight species, there are some differences in effectiveness, but in the main there is a strong comparative global advantage, largely because of the genetic resources held in trust by the four centres, and their history in the long-term investment towards improving germplasm for national programme refinement and adoption. A

continuation of pre-Grain Legumes breeding activities for all eight species is leading to steady adoption of new varieties. We could not make an evaluation as to whether it is continuing at the same pace as before Grain Legumes, or slowing or speeding up. Likewise, we were not able to determine the specific breeding objectives of ICRISAT, nor ICARDA, from the materials provided. These need to be elucidated clearly in an accessible document including project portfolio, staff involvement and focus.

In a similar vein, we do query the philosophy of supporting similar selection trials at geographically close locations in India, and then submitting the selected genotypes into all-India trials to test for broad scale adaption. The sets of traits needed across locations must be spelt out and then selection procedures undertaken accordingly.

The breeding programs in each species are moving towards generally high-quality, well-proven, phenotyping platforms for screening for abiotic and biotic stresses. This is then followed by regional cooperative testing. Shared protocols for phenotyping across centres/species should be an important feature of Grain Legumes, but only one rare example has been cited, hosted by USDA, where methods for phenotyping of legume germplasm were shared. Researchers from CIAT, IITA, ICRISAT and three USDA stations attended, focusing on simple canopy temperature and root morphology measurements.

Genotyping should provide a more intelligent access to germplasm collections as a whole – that is one of the real benefits of genotyping collections – reference sets of core accessions are then possible with a range of sample sizes to represent diversity for the future study and exploitation by researchers and breeders. However, there is a lack of congruence between the populations that are being phenotyped and those being genotyped, and we suggest that within each species these by better aligned. Serious consideration could be given to integration of genotyping and phenotyping to produce segregating populations as quickly as possible through convergent crossing using molecular tools and new technology to reduce generation time. These types of systems will become available soon through genomics-based projects – the breeding community should begin to design their use in practical breeding situations, including the use of rapid generation technology (RGT) which can reduce generation cycling time to 60 days. As a specific example of phenotyping, use of a mini-core collection of cowpea has allowed for identification of intra- and interspecific diversity for growth traits, including plant transpiration in response to VPD. We note that this work should be extended using the ICRISAT phenotyping facility, and to be run in parallel with genotyping activity. Clear argument as to the comparative improved efficiencies (in terms of time and costs) in enhancing genetic gain using the MAS approach are still to be penned, although the genomics team at ICRISAT is convinced of the MAS superiority. For example, identification of pleiotropic QTLs (QTL-hotspots) related to drought tolerance in chickpea has allowed for MAS with introgression of the QTLs into a broadly adapted and well-adopted variety JG 11 in India. This set of MAS backcrossed lines has performed well in all-India trials and at least one selection is set for release in a couple of years. This represents one example of the benefits of investment in genomics research at ICRISAT. Another is with MABC to introgress resistance to Fusarium wilt race 1 and Asochyta blight into an elite chickpea cultivar and availability of the chickpea reference genome published in by ICRISAT staff is helping to fast track this earliness programme using SNP and SSR markers. Yet another is candidate genes and whole genome sequencing being used for investigating heat tolerance in chickpea where the study is in progress and will take time to reach some conclusive output. In brief some candidate genes show differential expression but time will tell if something is conclusive.

In searching for plant type for machine harvest and genotypes with desired traits identified a number of chickpea lines with an erect growth habit that are suitable for mechanical harvesting have been identified. Similar searches were conducted with faba bean and lentil and combined in some cases with a screen for herbicide tolerance.

Good progress has been made to develop various sources of CMS and maintainers for production of hybrid pigeonpea, and this has been possible through donors from *Cajanus reticulatus* and *C. lineatus*. The sequencing of mitochondrial genomes allows for the exact mitochondrial genomic segments responsible for male sterility in pigeonpea to be defined. Novel photothermal control of MS through choice of suitable environments for seed production removes the dependency on restorer line technology.

Examples of varietal identification, release and dissemination are reported in the section 7 on Impact, and have been indicated in the studies referred to in Section 2.8.

6.4.2. Seed Systems

Effective seed delivery systems require both technical input and an enabling policy environment. Linkage of participatory research to innovation platforms is creating positive impact (for example though the Pan-Africa Bean Research Alliance (PABRA)). Such systems approaches are to be recommended across all seed enterprises. Different modalities for seed dissemination have been carried out effectively in an "action research" mode (e.g. marketing in small seed packets at low cost and permitting farmers to experiment with low risk; seed-for-grain models; standard private sector production; decentralised local production of Quality Declared Seed (QDS) with small NGOs and CBOs, value-chain development). This work has revolutionised the impact pathway and opened multiple channels to reach farmers, both outcomes of the effective partnerships within PABRA. A total of 16 new varieties of cowpea and 18 varieties of soybeans have been released in Africa, and 134 abiotic and biotic stress tolerant bush bean varieties were released across 16 countries in East-Southern Africa since 2010. Farmer Participatory Varietal Selection (FPVS) conducted in 7 African countries involved in TL II and PABRA has underpinned this success.

Regional seed policies used to support regional seed activities of this CRP were essential and have been supported for example by CORAF and ASARECA. The ability of these agencies to influence policy is exemplary. Other important regional actors to scale up improved seed delivery to farmers include the Alliance for Green Revolution in Africa (AGRA) and the Program for Africa's Seed System (PASS).

In India the development of an alternative seed systems model based on local village based seed enterprises (VBSE) are proposed implying that the current model is not ideal. There is good vision associated with the VBSE, but there is still a lack of clarity about how the structure would be developed and adopted from first principles.

The alternative to commercial investment in seed systems is to introduce new varieties through intervention of public policy, either subsidy of seed supply, or subsidy of commercial production. Consideration of grain legumes as if they were vegetable crops, both from the management perspective and for seed systems, could well be useful development objectives into the future. This is an extension of treating and managing legumes as if they were vegetable or horticultural crops, i.e. a sense of intensification. To achieve a major impact on yield management agriculture has to be more intensive, with greater use of inputs but with larger benefit cost ratios, guiding growers to possibly pull themselves out of poverty, even if they only cultivate a small parcel of land. Of course this also assumes that the farmer has the capital (or loan) available to finance the

added input. For low investment, legumes can also improve system performance e.g. by providing a rotational break and provide N for the following crop.

As an aside, during our visits to breeding and agronomy trials, we did note room for improvements in some of the field operations in terms of adoption of best practice electronic data collection, and through correspondence in the central storage particularly of genomic data for public use.

6.4.3. Agronomy

Agronomy (with the exception of investment in N2 fixation) appears to be the poor sister in comparison with investment into breeding and seed systems. New agronomy has reputedly not played a prominent role in the enhancement of production systems containing grain legumes, as evidenced by Pachico (2015) and Walker et al. (2014) but research into improved inoculants and inoculants-responsive genotypes, plus supplemental sources of P and Bo, on the basis of recent evidence are promising in Africa. This is in addition to the search for practices, other than use of varietal resistance, that help growers contend with biotic stresses.

Taking nitrogen fixation first, there is evidence of a great deal of activity, mostly at ICRISAT and ICARDA, both in comparing strains of *Rhizobia* and crop genotypes. For example, 50 genotypes of chickpea and 400 mutant lines of faba bean were evaluated for nodulation by ICARDA, and 296 chickpea accessions were screened under glasshouse conditions. In addition, a variety of carrier materials (for inoculants) were compared, and training for inoculant production was provided. In Africa, through N2Africa, activity is more focused at the farm level, with dissemination of inoculants and promotion of inoculant production.

Taking now agronomic production technologies, we were pleased to see some investment in and moves afoot to treat legumes as if they were vegetable or horticultural crops, i.e. a sense of sustainable intensification, to achieve major impact on yield management has to be more intensive, with greater use of inputs but with larger benefit cost ratios, leading growers to possibly pull themselves out of poverty, even if they only cultivate a small parcel of land. For low investment, legumes can also improve system performance e.g. by providing a rotational break and provide N for the following crop. Management of pigeonpea as a horticultural crop (transplanting to efficiently use field space and time, determination of optimal planting rectangularity) to ensure maximal growth before flowering, is being trialled in Tandur near Hyderabad in India with spectacular results.

The team was shown potentially ground-breaking R&D for the biological control of the pod borer *Maruca vitrata*, but no detail was provided to evidence the impact or to describe what the nature of the field data were or how they achieved pest control and if/how recommended practices were being disseminated or adopted by local farmers. This lack of measured success is a shame, for such practices if successful also have the additional value of promoting a “cottage industry” of women groups and/or unemployed youths to create a steady supply of biological control products and thereby provide an additional source of household income.

It is pleasing to be informed in writing that at a commercial level an exclusive MOU is in place between the Government of Benin, IITA and the company Elephant Vert for exploiting a fungal strain of the entomopathogen *Beauvaria bassiana* in the world’s largest production unit in Meknès (Morocco). Surprisingly, neither this project nor the facility was mentioned during our visit to this location in Morocco.

Activity for integrated crop management practices for extra-early varieties of chickpea and lentil for short season environments includes the development of novel biocontrol material in an

interesting novel project to use microbial-derived metabolites as antagonists to fungal diseases. This is early stage research and needs a clear plan for how it will be taken forward. This, and other research on fungicides and herbicides (see below), must be conducted in association with the agrochemical industry to maximise research gains. A more holistic approach is required that coordinates an understanding of the disease pathology and epidemiology, new chemicals before they become commercially available, together with agronomic practice such that recommendations can be made for growers.

Some good quality agronomy is being conducted in the search for appropriate harvesting machines, herbicides and cultural practices and positive recommendations are made about which varieties to grow and how they should be managed in the field. In several cases there was, however, no evidence that the regulatory and trade aspects (cross-country approvals of herbicides and residues in exported crops) related to herbicide tolerant crops had been considered.

Work should be continued to establish whether these factors hold true in different environments. Secondly, such rigorous trial practices should be used to inform how breeding lines are evaluated and to provide phenotype data to associate with markers for herbicide tolerance.

6.5 Integration and synergy and other topics influencing effectiveness

Grain Legumes proposed to develop an integrated approach to legume R&D in each region rather than through isolated efforts, i.e. to improve effectiveness of research. We reviewed the status of integration and synergy as they influenced effectiveness.

Our field visits provided exposure to a number of well-run projects, but it was quite evident that there was little interaction and exchange of results between projects. The mapping of activities within W3/bilateral projects to Grain Legumes requires more than coordination on paper; forums for lateral exchange of results/ideas and a centrally organised output/outcome database are indispensable for Grain Legumes.

Inasmuch as capacity building contributes to effectiveness, we were not in a position to comment on anything other than numbers of persons trained. These were impressive, but very centre focussed, and a follow-up process to monitor change of practice and output following training is essential to show value for money.

Crop simulation modelling for identification of impact domains (e.g. of heat tolerant germplasm with climate change scenarios) and for identification of the contribution of dissected traits for heat and drought tolerance are well developed. But, there is no evidence of synergy across crops or between modelling platforms. Modelling could also support efforts towards a systems focus for Grain Legumes. The whole CRP, with the expectation of pockets of research on seed systems, lacks a systems focus. The lack of a socio-economic input is illustrated by the weak focus on end users. A better collaboration with social scientists is required at the design stage of experiments in order to improve the utility of the work carried out. Links with other CRPs could be strengthened, using agronomy and systems approaches where they are well developed.

Staff reported reduced effectiveness in their research activity due to insecurity of W1/W2 funding allocations, to changing requirements for multi-level monitoring and reporting, and to inordinate demands on time for CRP Extension documents, and currently for the new phase of CRPs. For example, it was drawn to our attention during discussions that staff writing the Grain Legumes document were completely worn out by the drawn-out process and it negatively affected their productivity and morale.

Effectiveness, however, for the majority of scientists was not compromised by the lack of equipment and training, although 20% of survey respondents referred to these as constraints.

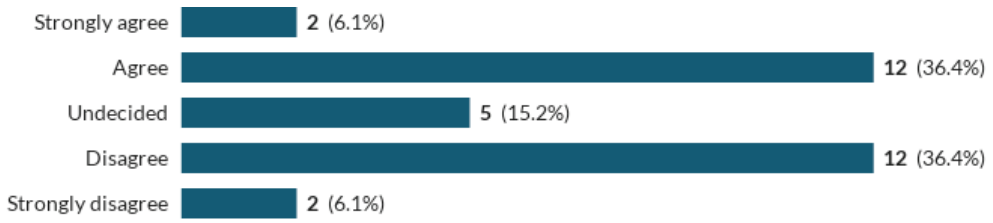
The effectiveness of the R&D activity to those not engaged in Grain Legumes is promising. Overall, Grain Legumes is well recognised and valued among respondents not engaged in the program (Survey Question 107). Eighty percent of non-Grain Legumes respondents were aware of the program; however, this includes 21% with current or former collaborative links to the program.

A sizeable majority of non CRP respondents, 61%, agreed that Grain Legumes is relevant to their work and 68% agreed that outcomes from Grain Legumes would add value to their work. However, three respondents (10%) negatively commented on the low return of CRP: *"...report-heavy and impactless", "...doing the best it could under the poorly designed CRP structure", "...limited value to those not working on specific crops", "...no commitment to understanding the farmer community and structural barriers to sustainable technology adoption".* Conversely, two respondents offered positive comments: *"Receiving information from breeders in order to orient research in crop genetic resources is always useful", and "The focus of the CRP is global; thus it includes solutions or ideas applicable in my own breeding projects".*

Bringing in new partners was one of the intentions of the new competitive grant and scholarship 'schemes', but these were thwarted by budget cuts.

Following on from interview discussions, the survey explored how much of the research activity, and therefore the efficiency, was driven by donor demands. Opinion was equally divided over whether PLs are donor driven (Fig. 3.4.1.2). The majority of comments however, suggested that the notion is not new: *"Activities may be donor driven, but then under the CGIAR system and Centers objectives were mostly donor driven."* Similarly, *"In as much as funding determines priorities/options for research. Large W3 funding is totally donor driven and thus, what remains is minimal in driving the agenda".* In addition, the difference between funding sources was noted: "*Yes, because >70% funding still comes from Donor funded (W 3) projects. Until the W1/W2 funding reaches >80%, this will continue to be Donor driven".* A middle-ground suggests that *"It is driven by both donors, ISPC and scientists. Unfortunately, the product lines are too narrow and not agile enough to respond to diverse national requirements. To be relevant one needs to be agile and respond to demands on the ground".* Others concur: *"...more flexibility is needed in the product lines."* A small number of comments suggest that researchers drive the agenda: *"they are researcher driven informed by their previous lessons"* or *"the product lines identified critical areas that were constraints in the focus geographies; the communities identified these as important and the donors [sic] interest matches the needs of the communities in those geographies".*

Figure 6.5.1. Activities within product lines are 'donor driven' (Research Manager)

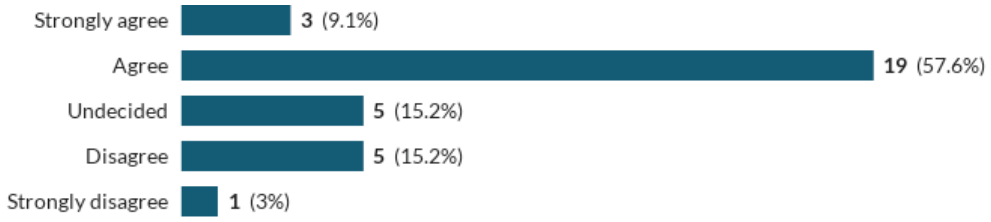


Source: Grain Legumes Survey

The existence of PLs as game-changers was voiced frequently during our interviews and field visits. Two thirds of Research Managers surveyed agree that Product Lines are "Game Changers"; 18%, however, disagreed (Question 16; Figure 6.4.1.3). Approximately half of the comments

suggested that the concept of "Game Changers" is somewhat redundant as PLs are a retrofit of pre-existing objectives: *"Product lines are simply restatements of previous objectives of the programs of the Centers. They may be more uniform and somewhat easier to comprehend, but the objectives are basically the same except for the "repackaging."* In addition, *"This is an old concept for most of us so I wouldn't give credit to this being a "game changer". Focused product development based on market requirements should be a fundamental component to crop improvement if high rates of adoption are to be realized".* Others suggested that PL outputs are delivering potential "Game Changers": *"Product lines identified 'clear products' to deliver and have worked to deliver the products for development; where they work, the results are game changers". "The delivery of the CRP and impact to be made depends on the Product Lines, how well they reflect the needs and priorities for the CRP and how the program is designed depends on the PLs."* As discussed in the section on the Way Ahead in the Executive Summary, we believe that in order to have true game changers, we need in fact to change the game, and we discussed one option for this.

Figure 6.5.2. Product lines are real 'game changers' (Research Manager)



Source: Grain Legumes Survey

6.6. Conclusions and recommendations

The crux of evaluating effectiveness is to ask whether on its own and/or through collaborative work Grain Legumes is improving the performance of eight priority grain legumes in households, on farms, and in markets. The current activities and processes within Grain Legumes do not allow us to definitively answer this.

Grain Legumes has been very effective in addressing component issues of research, but not the continuum from variety development to legumes on someone's dinner plate. Our overall assessment of the effectiveness of Grain Legumes in stimulating synergy, innovation and impact indicate that gradualism is more prevalent than innovation, as mentioned in Relevance. It also shows, as do publications, that there is little integration of disciplines or a focus on 'systems'. The absence of socio-economists from research teams is evident in the general lack of an end user focus. However, research on genomics, plant breeding and seed systems have made great strides forward, on the brink of delivering impact. Agronomy has been a poor sister, but some of the competitive grants have unearthed some potential game changers.

As mentioned earlier, the lack of an effective M&E, and therefore the ability to monitor impact pathways, and achievement of impact implies no systematic management of data, and therefore difficulty when attempting to evaluate the achievement of the Grain Legumes objectives.

One might have expected at least one attempt to try to develop publications between centres arguing for similar biologies/research approaches, bringing species together under one umbrella, but we did not find any evidence for this. It is most unfortunate that, due to budgetary cuts, the new 'schemes', e.g. competitive grants and scholarships, were cut off before gaining a foothold.

With eight species addressed by Grain Legumes, it is not unexpected that there will be little evidence of shared protocols across centres/species. One rare example was that hosted by USDA on shared methods for phenotyping of legume germplasm. Researchers from CIAT, IITA, ICRISAT and three USDA stations attended, focusing in simple canopy temperature and root morphology measurements.

Whether Grain Legumes is fit for purpose to achieve all of the goals is discussed previously. The original set-up with PLs and SCs was good, and the added reporting with new FPs brought no obvious benefits. They reinforced the kow-towing to bilateral funding through bias towards end users adoptions. In contrast to messages given to scientists as the CRPs commenced, no reductions in reporting requirement or in the search for funding were effected. The imposition of the restructure to FPs, while fine to suit development objective and outcomes (W3/bilateral) is not entirely suitable for a research institute.

Recommendation 6: To develop greater synergy, Grain Legumes should review management processes and the direction of research activities. In particular, **far more extensive integration of research and knowledge exchange across both African and Asian continents so that the best aspects of both can be shared**. A multidisciplinary approach is recommended that considers processing solutions, as well as breeding solutions, to capitalise upon the nutritional benefits of the grain legume crops. We recommend:

- **A better collaboration with social scientists at the design stage of experiments** in order to improve the utility of the work carried out and to understand its reach.
- **Supporting[10] the adoption of best practice electronic data collection, central storage and open access, particularly of genomic data, for public use.**
- Given the focus on the link between phenotyping and genotyping, we note that **there is a lack of congruence between the populations that are being phenotyped and those being genotyped, and therefore these could be better aligned within each species.**
- **Concentrating investment external to Grain Legumes on scaling up production of varieties with the most promising trait profiles to meet the basic seed requirement.**
- **Developing a more holistic approach that coordinates an understanding of the disease pathology and epidemiology, and of new chemicals before they become commercially available, together with agronomic practice such that recommendations can be made for growers.** Continuing work to establish whether agronomic factors hold true in different environments and to assess GxE effects within breeding programmes. Such rigorous trial practices should be used to inform the evaluation of breeding lines and to provide phenotype data to associate with markers for traits such as heat, drought and herbicide tolerance.
- **Considering grain legumes as if they were vegetable crops in terms of the strategy for intensification of production, both from the management perspective and for seed systems, will be a useful development objective into the future.** This will bring about more rapid intensification and is likely to increase farmer returns from investment.

Recommendation 7: **The CGIAR centres should focus in on the research for which they have a comparative advantage.** While imposing the restructure to FPs, which is fine for development objectives and outcomes (funded through W3/bilateral) it is less so for a research institute, and

[10] While the support can come from the CRP, the action must be taken by the lead and participating centres.

should not detract from the more basic work expected of an international CGIAR centre (or set of centres in a CRP).

- **Collaborative approaches should be explored within Grain Legumes**, e.g. similar biologies/research approaches, bringing species together under one umbrella. Similarly better alignment is needed to address the lack of congruence between the populations that are being phenotyped and those being genotyped.
- Despite positive impacts from research in genomics, plant breeding and seed systems, the lack of an effective M&E, already mentioned elsewhere, has reduced the ability to monitor impact pathways. This must be addressed.
- The absence of socio-economists from research teams is evident in the general lack of an end user focus. **Responsibilities of the different actors in the whole value chain must be considered and identified when developing impact targets, and the pathway leading to them, for individual projects. People with socio-economist skills must be part of the team from project inception so that appropriate frameworks are incorporated for measuring and influencing sociological and economic changes brought about by Grain Legumes research.**

7. Impact

Impact from activities of Grain Legumes is probably the key measure of its success or otherwise. Impact is determined by the funding investment available to PLs and the framework that exists for bridging the gap between pure R&D and the end users. In order to achieve impact there needs to be a clearly defined pathway at the inception of research activity that shows how the stated aims, goals and impact will be achieved.

Impact is ultimately felt by beneficiaries of technologies developed. Grain Legumes has not been in place sufficiently long enough to have created direct beneficiary impact. Hence, impact of past legume R&D, further supported by Grain Legumes has been reviewed, as was potential impact.

7.1. Efforts to document outcomes and impact from past research

The Self Assessment section 2 was used as the main source of data to inform the answer to this question, supported by observations and discussions during the field visits; and the online survey. In some cases the examples provided cannot be categorised as a measurable impact (see comments on each separate PL).

The team assessed the 'reach and significance' of impacts on the availability and consumption of grain legumes, on the effects of these on consumer health status, on producer income, and on income of others in the value chain. They also assessed the PL's approach to enable and demonstrate impact from its research. Data are summarised in Tables A2.1 and A2.2.

PL1: Impacts were well defined, far reaching, supported by metrics and had at least equal gender reach but often favoured women over men. PL1 has good relationships with farmers to enable on-farm testing and are proactive in releasing new varieties that benefit those that grow them. This PL is also exploring other industrial biotech options to provide food ingredients and non-food products from the bean crops. There has been good continuity from the Tropical Legumes projects that were the forebear of PL1. There is a structured approach to breeding activity in PL1 which incorporates rigorous testing and release programmes. There is an innovative approach to ensuring that new varieties are available to smallholder farmers; it would be better to share this best practice approach with other PLs. There is good synergy between the breeding programme and encouraging end-use of the crops for improved nutrition, particularly in the area of child

health. Impacts are quantifiable, measureable and the success of them has been appropriately monitored. A high score (30) is warranted for PL1 (Table A1.1).

PL2: Two impact cases were provided, although they were not supported by very detailed metrics. A heat tolerant chickpea variety JG 14 (ICCV 92944) was released in India in 2009 for late sowings and was more recently released as Yezin 6 covering over 40,000 ha in Myanmar during the 2012-13 crop season. It is not clear how this compares to the targets for new varieties and what proportion of total chickpea sown this represents. The second case referred to a heat tolerant faba bean variety in Sudan which has been adopted by 25,000 farmers on 50,000 ha, with income increases of $4,000 per family per annum. This is a more substantial impact case although it would have been useful to know how this compares to the total number of farmers and total hectares of chickpea. PL2 has been given a score of 15 for this area of assessment. It is not surprising that this is fairly low, particularly for the contribution of CIAT, for this is a new priority and area of research for that centre.

PL3: This product line addresses the most important abiotic stress (drought) and an important factor that affects quality of the produce (aflatoxin contamination) in groundnut. Assessment of aflatoxin contamination of grain legumes showed that the major impact target of PL3 – to reduce aflatoxin contamination – is still far from being met. A contamination rate of 95% was reported (over 20ppb) and although further mitigation efforts are planned there was no detail of these presented.

The biggest bottleneck in adoption of improved cultivars is the availability of quality seed. This is being addressed by strengthening both formal and informal seed systems. Enhanced adoption of improved cultivars and integrated crop management practices will lead to improved groundnut productivity and quality in drought prone environments. The Impact target is to produce groundnut in 0.5 M ha with a 15% yield increase in Asia. ICRISAT has produced 29 t of breeder seeds which are now with private companies for further multiplication. However, the picture in Africa shows that production is still falling short of demand with, for example, an eight-fold increase required in Malawi to meet demand. Efforts to address this are rather small-scale and may make individual pockets of difference but not necessarily the magnitude required. The recommendation is that investment is concentrated on scaling up production of varieties with the most promising trait profiles to meet the basic seed requirement.

Metrics are provided that indicate that knowledge dissemination through farmer training schools is very effective and reaches both genders. An estimated 286 farmers are reached for every farmer trained through a variety of media and face-to-face dissemination activities. This was linked directly to a 10% increase in production area in Malawi and work is ongoing to achieve similar outcomes in other Eastern and Southern African Countries. West and Central Africa is struggling to develop such a good training networks and will need more investment to achieve the yield increases sought.

Considerable progress has been made in terms of developing and utilization of labour saving equipment. Whist this has undoubtedly relieved women of much of the drudgery associated with groundnut production it is not clear if the new machinery is being used by women or if their jobs have disappeared. The provision of mechanical shellers has relieved women of this onerous task and it was reported that this enabled women to control more of the decision making process in the crop cycle although concrete evidence was not available to support this statement. It would appear that each sheller would leave 19 women displaced from work and that men in the community retained control of transport of the crop to market, of seed sourcing and of planning

the crop cycle. Whilst running the shelling machine is good for the woman with that responsibility it is far from clear what her former colleagues will be doing instead.

The self- assessment document provided three impact cases. Breeding capacity of groundnut has resulted in the release of seven new varieties but the extent of their utilisation of the target countries (Zambia and Tanzania) is not presented. Increased coverage using the improved groundnut is claimed but not supported with evidence. The CCEE did, however, observe the double population cropping system of groundnut in Malawi and saw evidence of the increased production resulting from it. These data are not presented in the impact case that refers to the same thing and it is fortuitous that the CCEE Team made the personal visit. The score of 15 was awarded, but it could have been higher if appropriate data were provided to evidence the claimed impacts.

PL4: Many of the items listed under impact in PL4 represent ambitions rather than having any support from concrete evidence that anything has been achieved. In some cases it was not clear what the measurable impact would be or what the pathway to delivery was. One of the impacts claimed by PL4 relates to part of an unspecified Wider Impact Program in which a process was set in motion to improve productivity, combining seed delivery, agronomic practices, extension and marketing. The particular emphasis on production of quality seed at various experimental stations, and the use of irrigation to multiply seed in the off-season, was exemplary. The CCEE wishes to know if the reported chickpea *Rhizobium* strains have been made available and taken up by the farming community in India. Due to lack of attributable impact to the efforts of PL4, a low score of 10 was therefore awarded.

PL5: Five impacts were listed in the final version of the self assessment document: Biological control of the pod borer *Maruca vitrata* in Benin, Burkina Faso, Ghana and Niger, impact to be achieved in 2017, with establishment in 2016 (PL5 was the only PL to provide us with output targets for their activity clusters. The estimation is that 200K farmers will benefit from a 40% yield increase by 2018. Screening trials have yielded extremely positive results and there is a clear plan of the next steps to rolling out the parasitiod release to the wider community. One of the other impact cases presented (commercial formulations of bio-pesticides) used research-based evidence to show the efficacy of the new products over existing alternatives and demonstrated that private partnerships had already been established to provide a route to commercialisation. An analysis of the final submission provided considerably stronger evidence and therefore a final score of 20 was awarded.

PL6. Several impacts were listed that documented clearly how improved chickpea varieties are being disseminated and utilised and on the whole are supported by good evidence to underpin the claims. It is particularly impressive how the short duration cultivars have led to welfare benefits within Andhra Pradesh. It is clear that new varieties and practices are adopted and that work from the PL has a positive economic impact on the user community. This PL was also able to provide an ROI value for investment in technology developed at ICRISAT (28%) which represents good value for money and is indicative of programme success. A good score of 30 was given.

PL7. Three impacts were listed. The first, multilocation trials on machine harvestable chickpea breeding lines under All India Coordinated Research Project (AICRP) on chickpea started from the 2014-15 crop season. The data from AICRP trials are required for release of varieties by the Central Variety Release Committee, but will not start to make impact until any variety has been released. This does however represent great potential impact, but it remains to be seen what difference it will make to livelihoods, economies, and social standing.

Release of machine harvestable varieties of chickpea, lentil and faba bean in Africa needs supporting evidence of adoption, a way of tracking how the knowledge exchange programme is reaching into the target community, how many women have been released from drudgery and what they now do in terms of employment.

There is a potential impact for researchers in terms of the development of genetic sources of herbicide tolerance in chickpea, lentil and faba bean, but this needs to be supported by evidence showing that the improved varieties are being accessed and used by the scientific and/or breeding community. The lack of suitable supporting evidence reduced the potential score for this PL to a final value of 20.

PL8. Three impacts were listed. Evidence was provided that the hybrid pigeonpea resource had impacted on the breeding community as they enabled the development and release of three hybrid varieties, but it was not clear how successful these varieties have been on the open market. Supporting data are required to describe the reach of the training activity and technical advice disseminated, and to what extent farming practices were changed as a result. The PL states that large-scale hybrid seed production was undertaken by stakeholders which sounds very encouraging, presumably representing a change in practice from non-hybrid varieties. It should be possible to monitor the impact of these varieties over time, by recording their sales and use and quantifying the additional value they bring to different economies. This is true especially since there are subsidy schemes underwritten by the governments of Andhra Pradesh and Telangana. There was also a description of large-scale demonstration of hybrid pigeonpea which was linked to increased seed distribution which represents a valuable impact that follows on from the one above and similar comments are relevant i.e. how many people did the demos reach, how much seed was distributed as a result and therefore how much was productivity in the region enhanced? The PL was awarded an overall score of 25, again reduced because the PL did not have adequate means of monitoring the impact of its activities.

7.2. Findings from the on-line survey

The online survey provides valuable support to the self-assessment data, and, in some cases, clarification. According to Research Managers, the major success of Grain Legumes was its capacity to provide a platform for collaboration within CGIAR Centres and with partners, thus enabling a more cohesive legume community at this early stage of the program *"...its success has been [the] ability to expand on the research human resources, bring together professionals from different organizations into fora to discuss strategies and research questions.* Others comment on specific strengths, such as breeding and crop improvement and its capacity to deliver technologies: *"...new areas of crop development were opened (heat tolerance, herbicide resistance, etc). Some modest communication among colleagues on common themes"*. The final sentence, however, qualified the issue of collaboration somewhat. Similarly, *"There has been some integration. The varieties are in place in the rice fallows. The big failure has been to adopt a coordinated and integrated approach to comparative genetics. This means that the genomics efforts cannot deliver."*

Research Managers perceived the major weaknesses to be implementation, funding and governance, as summarised by this comment: *"...the program is weak on actual implementation due to the persistent threat of budget cuts. Also, the management structure is awkward with there being CGIAR centers and their management structure and imposed on that structure is the structure of the CRPs. While the CRPs are expected to form complementary relationships and better utilize resources, they effectively siphon funds for management activities while reducing*

available resources for actual research." Specific weaknesses include lack of support for the Grain Legumes Director; M&E; value chain and diversification; gender diversity; and the time spent managing change. As indicated by the following: *"Poor support from the lead center to the director"*; *"Its failures has been on monitoring CRP as a program"; "More work is needed on value chain and diversification of production systems"* and, regarding efficient use of time: *"...we spend more time on log frames, reporting etc. rather than actual work. Change is always needs but, we spend lot of time on organizing ourselves for CRP."* Two comments specifically refer to gender diversity: *"The major weakness are [sic] more to do with governance issues and particularly gender disparities in the management structures";* and *"I think the challenge was that the gender component was added later, and the specialist who was on board left and so the program experienced a lag in the implementation of gender research."*

Scientists were asked how they perceived the impact of their research within the period of Grain Legumes. The majority noted an increase in production, sales and consumption of grain legumes (43% agreed, 31% strongly agreed), similarly 43% agreed and 28% strongly agreed that their research has led to reduced poverty, hunger or malnutrition. However, a sizeable number are undecided in both cases: 22% and 24% respectively. The impact on farming systems is stronger with almost two thirds agreeing or strongly agreeing. Comments provide specific examples of progress across the range of PLs. Three quarters of Scientists stated that their work will contribute to the objectives of Grain Legumes in future; however, 24% commented that their work will not. Timeframe for research outcomes varied between later in 2015 to 2025, although the mode was between 2 to 5 years.

A significant majority of Scientists agreed that there is evidence of improved crops or enhanced finances of smallholder farmers and the agricultural system arising from the ability of grain legumes to fix nitrogen in soils. Several respondents offered evidence to support their assertion.

It is not encouraging to note that almost one third of Scientists are unable to directly link research outputs to a CRP activity, and fewer than half can link outputs to a CRP activity. Examples given included varietal improvements; others specifically mentioned PL outputs, such as *"PL 6 and PL 7: Early chickpea varieties and Mechancially [sic] harvestable chickpea"*. Also, *"PL4/High N2-fixing ability of legumes - Standard operating procedures for the production, quality control and application of rhizobium inoculants..."*.

Several Research Managers acknowledged the value of publications and their dissemination, for example: *"This area seems to be an important outcome of the development of CRPs in general";* and *"In last 4 years there has been significant effort to assess impact and disseminate results. Some publications exist and others are in the pipeline"*. Others suggested a more systematic approach and wider dissemination: *"While some outcomes have been properly documented this is not the case across all 8 crops. Lessons learned could have also been better documented, including goverance [sic] and management of CRPs"; "More efforts should be made for wide circulation of documents or research outcomes among partners and media."* One respondent suggested the emphasis on publications is too strong: *"We are spending more time and resources to study and document the impacts, this should be rationalized. Documenting outcomes help us to build upon but we can draw analogies and need not make an attempt to document every research."*

Scientists were fully aware that publications are important pathways for impact and 80% have published within the last three years. Those that have not were either relatively new to Grain Legumes, midway through research activities or have publications in draft, e.g. *"Still new (less than 2 years). Still understanding the subject, but two articles have been lined up for publication".*

One comments that report writing encroaches on time for publications: *"Joined recently and no time for publications. Writing reports kill all the time"*.

7.3. Constraints to impact

The IDOs, as outlined earlier, are appropriate and feed into the CGIAR SLOs, but they are not achievable by the CGIAR centres associated with Grain Legumes on their own; their achievement depends upon the actions of downstream partners, who, as seen later in the Grain Legumes Governance structure, are not answerable to the Grain Legumes Director. Even the CGIAR scientists are not answerable to the Grain Legumes Director. The CGIAR involvement should rightfully be in the generation of suitable technologies that are to be adopted by beneficiaries for personal and public good, and these can only be relevant if there are close links to the end users, but to be involved in directly providing end users with such technologies is not wise investment of funding resources. The CRP does not have a complete set of Impact Pathways aligned with output targets (although these have been in gestation for 18 months), yet the examples afforded to the team would appear to be very suitable and to act as a means of linking project management to the broader impact pathways.

However, in the main, the achievement of most of the IDOs depends upon there being relevant benchmarked baseline data against which progress and impact can be measured, and these data are lacking. This is equally so for aspects of 'access' to grain legumes by the urban and rural poor, to more equitable income from grain legumes by low income value chain actors, especially women, to consumption of grain legumes with health benefits, to improved productivity and to lessened environmental impact attributable to grain legumes. Baseline data on each are required, and it is difficult to imagine how gains in each can be measured unless the respective baseline data are collected. There is an urgent need to invest in collecting baseline data, without which the very foundation for research in grain legumes is jeopardised.

With respect to the achievement of impacts, Grain Legumes has made a number of assumptions and considered the risks involved, particularly as they relate to the change in behaviour, capacity and the enabling environment. The adoption of 'innovation platforms', allowing for non-linear feedback loops and professional interactions between all players in the supply and demand chains, particularly for seed systems, is one example of success. It allows for inclusion of agreed-upon goals along the chains by individuals, bringing all into line as part of the development process. The involvement and overview by CIAT in the PABRA seed model is a good example of this. Inclusion of national institutions (their activities funded by through W3 and bilateral project) and change of behaviour of policy makers are integral to the success of Grain Legumes, but as indicated above, Grain Legumes itself can only influence but not dictate such outcomes.

7.4. Conclusions and recommendations

Work in Grain Legumes has enormous potential for real impact in scientific, commercial, farming, smallholder and household communities, much of which is being realised.

Interviews conducted by the CCEE during site visits showed that PLs are quantifying the area of adoption of varieties, but in most cases they are not measuring the impact on environment, health/nutrition. Since the health and nutritional benefits and the environmental gains from growing legumes are major arguments for supporting grain legume research the community is currently missing substantial opportunities to strengthen its own case for continued support.

Whilst there are some impressive examples of considering the whole value chain, e.g. white beans from production through to export and the adoption of 'innovation platforms', the pipeline to end

user is, in the main, built up piecemeal, with no clear definition of the end user nor differential responsibility of Grain Legumes and of partners.

The lack of robust time-defined impact pathways, however, has been highlighted in Section 7.4, and even though developed for PL5, timeframes are essential for measuring progress against prediction.

Recommendation 8: PLs need to become more adept at providing convincing cases in which impact is strongly evidenced, as this is likely to be a key factor in leveraging future funding.

- **Claimed gains must be referenced against baseline data,** and these are not always readily available. The CCEE Team realises that such impact evaluation represents a significant drain on resources, and Grain Legumes should determine whether the balance of costs to benefits favours such investment.
- **It is essential that Grain Legumes provides training to staff on what constitutes impact** and how it can be recorded.
- Specific, rather than generalised, **potential impacts arising from activity within Grain Legumes should be defined at the time of justifying the programme of work** and a pathway to impact should form part of the documentation prepared ahead of a piece of research commencing. . In other words, centres should submit work plans to Grain Legumes before they are undertaken using W1/W2 funds
- **Recommendation 9: The reporting activity must be streamlined to a single (brief) format that can be used to report to Grain Legumes, Centres and to donors for special project activities[11].**

8. Sustainability

In any long-term research programme of the type exemplified by this CRP there is an absolute requirement to assure participants of long term funding, and beneficiaries of the supply of outcomes. Without this motivation to engage, the CRP will decline.

As stated on the Grain Legumes website: "*Grain Legumes is a new Program, but it inherits a legacy of four decades of crop improvement impacts from the participating partner institutions as well as the vigorous pipeline of ongoing research-for-development. The pipeline will continue to deliver new germplasm, varieties, seed system innovations, advances in knowledge, capacity-strengthening and other impacts in the years to come.*"

In other words, the pipeline must be fully supported, i.e. sustainably funded, over time.

Another aspect of sustainability is in the durability of benefits of research outcomes, i.e. of their adoption. Given the newness of adoptions of improved varieties and technologies we were not in a position to evaluate the sustainability of projected, nor actual, adoptions. Presentation of defined impact pathways was missing in most PLs; once in place these will assist in this type of analysis. Even the sustainability of outputs and outcomes from the CRP will depend upon whether funding can be secured, especially for the promotion of outputs among NARS.

[11] While this can be led by the RMC/PMU it requires the agreement of the lead and participating centers with respect to W3 or Bilaterally funded projects that are 'mapped' to the CRP.

8.1. Commentary

We were informed by many of those interviewed that, at the establishment of Grain Legumes, they were told funding was now assured for the foreseeable future. They tended to believe this reassurance, only to be told soon afterwards that funding was not stable and that cuts were to be imposed on the programme. This course of events has undoubtedly affected some participants who are now disillusioned with the procedures. Other related comments were that the biggest single restriction to progress had been insufficient flexible funding to permit a viable interaction (e.g. joint field visits) as a Product Line, and that instability of funding had forced the group to recede into a defensive mode. Limited funding for R&D by national partners was also quoted as a factor that restricts the successful implementation of pipelines and programmes of research.

Despite the inconsistency of funding since 2012, analysis of the survey responses showed that a large proportion (73%) expected the benefits of CRP's activities to be sustained when Grain Legumes ends. In particular, collaboration with NARS and private partnerships: *"As long as efforts for Capacity Development of the NARS as well as key R&D institutions at the national level are well supported, the benefits from the activities will be sustained. Involvement of the private sector is key for this to happen"*. Responsibility was also placed on countries to focus on sustainability: *"Sustainability has been a major problem. Individual countries should [fund] these projects so that when the donors leave there will be continuity".* Strategic changes were anticipated in terms of M&E and planning: *"...Process of planning research will likely change as will M&E systems to become more agile, informative and pragmatic to support technology targeting, implementation and learning".* From an optimistic perspective: *"Most of the activities were based on strong research programs which do not depend on the CRP per se for continuity, if funding permits them to continue to function"*.

In discussions about the future options for a CRP merger, a diversity of opinions was expressed. In summary, this diversity was based on the Centre affiliation of the participant. Whilst the general view from ICRISAT scientists was that a merger with Dryland Cereals was to be recommended, a contradictory view was expressed strongly by at least some CIAT scientists who considered that such a merger would not be in their best interests nor in the interests of their mandate crops, as it would lead to an overdominance by dryland crops. These attitudes are reflected by some of the comments included below.

In results from the on-line survey, approximately 57% of Research Managers were concerned that steps have not been put in place to ensure sustainable funding; only 42% showed optimism (Figure 8.1).

Figure 8.1. Have steps been put in place to ensure sustainable funding? (Research Manager)

Source: Grain Legumes Survey

Some expressed concerns over the proposed merger with Dryland Cereals and Systems in terms of loss of focus: *"The proposals are being submitted for next phase. I strongly feel that merger of CRP-GL with CRP-Dry land will have negative impact on legumes research for development".* Others perceive a failure within the CRP system: *"This is very specific to each center, but there are no central efforts on behalf of the CRP". "Over the past 3 years, the CO assumed the responsibility (sometimes usurping the same from Centers). The CO does not have a proper plan."* Greater

stability is seen in bilateral funding: *"Centers have been bilateral funding as being more efficient and stable than W1/2 funding. This was especially evident in 2015".* Some linked sustainability with strong capacity building and effective relationships with NARS: *"Sustainability comes from enhancing capacity development in national program partners which is the case now".* Similarly, *"Lots of capacity building. Working with local partners encorages [sic] institutionalisation of approaches".* One comment refers to the proposed merger: *"in principle yes [steps are in place for sustainable funding], but what we see in the current configuration of GLADAS is not very reassuring for e.g. humid tropic legues [legumes]".*

There is some concern that the focus of the bilateral projects in Grain Legumes is more towards the downstream end of the delivery chain, that appealing to funding agencies wishing for reasonably quick impact. This means that there are always fewer funds available for equipping laboratories and upstream research. Similarly, at present, much of the training capacity in Africa centres around farmer schools to demonstrate new varieties, agronomic practice and technologies. Without an equally vibrant programme directed at breeders and other disciplines necessary to ensure delivery of improved varieties, the local efforts are unlikely to be sustainable.

There is also concern amongst centres that the ageing buildings and equipment will need to be replaced and this is increasingly difficult to fund. Reference may be made to the extract from the document describing the key assets and benefits of CGIAR "The multi-donor trust fund provides reliable and predictable financing to enable long-term planning and pools resources to support big-ticket research that aims to deliver step change." It is hoped that this will continue to be true for the foreseeable future.

8.2. Conclusions and recommendations

In summary, there is general acknowledgement that future funding is likely to become more limited, specifically in W1&2 and there is understandable concern over the support for the staff and basic infrastructure that underpin the Grain Legumes programme. For example, it is reported that staffing in parts of CIAT has been dependent on W1&2 and that this is too unstable to re-establish a critical mass.

The present system whereby W3 and bilateral projects do not pay a realistic level of overheads means that such projects are being effectively subsidised by W1&2. This position is not sustainable in the long term as there will be a progressive but definite loss of basic skills and resources in the core centres. The only obvious options to prevent this outcome include a severe reduction in the fixed costs of the centres and/or a refusal to accept W3 and bilateral funding with an inadequate overhead component. In the latter case there is an obvious danger that funders will move their resources away from the CGIAR system towards other, perhaps less expensive, suppliers of research, and possibly more relevant development expertise. This issue must be addressed.

The need for continuity in funding is clearly recognised at all levels, as shown by this extract from the notes of the CGIAR Consortium Report at the Fund Council Meeting held at Bogor in April 2105:- "*One additional role remains key to fill this year, addressing directly the Centers' request for increased Consortium focus on efforts to secure resources from non-traditional sources, seen as one part of an overall CGIAR system wide strategy to improve longer-term predictability and sustainability of funding*."

There is obvious difficulty in ensuring predictable spending at the Consortium level itself as shown by variances in spend compared with the approved 2014 budget (as reported at Bogor). The variances that were higher than budget included consultants (+11%), travel (+13%), meetings

(+32%), overhead (+46%) and other operating expenses (+61%). Although there are some extenuating circumstances (relations with Bioversity), these overspends against budget demonstrate an intrinsic problem. This problem must be set in the declared context that 2015 will see a year on year decline of $40 m (19%) in overall W1&2 funding. This reduction has its foundation in many uncertainties, which include "*the heavy reliance on annual contributions rather than multiyear commitments, unpredictable and sporadic payments time during the year, independent and disconnected decision making by the donor community on bilateral funding external to the CGIAR Fund mechanism, the continuation of what is essentially a bilateral funding" mechanism through Window 3 and consequently, direct donor negotiation with individual Centers on funding*."

The scale of decline before and after the establishment of the CGIAR fund is demonstrated in Table 8.2.

Table 8.2. Growth and Distribution of CGIAR Funding ($million) by Year, pre and post CGIAR Fund

Prior to CGIAR Fund							
Year			**Unrestricted**			**Restricted**	**Total**
2008			192			339	**531**
2009			205			401	**606**
2010			229			444	**673**
CGIAR Fund							
	W1	**W2**	**sub-total**	**W3**	**Bilateral**	**sub-total**	**Total**
2011	254	62	**316**	69	532	**601**	**917**
2012	184	132	**316**	198	525	**723**	**1039**
2013	217	136	**354**	299	524	**823**	**1176**
2014 *estimated*	189	111	**300**	255	490	**745**	**1044**
2015 *projected*	160	100	**260**	210	490	**700**	**959**

Notes: W1, W2 and W3 are based on receipts while Bilateral is based on spending
2014 – Bilateral spend is estimated as figures are not yet available.
2015 – Projections include received, confirmed and unconfirmed amounts

From http://cgiarcm.com/wp-content/uploads/2015/05/CGIAR-System-Resource-Mobilization-Issues-Paper.pdf

It is estimated that the 2nd round of CRPs will require funding of approximately $5 b over five years, with the ambition being to find 20% of the first tranche through new donors and partnerships, as part of the Resource Mobilization Strategy. In the absence of long term certainty the scale of the budget allocated to each of the new CRPs should be very conservative, a feature that can only be achieved by restricting/reducing the scope, probably quite significantly. This suggestion may be more easily managed if the focus in the Grain Legumes area moves to one or more smaller CRPs, rather than to a single larger catch-all project.

A recent editorial in Science (Normile, 2015) illustrated the problem of sustaining funding across CGIAR, particularly with the reference to uncertainty over the World Bank contribution. A letter to the World Bank president recently stated "*The role played by CGIAR is too critical to the future of the world's food supply to ignore*."

Recommendation 10: **As Grain Legumes moves into the future, and if sustainable funding cannot be assured, decisions must be made concerning a reduction in activities,** keeping some caretaker breeding maintenance, and focus (as has TL III) on fewer species and a reduced geographic focus. Zeigler (Director General of IRRI) states "…*time and effort would be better spent … making tough decisions about which programs deserve the precious support."*

- The present system whereby W3 and bilateral projects do not pay a realistic level of overheads means that such projects are being effectively subsidised by W1&2 and there will be a progressive but definite loss of basic skills and resources in the core centres. **To prevent this outcome it is necessary to significantly reduce the fixed costs of the centres and/or refuse to accept W3 and bilateral funding without an adequate overhead component.**
- **In the absence of long term certainty, the scale of the budget allocated to each of the new CRPs should be very conservative,** a feature that can only be achieved by restricting/reducing the scope, probably quite significantly.

9. Cross-cutting issues

In this section we discuss the evaluation of non-technical issues that impinge upon the achievement of its goals by Grain Legumes.

9.1. Gender

The review considered gender mainstreaming within research design and sought evidence of outcomes demonstrating gender equity. The lens is influenced by the challenge of social equality for all genders through positive empowerment over societal constraints. The practical application is outlined in an earlier section of this report: "the review will assess to what extent such barriers are overcome by implementation of the research strategy". The review team searched for data that describe how each product line is able to contribute to the increased income, food security, nutrition, environmental and resource conservation for resource-poor women and men existing in rural livelihoods.

9.1.1 Introduction

The Consortium Gender Strategy (CGIAR, 2010) describes a two-stranded approach to promoting gender equality. Firstly, building capacity to *"address the gender dimensions of agricultural research and development at the Consortium level, and the second is to integrate gender into individual programs. All CRPs are required to consider gender in research and to monitor gender outcomes."* The strategy also commits to monitoring progress to *"ensure accountability, research results, the resources allocated to achieve results and the gender expertise deployed for research".* This strategic commitment to improving gender equity and promote diversity is endorsed by the budget allocated to Gender at the outset of Grain Legumes in 2012 (Table 9.1.1). An updated budget set out in the Gender Strategy document (2013), showed continuing financial allocation (Table 9.1.2). Approximately 4% of the total budget is allocated to Gender; higher than that allocated to Management.

Table 9.1.1. Gender Research & Analysis Budget 2012-2015 (US$ '000s)

Partner	Year 1	Year 2	Year 3	Total
CIAT	367	460	488	**1,315**
ICARDA	156	164	172	**492**
ICRISAT	449	611	682	**1,742**
IITA	489	532	553	**1,574**
GCP	51	51	35	**137**
Total Gender Research Budget	**1,512**	**1,818**	**1,930**	**5,260**

Source: CGIAR Research Program on Grain Legumes, 15 August 2012.

Table 9.1.2. Gender Actuals and Budget Table 2012-2015 (US$ '000s)

Budget table

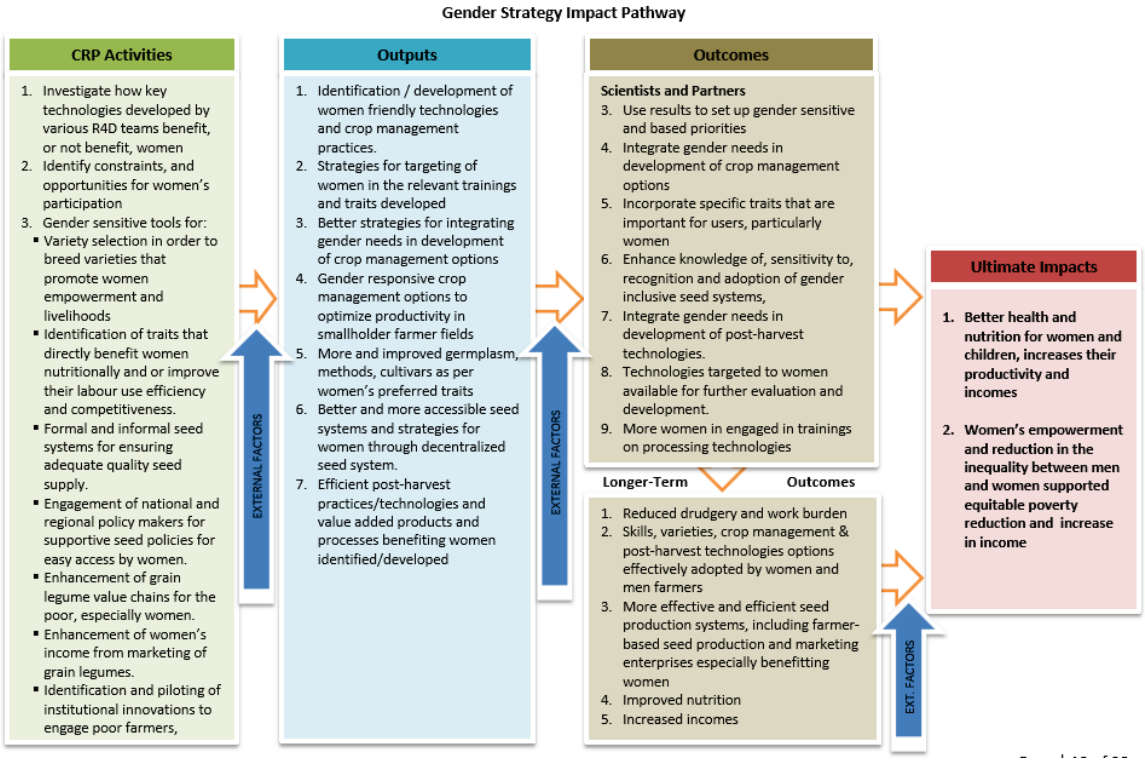
Amount in US$ 000	Windows 1 & 2				Bilateral + W3				Total			
	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
Summary Report - by Theme	Actuals	Budget	Budget	Budget	Actuals	Budget	Budget	Budget	Actuals	Budget	Budget	Budget
PL 1 Drought and low-phosphorus tolerant common bean, cowpea and soybean	1,514	5,031	2,964	3,288	3,650	9,137	9,137	9,137	5,164	14,168	12,101	12,425
PL2 Heat tolerant chickpea, common bean, faba bean and lentil	774	2,130	1,277	1,417	1,314	5,595	5,595	5,595	2,088	7,725	6,872	7,012
PL 3 Short-duration, drought tolerant and aflatoxin-free groundnut	1,049	2,618	1,589	1,763	3,299	7,642	7,642	7,642	4,348	10,260	9,231	9,405
PL 4 High nitrogen-fixing chickpea, common bean, faba bean and soybean	1,194	4,182	2,492	2,764	2,331	7,171	7,171	7,171	3,525	11,353	9,663	9,935
PL 5 Insect-smart chickpea, cowpea and pigeonpea production systems	824	2,588	1,571	1,743	1,628	3,763	3,763	3,763	2,452	6,351	5,334	5,506
PL 6 Extra-early chickpea and lentil varieties	680	1,249	758	841	1,462	3,040	3,040	3,040	2,142	4,289	3,798	3,881
PL 7 Herbicide tolerant, machine-harvestable chickpea, faba bean, lentil varieties	651	2,039	1,237	1,373	1,121	2,363	2,363	2,363	1,772	4,402	3,600	3,736
PL 8 Hybrid pigeonpea	509	1,346	817	906	1,602	3,930	3,930	3,930	2,111	5,276	4,747	4,836
CRP Management/Coordination	10	1,547	1,624	1,705	-	-	-	-	10	1,547	1,624	1,705
Gender Strategies	262	350	350	350	430	-	-	-	692	350	350	350
Total – all Costs	**7,467**	**23,080**	**14,680**	**16,150**	**16,837**	**42,641**	**42,641**	**42,641**	**24,304**	**65,721**	**57,321**	**58,791**

NB the Gender Strategies relates to central expenditure issues and we estimate that ca 10% of the budget within each PL will correspond to gender.

Source: CGIAR Gender Strategy (Grain Legumes), 2013.

The Gender Strategy document for Grain Legumes was agreed in 2013 (Source: Coming Together Annual Report, 2013). Accessible in terms of narrative and language, it is a valuable resource with a broad statement of intent which defines outputs, outcomes and impacts. However, to facilitate gender mainstreaming, whereby gender equality is central to all activities, the goals and objectives and the Gender Strategy Impact Pathway (Figure 9.1.1) within the strategy document should be practically embedded in either the PL impact pathways or strategic components.

Figure 9.1.1. The Gender Strategy Impact Pathway



Source: CGIAR Gender Strategy (Grain Legumes), 2013.

9.1.2. Implementation of the gender strategy

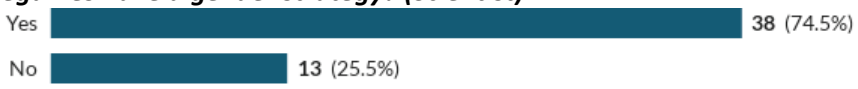
In spite of Grain Legumes' strategic support for gender research, our survey suggests that the most notable motivation to mainstream gender issues was donor requirements. One respondent commented: *"I have not read the strategy but I have always mainstream gender in my research becasue [sic] of donor requirements and awareness created by them*". Moreover, in practice, gender outcomes in Grain Legumes are more often measured in terms of numbers rather than qualitative outcomes and impacts. Currently, clear strategic objectives and baseline gender data by which to measure progress are currently lacking within Grain Legumes. Thus, a focus on gathering such data and setting measurable objectives is essential to facilitate M&E activities.

Integration is the key to driving the Gender agenda forward, and the challenge for Grain Legumes is to achieve a proactive mindset where individuals at all levels are seeking opportunities to increase diversity in all their activities. In 2015, Grain Legumes conducted a gender workshop for PLCs in Ethiopia. Such capacity building workshops are essential to develop a sense of ownership among managers, enabling them to proactively seek opportunities for gender diversity within their work. It is understood, however, that three of the eight PLCs did not attend; the reason for non-attendance is unclear. Despite the budgetary commitment to Gender at a senior level, management must support the Gender Team by labelling such workshops as mandatory without an opt-out option.

According to various Grain Legumes documents (e.g. POWB 2015), gender activities are distributed throughout Grain Legumes. However, the following comment indicates that Scientists require direction to assist with mainstreaming gender in research design: *"well, the gender strategy looks a bit top-down to me. i'm keen to be "gender-sensitive" but i have to admit i have*

not seen anyone telling me what i would need to do in my own research to be so". Moreover, 26% of Scientists are unaware of the Grain Legumes gender strategy (Figure 9.1.2.). Few respondents mentioned the gender specialists within Grain Legumes; although there is some acknowledgement of interactions with PLCs: *"We have gender specialist, who engaged in discussions with the Product Line coordinators to establish 'priority gender research' in the CRP-GL".*

Figure 9.1.2. Does Grain Legumes have a gender strategy? (Scientist)



Source: Grain Legumes Survey

Although 82% of Scientists believed that gender is adequately considered, many responses in the survey lacked substance in terms of proactively seeking opportunities for gender equity. Gender awareness may be high among Scientists, but it appears to be a predominantly passive attribute. It is, however, a sound sensitivity base on which to build.

9.1.3. Outputs and outcomes

Nevertheless, examples of notable gender initiatives were identified during field visits. For example, in Benin, PL5 has enthusiastically integrated diversity within its activities, engaging with women farmers' and youths to develop the most equitable means of gathering, processing and marketing natural insect repellent products while maintaining cultural norms. Women are gathering and processing, youths are taking the product to market. The implication is that several groups benefit, rather than domination by the majority group. In Malawi, in association with partners in East and Southern Africa, CIAT have developed innovative approaches to improving nutrition for children, such as incorporating nutrient enriched bean flour products into snacks. In India, Scientists in PL8 are collaborating with Gender Scientists and Socio-economists to identify the impact of mechanical harvesting on agricultural labour and the potential displacement of female labourers. In Kenya, a novel initiative is improving the accessibility of certified seed for new varieties. Seed suppliers have introduced small packs of grain legume seed at low unit cost, which are being purchased by young people and women. Children are purchasing at agricultural shows and women are buying when visiting suppliers for seed for other crops. Other projects are considering the impact of a shift from cash crops considered to be predominantly female, such as tobacco, to male dominated crops such as maize.

9.1.4. Diversity within Grain Legumes

Among research staff in Grain Legumes, there is male oriented gender imbalance. PL1 has the least imbalance with a ratio of 2:1 (Table 9.1.4); PL5 has the greatest imbalance with a male dominance of 10:1. The situation regarding the student profile is very different. PL3, PL4 and PL8 have marginally more female students than males, and PL2 has gender balance in postgraduate students. Gender balance is not so healthy in PL1 and PL7, with 3.5:1 in PL1 and 7.5:1 for PhDs in PL7. A more equitable gender balance in students is commended, as it is facilitating a gradual balance shift over the longer term. In the short-term, greater attention to the recruitment and retention of women scientists is necessary at every level. In addition, Grain Legumes needs to ensure that working environments are gender sensitive and that recruitment processes within partner centres, including promotion opportunities are equitable. In 2015, the RMC was expanded to include FPCs, in an attempt to reduce the considerable male dominance in the committee structure. According to the Extension Proposal (2014), management of the program will be

restructured to include women in disciplines other than biological sciences. Although female representation is improving, further opportunities for developing female leadership should be explored. The SC and IAC were merged in 2015, with a resulting improvement in the gender balance of the SC but a dilution in that within the IAC.

9.1.5. Conclusions and recommendations

Gender is not mainstreamed, but there is some evidence that this is improving, especially with dedicated gender specialists (but one senior post was vacant during the review period) and capacity building initiatives being delivered across Grain Legumes. Cross Cutting Area 1 (CC1) in the Extension Proposal document (2014) sets out a clear intent to conduct gender analytical research to identify areas where interventions may have the most significant gender disaggregated differential effect to enable prioritisation of work.

Gender must be approached through the vision of agriculture as a social practice, with recognition of what changes will be acceptable culturally and what not, and capitalising upon the perceived and actual features of production and processing that grain legumes are primarily women-based crops. Baseline data, however, are critical to identifying gender gaps and to test common perceptions, as shown by a recent study by the World Bank (Palacios-Lopez, Christiaensen, Kilic, 2015). Women are commonly perceived to contribute a major share to agricultural labour, in particular the cultivation of legumes, weeding and crop harvesting in both Africa and India. In Africa, the contribution is often cited as between 60-80%; yet, using nationally representative household surveys in six Sub Saharan African countries, the average female labour share in crop production is estimated at 40%. Differences existed across countries, with contribution highest in Uganda (56%) and lowest in Niger (24%). The study also examined the perception that women are less involved in cash crop production: true in some countries (Malawi, Uganda) but not in others (Tanzania, southern Nigeria). Although there were few cross-country consistent patterns, female labour shares tended to be higher in households where women own a larger share of the land and when they are more educated. The survey identified no systematic differences across crops and activities, but notes that female labour share decreases as mechanisation increases. Points of particular relevance to policy making and objective setting across all CRPs include the impact of mechanisation on women; higher female involvement in cash crop production and lower female labour share than commonly assumed. As a priority, Grain Legumes must gather baseline data, *inter alia*, to determine the status of female involvement in cash crop production and their share of agricultural labour within the program's target communities. For example, is there higher female involvement in cash crop production than generally perceived and are there systematic differences across crops, activities and countries? Also, is the female labour share in grain legumes production high enough to warrant the focus on women farmers to increase production? Grain Legumes must acknowledge that household surveys are an important tool to provide a solid empirical baseline for policy decision-making.

Recommendation 11: The challenge and goal for Grain Legumes is to achieve pro-active gender mainstreaming, which facilitates opportunities for gender diversity within all activities, from employment processes through research to end users.

- **Strategic measurable gender indicators need to be embedded in research design**, for instance, through specific IDOs for each of the flagships projects. Accurate baseline data are also required to facilitate M&E reviews of progress.
- Implementation of the Gender Strategy is the responsibility of everyone, not solely the Gender Team. Thus, **ownership could be encouraged by setting personal development**

for key personnel objectives with specific outcomes, e.g. employment practices or research outcomes.

- Recognising the positive gender initiatives in progress or planned, feedback must be communicated and integrated into broader research planning to share opportunities, methods and outcomes.
- In addition to promoting gender equity in research, **Grain Legumes** also **needs to ensure that working environments are gender sensitive and that recruitment processes,** including promotion opportunities **are equitable**. Gender imbalance in management should be actively examined to identify further opportunities for developing female leadership.

Table 9.1.4. Scoring of gender balance and sensitivity in each Product Line from PL survey.

PL	Staff ratio (M/F)	Score (25 Max*)	Research student ratio (M/F)	Score (25 Max*)	Comments on narrative Good – 15; Some – 10; Limited – 5; No – 0 + 5 bonus for two or more 'Good' values within the gender assessment	Quality score for narrative (50 Max)	Overall gender balance & sensitivity scaled to a maximum possible of 15%
1	2:1	20	3.4:1	15	Good engagement, good planning, good actions	50	13
2	4.7:1	10	3.5:1	15	No comments	0	4
3	3.2:1	15	0.8:1	25	Some engagement, limited planning, limited actions	20	9
4	4.8:1	10	0.7:1	25	Limited engagement, limited planning, limited actions	15	8
5	11:1	5	2:1	20	Good engagement, limited planning, good actions	40	10
6	4.8:1	10	3.5:1	15	Good engagement, some planning, limited actions	30	8
7	4.6:1	10	3:1	15	Some engagement, some planning, limited actions	25	8
8	2.6:1	15	0.9:1	25	No engagement, limited planning, some actions	15	8

* Scores for staff ratio and research student ratio calculated as follows: ratio ≤1 = score of 25; ratio ≤2.5 = score of 20; ratio ≤4 = score of 15; ratio ≤5.5 = score of 10; ratio >5.5 = score of 5

Source: Evaluation of Product Lines by CCEE Team, 2015.

9.2. Capacity building

9.2.1. External: partners and beneficiaries

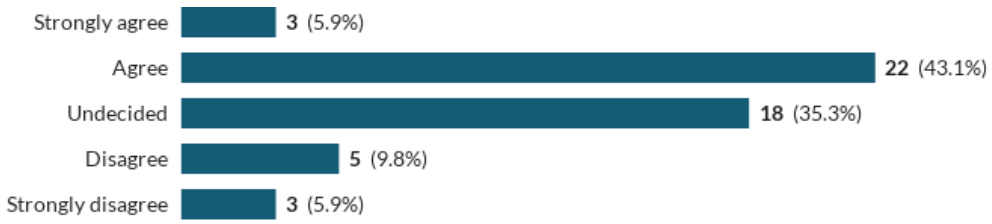
We were not made aware of a master-plan for training activities to be conducted throughout the life of the Grain Legumes. In that sense, the capacity building efforts are not clearly aligned with the research mandate and delivery of Grain Legumes. However, having said that, there are a number of training activities that are being undertaken by Grain Legumes, largely through the W3/bilateral project. For example in PL1 >130,000 persons have been trained since the Grain Legumes began, and likewise in PL6 and PL8, thousands of farmers have been trained and trials installed. But, no mention was made of follow-up to the trainings, as to whether the training materials (written, varieties) have been adopted, what the dissemination to further audiences was; numbers conceal the quality of the training and the likely impacts that such training might have on production, and post-harvest practices. Gender balance never reaches parity, but it appears that efforts are made to include female participants. Within the survey, scientists report capacity building for NARS partners in topics such as gender, genomics, seed systems, data collection and analysis; and several partners acknowledge personal development capacity building such as under- and postgraduate degrees. Within the evaluation timeframe it was not possible to conduct external surveys to further validate or review external capacity building efforts in Grain Legumes.

9.2.2. Internal: Grain Legumes staff

Training of scientists has also taken place, for example with MAS at ICARDA, but in reality the lack of documentation of such training through M&E means that the information is not easily retrievable.

From our survey, 41% of Scientists have personally benefitted from capacity building within the timescale of CRP. Most was supported by CGIAR Centres. Mentoring of the Grain Legumes research community is also considered capacity building, but responses were inconsistent: several Scientists suggested that no mechanism exists for mentoring and little effort is exerted in engaging Scientists in providing mentoring (Figure 9.2.2). One respondent stated that CRP 4 was better, as it *"...has a pool of more experienced Nutritionist[s]"*.

Figure 9.2.2. I am mentored effectively (Scientist)



Source: Grain Legumes Survey

We evaluated the cohort numbers of post-graduate students aligned with each PL (Table 9.2.2) and the output metrics closely mirrored the metrics for the number of MSc and PhD students per FTE, perhaps not surprisingly since the vast majority of research publications are based on the work of early-career researchers.

Table 9.2.2. Summary of PhD and MSc students per Product Line [Raw data from self assessments].

PL	Number of research students	MSc (M/F)	PhD (M/F)	Number of research students per FTE	Number of MSc students per FTE	Number of PhD students per FTE
1	35	19 (14/5)	16 (13/3)	2.1	1.1	1.0
2	9	5 (2/3)	4 (3/1)	0.9	0.5	0.4
3	25	23 (10/13)	2 (1/1)	1.5	1.4	0.1
4	10	7 (3/4)	3 (1/2)	1.1	0.8	0.3
5	36	3 (2/1)	33 (22/11)	7.6	0.6	7.0
6	9	3 (2/1)	6 (5/1)	1.2	0.4	0.8
7	32	15 (9/6)	17 (15/2)	4.8	2.3	2.5
8	27	9 (5/4)	18 (8/10)	4.0	1.3	2.7

Source: Evaluation of Product Lines by CCEE Team, 2015.

In all PLs apart from PL3, the number of PhD students per FTE was approximately the same or in excess of the number of MSc students trained over the same period. This is an efficient use of human resource, since PhD students are considerably more likely to generate work of publishable quality than MSc students. PL1, PL3, PL4 and PL6 all have very low numbers (≤1.0) of PhD students per FTE despite having 16.8, 9.0 and 7.3 FTE respectively. PL6 is actually producing a substantial number of peer-reviewed outputs with an impact factor per FTE (8.5), but it would seem that this has not been generated from many PhD students. This observation could mean that the PL is not able to attract many PhD students to its work or that it has chosen not to engage with this community. Without a vibrant and connected cohort of PhD students the environment of each PL will suffer and the dialogue that is essential for sparking new ideas will be lost.

We were pleased to note that in most PLs there was parity in gender representation amongst students.

We probed a representative section of the student body at ICRISAT to determine the level of institutional support and it is regrettable that this cohort of students did not seem to be organised into, or considered as part of, any coherent research community. There is an apparent overall lack of cohesion about PhD students within a single centre (ICRISAT), possibly due the management style of the Learning Systems Unit. Post-graduate students are the researchers of the future, and we feel that they deserve suitable support, with access to CGIAR emails, with full support in accessing up-to-date journals and articles, providing information of relevance to their studies (e.g. advised of seminars, visitors from outside) centralised statistical support and facilitation of social media peer groups. We do recommend that ICRISAT pay attention to their new cohort of researchers by treating them equitably in the future. Tellingly, our meeting with the students was the first in which many had met together. We noted that there is a tendency for researchers in the Grain Legumes to be in their middle age or older, only a few staff are at entry level, hence the

need to cultivate potential new staff. We strongly believe that cohort building activities should take place within each Product Line and across Grain Legumes. These should include regular seminars, social events and an annual postgraduate conference at which first year students present a 'three minute thesis', second years a poster and final years an oral presentation. It is recommended that small prizes be awarded in recognition of the best quality performance in each category. An external keynote speaker (or more than one if appropriate) should be invited. Supervisors would be expected to attend, and to judge performance, but the students themselves should form a committee to organise the meetings, arrange chairpersons and coordinate local organisation. They will need the existence of, and access to, a central database which curates all postgraduates engaged with Grain Legumes.

9.2.3. Conclusions and recommendations

Training activities appear to be rather centre-specific, not following a coordinated programme managed by the Grain Legumes. Numbers of persons trained and their gender, are important, but more important is a measure of the effectiveness of the training, which is not being monitored. Training of scientists is significant, with >40 benefiting. Postgraduate training is varied across PLs, with some opportunity to increase numbers being supervised. Support for postgraduates at ICRISAT could be better coordinated, satisfying more of the students' needs.

Investments in capacity building must be followed up by measures of effectiveness, career progressions etc. For this to happen there needs to be a database of all postgraduate staff (linked to a database of all staff) which provides contact details, a means of recording career progression of current students and alumni and affiliations and outputs linked to all students.

Recommendation 12: **It is recommended that a training plan be devised** to ensure that capacity building efforts are more clearly aligned with the research mandate, delivery and timeframe of Grain Legumes. Moreover, we recommend that ICRISAT develop a strategy to treat their new cohort of researchers more equitably in the future.

9.3. Partnerships

The review team is aware of how significant and important external partnering with organisations, projects and individuals can be to the success of a research programme. We examined to what extent there is effective involvement of partners in research and activity programming, what the criteria are for developing partnerships, how they are maintained and managed, and tangible outputs of partnerships within Grain Legumes.

9.3.1. The context for effective partnership involvement in research

Central to any policy to achieve optimum use of scarce resources should be the avoidance of overlap with others working in same area. Such avoidance is only possible if effective contact is established with those other parties, in other words the development of partnerships to share learning and to maximise benefit to cost ratios.

This need was clearly recognised in the initial proposal for a Grain Legumes 3.5 programme in February 2012, where the whole of Chapter 6 (10 pages) was devoted to "Partnerships and Networks". It was stated repeatedly that partnerships are critical and "*will generate IPGs (international public goods) that will be customized to meet local needs and conditions by the partners. To connect global intent to local action, CRP 3.5 will harness a few of the well-established regional networks. Regional networks are highly effective for accelerating impact and strengthening capacities. However, the focus of these networks in the past has largely been limited*

to exchange germplasm and technologies. CRP 3.5 GRAIN LEGUMES will work with the regional networks to widen their scope and impact along the legumes value chain."

This view was stressed by the additional intention: "*Strategic objective 5 will work closely with value chain agencies and enablers in the course of mapping and discussing the implications of its R4D findings. They include partners such as government food technology and food policy agencies, legume trader associations, major legume products manufacturers, supermarket chains, health-oriented NGOs, community-based organisations such as women's self-help groups and cooperatives, and others as relevant to the chain under study*."

In the summary, **"***In addition to TL-I and TL-II projects, CRP 3.5 will work closely with other projects such as the Generation Challenge Program (GCP), N2 Africa, SIMLESA, AGRA/Soil Health, and PASS, especially in SSA*."

From the various partners referred to in this list, it is especially important to note the specific comments concerning N2Africa: "*Considering the benefits of N fixation in legumes, the newly bred varieties of chickpea, cowpea, pigeon pea and beans, should have improved BNF using efficient Rhizobium strains. The partnership with N2 Africa will be useful to access information on crop-soil-bacteria interactions under different environments. The two initiatives are working closely through mutual exchange of technologies. Varieties developed under TL-II and other projects are being used by N2 Africa; while the Rhizobium inoculum technologies developed by the latter will be used to the benefit of African farmers in the CRP 3.5 GRAIN LEGUMES*."

Despite the logic and ambition evident in this initial document, six months later the final approved programme (August 2012) had only one page devoted to Partnerships and Networks, and there was no mention of many of the partners proposed in the earlier version.

This omission is surprising, and perhaps it is this significant reduction in the proposed scope and depth of partnerships that affected the psychology of Grain Legumes as eventually constituted. It is certain that we saw very little evidence of any strategic partnerships of the type mentioned in the early draft. Of particular regret is there was in the first phase no effective collaboration with N2Africa. This absence could easily have been remedied with little additional effort from the relevant PL (i.e. PL4). The Extension Phase has more mention of partnerships between PL4 and N2Africa, but we were certainly not made aware of any working relationships effective by the middle of 2015.

9.3.2. Criteria for developing partnerships

It is instructive to assess other perspectives on this matter. The issue of there being an obvious, yet still unmet, need for effective partnerships was recognised by the IAC who recommended in February 2014 "*that the GL CRP diversifies its partnerships to include different interest groups such as the farmer organizations, private sector, NGOs, CBOs, SROs, ROs etc., especially where these can add value to the CRPs mission.*

Diversifying partnerships with NARS and regional programs to include the private sectors, NGOs, CBOs, SROs (who are particularly key for advocacy and lobby for favourable policies required for up scaling) etc.

Emphasis be given for diversifying partnerships with NARS and regional programs to include the farmers, private sectors, NGOs, CBOs, SROs, ROs etc."

The same group (IAC) in November 2014 emphasised the need for "*Stakeholders' involvement in scaling up/out, mainly supported by National Programs and other partners including SROs/ROs*."

and said "*This is intrinsic to the operation of the CRP and will be further enhanced in the development of the second phase proposal."*

Despite this assessment and consequent recommendations there seems to be no obvious response or specific changes in approach, as judged by the absence of any administrative actions taken within Grain Legumes to promote partnerships. Lack of funding to support interactions and visits with potential partners was cited, and a master-plan of suitable potential partners was not evident.

9.3.3. Maintaining and managing relationships with partners

There were some excellent, but isolated, examples of individuals who had established effective working and constructive relationships with partners in NARS, (e.g. development and release of hybrid cultivars of pigeonpea), existing networks (e.g. PABRA and CIAT) and the commercial sector. Amongst these latter examples were the impressive efforts in developing the seed sector value chain in Kenya. This project showed the success of a strategic approach involving all actors from research scientists, through seed producers to commodity brokers (e.g. Smart Logistics Solutions Ltd). It is regrettable that such coherence was not more evident elsewhere.

Data from the on-line survey provides some interesting background attitudes to this subject. For example, analysis of the survey showed division in that out of the 48 scientists who responded 18 (37.6%) agreed (3 strongly) that they were satisfied with the incentives given by Grain Legumes for working with partners, 17 (35.4%) disagreed (6 strongly) and 13 were undecided. However, a different response was given when asked whether partnerships with other organisations are well supported by Grain Legumes; 65% of Scientists agreed. It was stated that the majority of partnerships are with NARS, other CGIAR Centres or Universities. Partnerships with the private sector were uncommon. The benefit in legume researchers formally engaging with one another was unanimously agreed by non-Grain Legumes respondents.

The opinions of Research Managers regarding Partnership were also divided; similar numbers agreed and disagreed that NARS and other partners are sufficiently well represented in the structures of Grain Legumes, although 21% were undecided. There was a broad range of opinion regarding NARS in particular: *"NARS are represented in the RMC, the highest management structure of the CRP; however, its [sic] not possible to have all the NARS from all countries represented in this structure; at the product line level, most implementing teams come from the NARS"*. Conversely, *"[NARS] are poorly represented and engaged, but to be more so they need a greater stake in the activity - that is difficule [sic] with a diminishing W1 budget".* Constructive comments: *"We can expect better and quality engagement of NARS through competitive grants (this is active participation!) rather than involving them in planning and other meetings (this is passive participation)". "While I agree, more could be done to incentivize NARS to contribute and engage more. At ICRISAT we are now working on country strategies that are driven by the needs of farmers and markets that has [sic] been well received by all and fosters stronger NARS engagement."*

9.3.4 Outputs/outcomes demonstrating positive synergy among the various partners

It is instructive to note that two of the major original partners, EMBRAPA-Brazil and GDAR-Turkey, were barely mentioned during our face-to-face discussions and through review of documents. We believe this represents a great loss of potential to the Grain Legumes.

However, ICARDA has signed MOAs with University of California-Davis and University of Saskatoon–Canada for lentil genome sequencing, North Carolina State University-Raleigh for

development of a lentil growth and development model, Washington State University-Pullman for development and validation of EST-SSR markers, and North Dakota State University-Fargo for bio-fortification of short duration varieties of lentil with Fe and Zn. Concrete outcomes from these partnerships were difficult to identify during our review.

The survey provided valuable data to expand interview findings regarding partnerships. A considerable number of survey respondents not associated with Grain Legumes commented on the facilitating role of Grain Legumes and Tropical Legumes (TL) programs in developing synergies. However, they also acknowledged that other mechanisms exist: 63% are members of networks, other than Grain Legumes and TL, which support research synergy. Opinions about networks varied from *"CGIAR-led global programmes have the capacity to be truly global in reach"* to *"...forced synergies often fail, especially from a research perspective"*. The majority of those who commented acknowledged the value of face to face contact, whilst many highlighted the challenge of sustaining a common focus: *"It requires projects for us to work together across institutions, not just nice thoughts"; "...usually there is not time or facilitation to get real synergistic thinking done"*; and *"...research gains in one legume species may have little application to another legume species".* Partnerships are generally valued in terms of developing synergy, when supported by face to face meetings, yet the associated practicalities, logistics and expense are notable drawbacks.

Similarly, a large majority of Research Managers (80%) agreed that CRP partners are effectively leveraging their knowledge and research capacities, enabling them to coordinate strategies with diverse public and private organisations. Some comment that further collaboration is required: *"Yes and No. Partners are leveraging their knowledge but the GL CRP has underperformed in the case of private sector engagement. More can be done with GL processors and promoting legumes as companion crops for seed companies that market maize." "I don't see much evidence of that, but maybe it is still early for the CRP." "Some knowledge is shared and there are some indications that experiences are shared across organizations for mutual benefit. Getting people together for discussions of common problems may be the net benefit of the CRP."* The ever-present theme of funding is also mentioned: *"The CRP Partners are doing their best. However, the uncertain and paltry funding has negatively affected the partnerships with NARS that was built over past 3-4 decades."* Opportunities for private partnerships are similarly valued, but greater effort, collaboration and resources are considered necessary to bring more to fruition. As previously stated, one notable exception is the seed sector value chain developed with a broad range of partners, including the private sector in Kenya.

9.3.5. Conclusions and recommendations

Although optimism is expressed by the great majority of Research Managers that partnerships were working well to leverage knowledge and research capacities, scientists have a less favourable view, particularly in terms of their incentives to participate. It seems likely that the activities taking place within Grain Legumes were, in the most part, continuations of previous collaborations. This is not surprising in light of the reduction in the strategic emphasis on partnerships noted above, and the consequent lack of opportunity and ambition for establishing novel partnerships.

Recommendation 13: **To develop a more coherent strategic programme designed to eliminate overlap and promote synergy between programmes with common aims, Grain Legumes should hold a meeting or series of meetings with a range of partners.**

10. Broad overview of governance and management

10.1. Introduction

In answer to whether the Grain Legumes institutional arrangements and management and governance mechanisms are efficient and effective, nominally the organisational structure as indicated in the Inception Report (2015), and the adoption of the governance structures that resource the management structure appear to be well thought through. The format is standard across the CRPs, according to the principles outlined in the CGIAR Strategy and Results Framework, with a Steering Committee tasked to ensure that the overall strategic and programmatic direction of Grain Legumes is in line with the proposal, an Independent Advisory Committee (IAC) to provide impartial advice as to the research and development directions and links to allocation of resources, and a Research Management Committee (RMC) to manage the implementation of the research and development activities and the research progress and outputs. By the time this evaluation had begun, the Steering Committee had met five times (once virtual, three as the SC alone and once in May 2015 with the IAC), the IAC three times (once only face to face, one virtually and once together with the SC in May 2015), and the RMC five times (four face to face).

The SC did not make any major decisions during the term of Grain Legumes. However, we do believe that there is a conflict of interest in having the DG of the Lead Centre as the Chair of the SC (and continuing beyond the two year designated term). The IAC has not suggested change of any research focus; this is mostly sensible, but some minor re-focusing would be expected if outputs are not up to the expectations. We did not see any evidence for such re-focusing taking place. The IAC has suggested many useful activities, such as increased focus on partnerships, on regular updating of the www site, improve communication between members of Grain Legumes, and serious strengthening of the M&E aspect of Grain Legumes. The RMC has contributed to much discussion of the day to day management but, other than though Annual and biannual reports, the quality of which has been routinely questioned by the RMC, there is little crucial evaluation of the research progress and outputs. In the original proposal it is stated that "*All partners will conduct their own internal M&E of agreed research activities with the results presented to the RMC*." It is not apparent that this took place. The RMC has also not commissioned any focused external research, other than the one year of competitive funds, largely due to lack of financial resources.

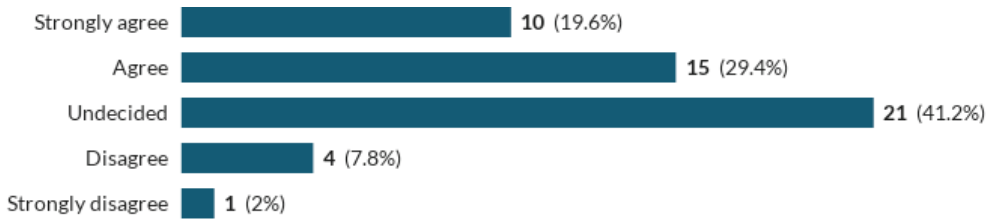
From the survey of Research Managers, three quarters agreed that Grain Legumes has an integrated approach to governance and management (18% strongly agree, 58% agree); yet, respondents' comments offered notable qualifications. These include: implementation is fragmented; governance is bureaucratic and cumbersome; multilayers creates confusion; originally dominated by ICRISAT; poorly designed at the beginning; need more diversity of stakeholders; and poor representation of partners, particularly NARS. Our own review of documentation indicated that sources of a number of documents are not identified, no date nor origin provided, and we recommend that an implementation of an effective M&E address this.

The following sections report on the effectiveness of governance and management as reviewed by the CCEE Team through document analysis and personal interviews, and through survey responses.

10.2. The cost of Grain Legumes

With the imposition of a CRP structure on top of existing centre structures the increase in costs (transaction and management) to the overall system must not come as a surprise to funding agencies, nor to the CO. In addition to a common theme during field visits and interviews, such burdens were reported by scientists in responses to a survey question on transaction costs (Figure 10.2.1). What must have been a surprise is the constant affirmation we observed and report in terms of the minimal added value that Grain Legumes provides when compared to the pre-CRP state. One half of Scientists agreed that transaction costs are too high; only 10% disagreed and the remainder were undecided. Costs which may have increased are cited as relating to governance, meetings, travel, overheads and increased numbers of staff due to the structural hierarchy. For example: *"I think the PL and Flagship coordinators might be adding extra cost, besides integration of CRP management and the Center's management".* In addition, *"Scientists and managers spent too much energy into governance and management of the CRP".* The cost of research methods may also be increasing, such as modern breeding methods. Other costs may have decreased, however, such as those associated with access to infrastructure and equipment. But the costs associated with reporting have increased. This is, in fact, a major concern by staff, the need to double (or even triple) report and in very different formats to suit different purposes. It should be possible at the CGIAR level to have one and only one format for reporting, including publications, students, funding, and staffing which can be uploaded centrally and open to extraction in whatever format is required.

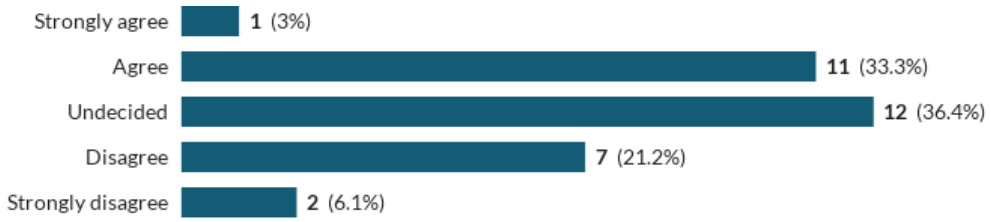
Figure 10.2.1. Within Grain Legumes, I perceive transaction costs to be high (Scientist)



Source: Grain Legumes Survey

As a response to the reported increase in transaction costs from the commencement of the Grain Legumes, Research Managers' opinions are split regarding whether structures are in place to minimise CRP transaction costs: 33% agree that they exist; 36% are undecided and 27% disagree or strongly disagree (Question 14; Figure 10.2.2). The following comments summarise the consensus of those in disagreement: *"The formation of the CRPs for the various activities of the CGIAR Centers effectively imposed an additional management structure within existing management. It is not entirely clear how this helps overall research progress. Clear supervisory controls are difficult to ascertain"* and *"Centre and CRP management are in opposition".*

Figure 10.2.2. Structures are in place to minimise general management costs/processes (Research Manager)



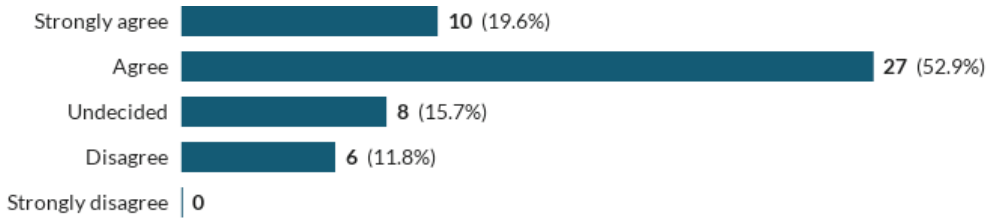
Source: Grain Legumes Survey

Given the strong belief that transaction costs are high, emphasised throughout our visits to the field with Grain Legume staff, the real question in our minds, therefore, is whether the benefits outweigh the costs. Not whether Grain Legumes institutional arrangements and management and governance mechanisms are efficient and effective, but rather whether there is a real justification for bringing the centres together, whether there is a desire amongst the centres to work together and even if the governance and management were effective and efficient if there would be any added value in having a CRP rather than simply each centre focusing on their own species and domains. Perceived value added by Grain Legumes at the CGIAR centre level is one of maintaining global leadership in grain legumes, but at regional and local levels this is not of importance; what matters is the impact achieved on the ground.

10.3. In support of continuing Grain Legumes

As support for continuing the Grain Legumes CRP, 88% of Research Managers believe that Grain Legumes activities have enhanced the synergy in research and development (Figure 10.3.1). Comments, however, showed a more balanced split of opinion. Supporting comments cited the collaboration between centres, and NARS; and some specific outcomes, such as seed systems. *"The CRP has brought together institutions that were not used to work together. This is noticeable at the country level." "There have been some good outcomes (e.g. physiology across legumes, seed systems, applications of genomics)."* Conversely, a similar number indicated limited and strained collaboration or the high financial implications within Grain Legumes: *"CRP activities have fostered greater collaboration and synergies. However, these have come at large transaction costs that need to be addressed in the design of a second phase of CRPs."* In addition, *"It seems that on-going work of the Centers has been forced into a so-called "collaborative" research structure. Maybe some synergies that have developed but they are not readily apparent."* Similarly, *"Very little true interaction within the Product lines".* Balancing the synergies achieved is the time spent by scientists in meetings for planning, integration, evaluation and reporting in order to achieve synergies.

Figure 10.3.1. CRP activities have enhanced synergy in research and development (Research Manager)



Source: Grain Legumes Survey

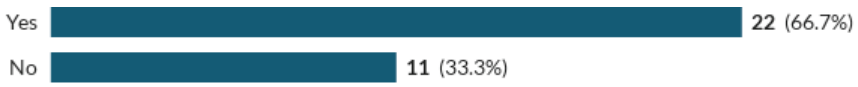
As the IAC notes, the theoretical basis of added value of Grain Legumes as distinct from its component activities acting separately is clear in terms of comparative biology across the species, shared aspects of the value chain, nutritional outcomes, environmental services and seed systems. However, the actual shared or coordinated work is still lacking, and requires further documentation and planning within any extension phase, for this is central to the justification of the existence of Grain Legumes. We saw no evidence of cross-centre movement of staff to capitalise upon use of resources, expertise or germplasm.

10.4. CGIAR reforms

In 2014, Grain Legumes was asked to bring in change in line with the reformed CGIAR organisational structures and processes. In particular, there was an attempt to improve the gender balance in the committee structures (originally they were: Steering committee 9 males and 0 females, IAC 5 males and 3 females, and the RMC 15 males and 0 females). In line with the introduction of Flagship Projects (FP), and their representation through FP coordinators (FPCs) on the RMC the number of females increased (to 3), but so too did the overall size of the RMC, a size (17 persons) that we believe is too unwieldy to make effective decisions and manage the activities of Grain Legumes. Likewise, we have concerns over the integration of the IAC with the Steering Committee. This essentially removes any independence from the governance of Grain Legumes, since the Independent Steering Committee will still include the DGs of the member centres. This is particularly important as independence is needed to ensure that research agendas and directions do not simply continue the status quo; there must be continual questioning of the relevance of research agendas of the centres, and for the continual assessment of crop and region priorities, identification of potential partners, and so on. Integration of what was essentially an independent committee into an Independent Advice Sub-Committee, while improving gender representation, does not augur well for independence *per se*.

Discussions during field visits offered different views of the value of the CRP design, and opinions regarding the efficiency and complexity of the overall structure. This was mirrored in survey results, although two thirds of Research Managers agreed that value has been added by the programme's design and implementation, management and commissioning. Moreover, it is not clear whether the reformed CGIAR organisational structure has increased efficiency and successful program implementation (Figure 10.4.1). Some commented on increased efficiencies; for example *"...in utilising the shared facilities; individuals covering more than just one centres [sic] work and having common agendas. However, this may not be uniform across all CRPs projects and activities".* In addition, [Grain Legumes is] *"...more transparent than in the past. Resource allocation to NARs has improved".* Nevertheless, the current structure is widely considered to have too many layers, resulting in complex, difficult and time-consuming management processes. For example: *"...reform has NOT increased efficiency. Lessons? There are too many. Build on your strengths, don't alienate strong actors as if they are competitors. Be humble, leadership is not the same as bullying. Consult honestly with integrity. More structure does not equal better".* Similarly, the overlap between Grain Legumes management responsibilities and those of Centre/Research management (see section 10.5) is acknowledged: *"The roles of center management and CRP management need clarification."*

Figure 10.4.1. Has value been added by the programme's design and implementation, management and commissioning processes? (Research Manager)



Source: Grain Legumes Survey

10.5. The Director's compromised role

Although the structures put in place appear to be well thought through, one potential, and since the appointment of the Grain Legumes Director an actual, issue had been overlooked in the management structure: the parallel responsibility for outcomes of Grain Legumes by (a) the Grain Legumes Director and by (b) the Institute Directors of their Respective Legume programmes. The Grain Legumes Director has responsibility to coordinate the implementation of Grain Legumes, and to ensure that Grain Legumes delivers its programmatic and financial targets, but that person has neither financial nor HR responsibility within the CGIAR centres that are party to Grain Legumes. This was raised by various CRP staff on a number of occasions, and is believed to have seriously influenced the efficient management of Grain Legumes. Minutes of the 13th May SC meeting state: 'More generally, the Grain Legumes Director can ask for engagement but cannot tell anyone what to do'. This anomaly affected the authority of the Director of Grain Legumes, the Director essentially having no 'teeth' or power to impose on partners within Grain Legumes to follow his directions and therefore being a director in name but not in practice. He/she also has no input into staff appraisal and performance management. This lack of authority has extended through to the PL coordinator level. Various PLCs indicated that it is a major challenge to get timely responses from scientists working in four different centres, who are not administratively linked to Grain Legumes but rather to their Centres. This sentiment was not reflected for a single centre or two centre PLs. One PLC noted that it is equally difficult to answer some of the complex questions that are not understood properly or in the same context by the concerned scientists. Another was fearful of potentially overlapping responsibilities with the FPCs in the extension phase.

The anomaly with the Director's position was then promulgated through the actions, or lack of them, as requested by the Director through the RMC. Minutes of RMC meetings refer to the lack of response from some of the partners and individuals in Grain Legumes in terms of timely reporting, of timely provision of publications, and of responses to requests for clarification/rejoinders to queries about the actual science and development activities within Grain Legumes. With the exception of minutes from RMC meetings indicating such requests, minutes from Steering Committee meetings do not reflect the compromised weak position of the Director and the difficulties in the management of Grain Legumes.

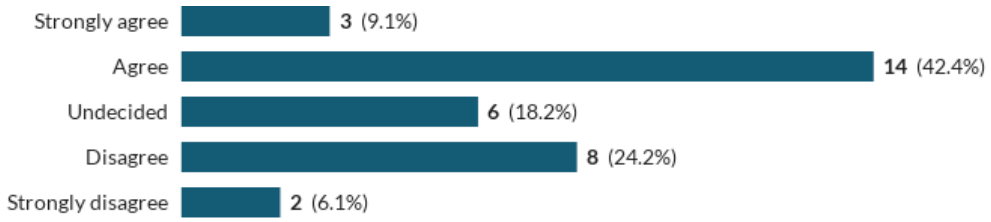
This is clearly illustrated by the absence of an effective M&E facility. With the absence of formal progress monitoring very little arises in terms of providing feedback to all stakeholders. The Director has repeatedly raised the issue at RMC but to no avail.

The Director has no oversight of the training of CRP staff, and all training activities are confined to within the policy of the respective centres.

The survey sought to investigate opinions regarding change emanating from M&E activities. Approximately half of Research Managers agreed that opportunity exists for radical modification of research direction followings findings from M&E (Figure 10.5.1); yet, comments qualify that

agreement. Notably, with the absence of routine M&E activities, many comments referred to the CCEE review: *"The current research direction is good and needs to be continued. What will a bunch of people with limited exposure to Grain Legumes be able to suggest compared to scientists who have 10 to 30 years of experience in legumes?"* Others are more accepting of change: *"Both research management and direction can be modified following the review." "More integration is expected in the GL CRP across all commodities after the findings of M&E."* Others commented on the function*: "M&E can not [sic] modify research direction. It helps in how improving the way work is conducted"* and *"If we need to reduce trasaction [sic] costs and need to be effective, it is imperative to improve the structure."*

Figure 10.5.1. Opportunity exists for radical modification of research direction following findings from M&E (Research Manager)



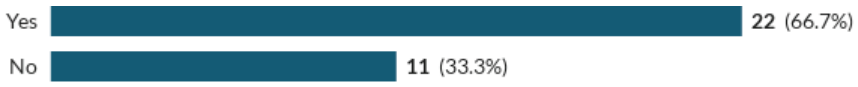
Source: Grain Legumes Survey

A further anomaly linked to the lack of authority embodied in the Director was reported: annual allocations to centres of W1/W2 funds to support designated CRP activities could be used by centres essentially to fill gaps in their budgets; indeed, the W1/W2 funds were reputedly used to cover salary costs leaving little over for operations. We believe this represents an important, but perhaps unintended and maybe unrecognised, subsidy to many of the W3/Bilaterally funded projects.

Moreover, the Director's responsibility to undertake a better monitoring of publications appears not to have taken place. Our team's effort to track down CRP-related publication has been fraught with difficulty, as exemplified by the absence of any content in the "Publications for 2014" section of the Grain Legumes website.

The survey findings compound the complex and sometimes conflicting views regarding the authority of the CRP Director. Two thirds of Research Managers (67%) agreed that the Grain Legumes Director should have control over the budget to assist with strategic, prioritised and transparent budget setting, within clear boundaries of control (Figure 10.5.2). The following comments highlight the broader issue of conflict surrounding accountability and management control within Grain Legumes: *"Assigning budgetary control over W1 and W2 effectively neutralizes the management of the CG Centers, making them secondary to the managers of the CRPs. It needs to be one way or the other."* Conversely, *"CRP GL director should have control over management of budget at centre level and not at scientists level. CRP director should provide oversight and guidance and not execution and (micro)management".* Moreover, *"This [budget control] should be the prerogative of the Centers who have to deliver. Both CRP Director and Center Program Managers need to agree". "Actually, if research program directors are CRP directors, we wouldn't have been discussion [sic] this issue."*

Figure 10.5.2. Should the Grain Legumes Director have budgetary control over all W1/W2 expenditure? (Research Manager)



Source: Grain Legumes Survey

During discussions with ICRISAT staff not located at the headquarters in Patancheru, suggestions were voiced that the physical location of the Grain Legumes Director be in a neutral, many thought ideally African, location rather than at ICRISAT headquarters. This, it was stated, would have allowed for greater efficiency in terms of linkages with all centres and in terms of transparency in the management of Grain Legumes, although this suggestion did not consider the logistic support afforded by ICRISAT HQ to the Director and his staff.

10.6. The budget

As outlined in the Proposal, the initial budgets set amounts for each of the Product lines with respect to outputs and outcomes. In the main, these were allocated in response to secured bilateral funding to each centre, with additional funding allocated based on priorities and projected expenses. A budget shortfall of 24% was indicated ($33.5 million) in the August 2012 Proposal, W1/W2 was projected to fund 44% of the required budget, later figures addressed in another document (SC Meeting 1ST November, 2013) (Minutes of 2nd November 2013 SC meeting) indicate that W1/W2 will take up the slack although the Minutes from that meeting indicate that this is unlikely. As indicated earlier, W1/W2 funding has dropped to c. 25%, creating great pressure on individual scientists to search for funding to keep their proposed research buoyant. Due to mistakes made at the CO, W1/W2 was higher than planned in 2013, but lower than planned in the succeeding years, and it is this year to year budget variability and uncertainty until the end of the financial years that made management difficult and scientists' confidence in management wane.

Major modifications of the budget allocation undermines research investment and confidence of centres and partners in the system. For example, vocal concern over the exclusion of some countries and crop species in TL III crops and countries raises issues over the continuity of breeding programmes and prior investments in research efforts (such as the regional pigeon pea breeding programme in Kenya). Likewise, the cessation of ongoing competitively-funded projects, such as those funded in Indian partner institutes, jeopardises earlier co-investments by partner institution s as voiced by a number of scientists during our visits in India. Jointly the RMC, the IAC and the SC must take action to prevent the negative effects brought on by budget fluctuations. The CO is also reminded of its responsibility in ensuring sustained financial support for CRPs, based upon value for money. As one recent CGIAR Fund document http://library.cgiar.org/bitstream/handle/10947/3901/CGIAR%20Fund%20-%20More%20Value%20for%20Money%20May%202015.pdf?sequence=1) espouses:- "Its objectives are to provide stable and reliable multi-year funding to enable long-term delivery of research, based on agreed priorities, and to ensure disbursement of funds in a timely and predictable fashion." It is also, perhaps surprisingly, claimed by the CGIAR that they have moved from a period of "Declining financial support" to "Secure and growing funding". Is this really a true reflection of reality rather than an exaggerated ambition?

Regarding budgets and finance allocations within Grain Legumes, a small majority of survey respondents (58%) agreed that they are clear; 27% are undecided and 15% disagreed (Question 13). Comments variously acknowledged themes of transparency and inclusivity; lack of clarity in allocation or prioritisation; and outright confusion. Transparency: *"The CRP budget proposals and allocations are open information from the CRP Director and all the product line leaders are involved in the process".* Lack of clarity: *"The allocations are pretty clear, even an attempt to break it down at the FP level, etc. Less clear how the decisions were made re priorities/needs/opportunities"* and *"The BUDGETS are clear, how they are spent at centres is less so".* Confusion: *"There is utter confusion created mostly by the Consortium Office who do not seem to know what they are doing"*. One constructive comment suggests that *"This is a complex and somewhat political process. It could be made more transparent based on area cultivated, the number of poor the crop serves, performance based on standard KPIs."*

Further vehicles for improved efficiency include bilateral projects which are seen as more cost effective than W1/W2 (the latter covered a higher proportion of salary costs) where transaction costs are disproportionately higher. One of advantages of the W3/bilateral is that the funding is known for what it is in advance, whereas for W1/W2 this is not so until the end of the year, and then it may be significantly less than what was promised. It is unreasonable then to demand for accountability if the game changes during the year. Change management is also cited as inefficient in the survey; it *"should be introduced systematically and rolled out in phases to enable the program/project staff to smoothly transition into the new structures".* One comment suggests that States should plan for radical change in funding patterns: *"Not only for this CRP, but for the whole CGIAR system, countries must take much more responsibility and contribute financially for the strengthening of infrastructure and staff. The model of depending on a few charity donors and international agencies will not last long. Many countries that were miserable in the recent past now would be able to contribute with funds and qualified people, and consequently, in the governance of the whole system"*. It is quite clear that when basic financial planning takes place, integration of W1/W2 and W3/bilateral sources must occur, and be linked to anticipated outcomes and impacts.

Budget planning, monitoring and review demand different amounts of time from the RMC. Planning is through the POWB for each year, and is presented to the RMC where some discussion takes place around the document. This is then passed to the SC via the DG of ICRISAT and then on to ICRISAT Board as that of the lead centre. Monitoring of budget spending is one aspect that we did not consider, given that a parallel review is underway (Reference Tom Hum). In times of budget cuts, the RMC adopted a mitigation approach to cuts in the W1/W2 allocations in 2014 and 2015, and the cuts were made pro rata to each of the centres, i.e. there were no difficult decisions made about the importance of maintaining one activity at full funding vs. cutting another. This implies that priority setting by the RMC is not strong. The theme of sustainable funding runs throughout the survey, e.g. *"Level of funding and control of budgets/research agendas made it difficult to make radical changes. Control still mostly by Centers, and donors who support specific agendas."*

However, the RMC is vigorously engaged in the development of Phase 2 plans (and one assumes of the re-configuring of CRPs), and a different focus was proposed for Phase 2, that nutrition underpin R&D (to suit the buzz that this brings) but ability to convince funding agencies of direct impact tended to cool discussion on this theme.

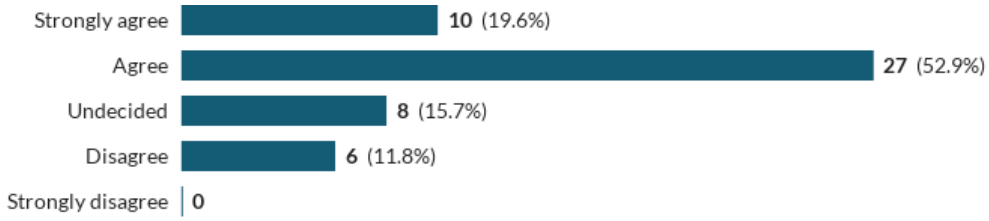
10.7. Sense of belonging to Grain Legumes among staff

A large majority of Scientists surveyed (82%) agreed that they feel an integral part of Grain Legumes, although 18% disagreed (Question 37; Figure 10.7.1). Moreover, 12% do not understand the organisational structure in which they work and 16% are undecided (Question 38; Figure 6.7.2). Understanding, however, does not necessarily mean acceptance: *"I understand it but that doees [sic] not mean this is the structure I prefer".* Clarity may be better where collaboration is highly valued, *"it provides the forum for me to work closely with international instituite [sic] like ICRISAT".* Others are unsure of key personnel and relationships: *"Not sure of the collaboration between centres due to differences in standards of operation in seed systems"* and *"I don't know some key people in the CRP line".*

Figure 10.7.1. Do you feel an integral part of the CRP? (Scientist)

Source: Grain Legumes Survey

Figure 10.7.2. I fully understand the CRP organisational structure in which I work (Scientist)



Source: Grain Legumes Survey

10.8. Conclusions and recommendations

The standard format of committee structure and responsibilities is common to other CRPs, as are the attendant problems. One of the major problems is that the Grain Legumes Director has responsibility but no authority; hence, even with the support of the RMC, he/she is unable to 'direct', in the literal sense of the word, the activities of Grain Legumes. Minutes from governance and management meetings do not reflect the compromised weak position of the Director and the difficulties in the management of Grain Legumes. Nor do the minutes reflect concerns about the amount of time spent by scientists in meetings for planning, integration, evaluation and reporting.

The changes brought in by the CO have not helped promote any greater authority and capacity of the Grain Legumes Director to direct. Likewise, they do not address any of the issues with the conflict of interest in having the Lead Centre chair the Steering Committee. Indeed, we believe that the combining of the Steering Committee with the Independent Advisory Committee, besides becoming unwieldy in number, annuls any sense of independence in advice offered to the Grain Legumes management.

We also see the same sense of helplessness with the role of the PLCs. They have responsibility but no authority in managing the affairs of their PL, and they have no access to funds with which to promote intellectual collaboration and cooperation.

We have concerns with the declining proportion of W1/W2 funds (as expressed in the section on Sustainability), and believe that when basic financial planning takes place, integration of W1/W2 and W3/bilateral sources must occur, and be linked to anticipated outcomes and impacts. This will ensure a close alignment of collaborators' and partners' objective and contributions to that of the Grain Legumes. We also queried the formality, or lack of, surrounding the approval of annual budgets, and the level of priority setting when budgets are cut.

Recommendation 14: Governance processes should be re-assessed and the structure altered to ensure that the Grain Legumes Director has the authority and budget control to drive the execution of strategy.

- **The ISC should be truly independent and given the power to influence strategic decisions before they become final.** We also recommend that PLCs are provided with the authority to manage the direction and finances of their PL; and that **ring-fenced funds are provided for the promotion of collaboration, coordination and staff training**[12].

11. Conclusions and the future outlook for Grain Legumes

11.1. Conclusions

Grain legumes are a desirable commodity as a cost-effective option for improving the diets of low-income consumers who cannot easily afford meat, dairy products and fish; by those who choose not to eat meat for ethical or religious reasons, and as a source of dietary protein with a low environmental impact. Grain legumes generate substantial benefits to the well-being of smallholder farm families. Often a crop cultivated by women, harvests may be consumed at home or sold to generate family income. Grain legumes also provide on-farm agronomic benefits. Complementing cereals, roots and tubers in farming systems of smallholder farmers, legumes can help intensify *and* diversify systems. The Grain Legumes program focuses on the poorest sectors of society in order to generate a range of economic, social and environmental benefits. The program has delivered according to its logframe, but this is in spite of, rather than because of, its management structure. Whether the outcomes and impacts would have been greater without the Grain Legumes is a moot point.

The Executive Summary presents, in abbreviated form, the main conclusions and recommendations and these are not repeated here.

11.2. The way forward

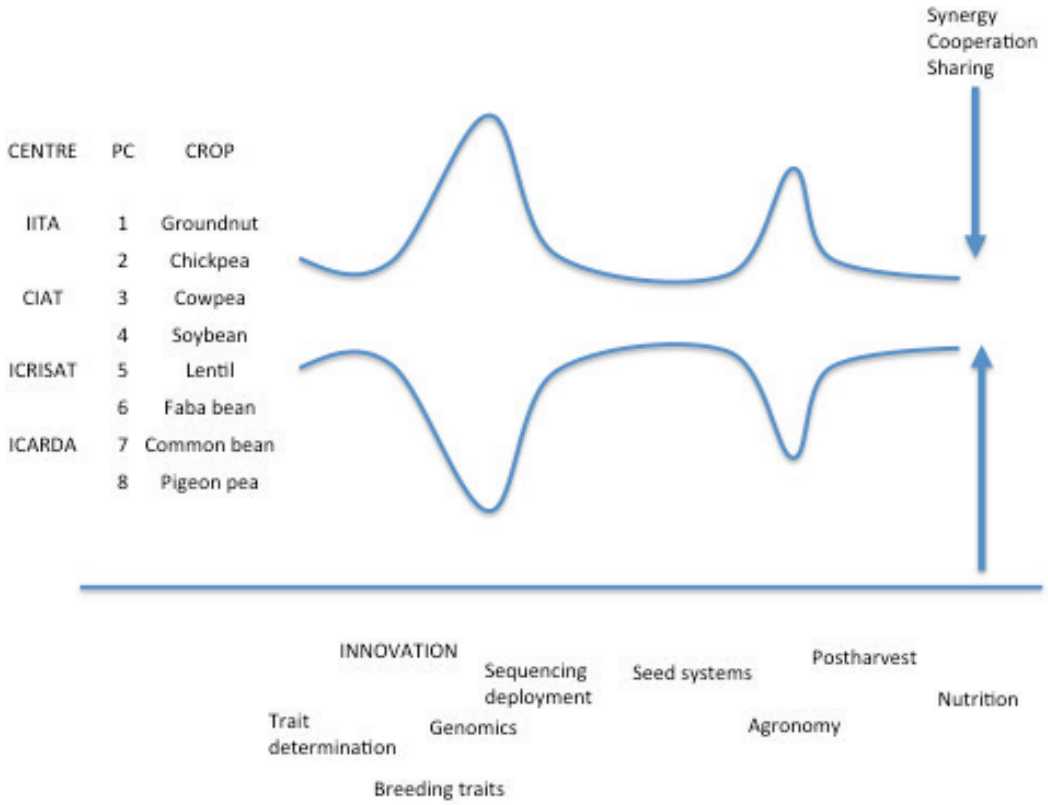
In our view, having seen the strength in fewer or sole centre partnerships, and the ineffectiveness of many of the attempts (or lack of attempts) to harness synergies between multiple centres, we believe that there is little to justify a full retention of the eight legume species and four CGIAR centres in a CRP. TL I and II and PABRA have shown to be reasonably good cross-centre and single centre integrated programmes, but even they suffer from incomplete value chain approaches to increasing rural incomes while increasing food and nutritional security; they both need multi-faceted solutions which are not immediately forthcoming from Grain Legumes.

Figure 11.2.1 broadly shows the perceived current and potential degrees of synergy between centres, PLs and species, and is discussed more in the text. It is clear that the value chains for

[12] This requires action by the lead center and the agreement of the lead and participating centers: ultimately this is the responsibility of the lead center Governing Board.

individual species from trait determination to nutritional impact have more cohesion than do the individual activities (e.g. trait deployment) across species. For this reason we believe that the future for research in Grain Legumes is best addressed by focusing on each of the species separately, and within an ecosystem framework; any synergy for research across species can be effected through communication and not necessarily through obligatory cooperative research. The ecosystem framework will allow for strengthening of agronomy type systems research, the arguments for benefits of inclusion of grain legumes in cropping systems, which is notable by its absence in much of what the Grain Legumes currently undertakes.

Figure 11.2.1. Stylised viewpoint for synergy, or lack of it, between CGIAR centres in the R&D supply chain.



We therefore agree with the innovation in agri-food systems approach of the CG, and believe that Grain Legumes rightly belongs in the Dryland Cereals and Legumes Agri-food Systems.

Thus, we believe that the Option (Figure 11.2.2) as discussed and agreed by the members of the CRPs, Dryland Cereals, Grain Legumes and Dryland Systems (Peter Carberry, Pers. Comm.) is closest to the best way forward, provided that funding is assured and secured, and a consistency and unity of purpose exists across the programme. Indeed the inclusion of grain legumes may not warrant even a CRP alone, rather the legume components should fit in with the major crops that determine the production systems. Legumes will always be subservient to the major cereals, as necessary adjuncts to the whole production system, providing both nutritional diversity and environmental services, neither achievable from cereals alone.

Figure 11.2.2. Most suitable option for integration of Grain Legumes and Dryland Cereals into an Agri-Food Systems CRP, [Peter Carberry, pers.comm.]

Agri-Food Systems	Priority Setting & Impact (Enabling Environments?)	Crop Improvement & seed production	Seed Systems & Input Services	Integrated & Water Productivity	Livestock & Livelihoods	Postharvest Value & Output Markets
Grain Legumes and Dryland Cereals	Sorghum, Millet, Barley, Pigeonpea, Groundnut, Chickpea (90%), Cowpea (50%), Soybean (20%)					
Maize						
Rice						
Wheat						
RTB						
FTA						
Livestock						
Fish						

- Incorporates ex-Dryland Systems, Dryland Cereals, , Grain Legumes, some HumidTropics, some ex-Livestock &Fisheries into a new CRP
- Will cover full agri-food system VC for all 8 legumes in all ecologies, but must interact (dock) with the relevant AFS-CRPs for the dominant cereal in the relevant ecology
- Hence, will need to negotiate with other Agrifood Systems-CRPs on who does what for legumes
- In addition, responsible for sorghum and millet in the mixed dryland crop-livestock agro-ecologies

For major game changers to be effected, we believe that the game has to change, and there is little evidence of this. The direction of CRPs is the correct route, but the journey has not yet come to its destination. A major change of game [such as the adoption of a Flagship Project approach as exemplified by the Australian CSIRO – where flagships contract services from centres of research excellence] would be painful to implant.

The CGIAR system is going down the right pathway but it has not gone far enough.

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Appendices

A.1. Evaluation of Product Lines

A.1.1. Product Line 1: Drought and low P tolerant beans, cowpeas and soybeans

A.1.1.1 Relevance

This PL comprises part of the efforts to ensure climate reliance amongst the grain legumes. As such, besides developing practices (varieties and agronomy) that impart resilience, it has activities that model the biophysical (but not the bio-economic) extent of adoption domains, but these do not add to any understanding of the trade-offs among economic, environmental and sustainability.

As with all the PLs, the narrow focus within the title tends to nominally exclude some, or indeed much, of the ongoing research, especially that underpinned by breeding, that cannot be stopped and started willy-nilly, on the whim of funding opportunities. The relevance therefore extends beyond the issues of drought and low P tolerance, into issues with the general development of improved germplasm of these species, by CIAT and IITA respectively. It also encumbers analysis of production and marketing corridors and consumptions patterns, especially of beans, the development of locally nutritious meals from legumes, and the evolution of efficient seed systems that are effective in reaching the intended beneficiaries, with new improved varieties. However, with the inception of Grain Legumes, the focus of this PL is genetic improvement, dissemination of varieties in drought prone and/or low fertility areas, and the adoption of improved varieties of the three legume species, beans, cowpeas and soybean. The approach assumes that germplasm will face multiple stresses, singly or in combination, and screening for tolerances takes place accordingly.

The separate inclusion of breeding for drought tolerance (in addition to tolerance to heat) in chickpea, faba bean, lentil and common bean in PL2 implies that parallel efforts are underway in different groups of species (and different CGIAR centres), undermining the opportunity to cooperate and make efficient use of facilities and other resources. Likewise, in the proposal PL3 for groundnut there is explicit reference to research and development efforts on drought. The proposal speaks of identification of genomic regions governing drought tolerance serving to improve cross species tolerance. Stated research on effects of low P on nitrogen fixation does not link to PL4 with its focus on N2 fixation.

A.1.1.2. Efficiency

These comments are in the main common to all PLs. Research managers, and indeed even the individual researchers from centres have been expected to contribute substantial amounts of time in addressing the constant changes brought about by the CO for iterations towards a markedly refined Results Framework template. This causes serious interruptions to the smooth conduct of research, diverting attention away from creative endeavours and often causing worry about securing funding for the very research they are conducting.

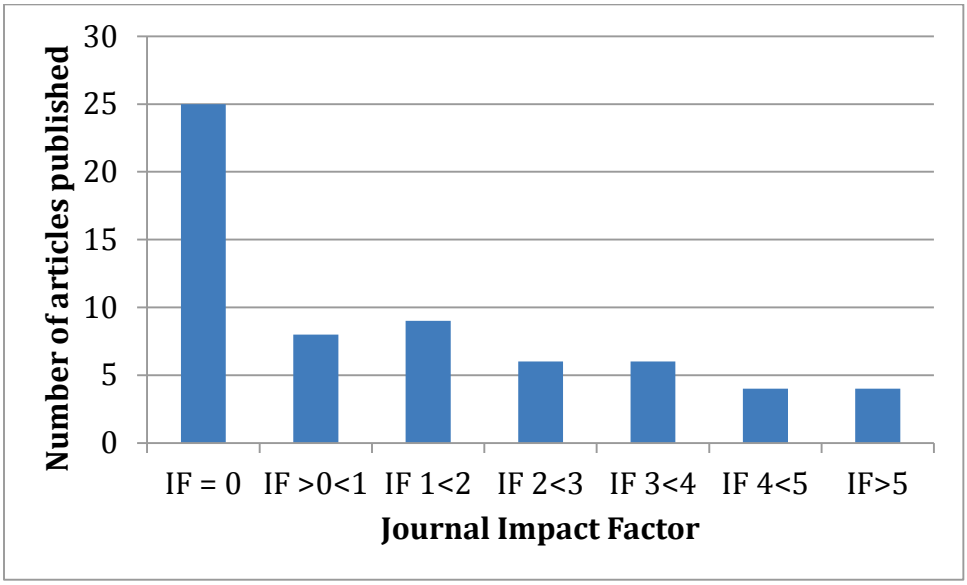
For maximum efficiency, scientists' time should be spent constructively with their research, not worrying about funding, and managers' time should be directed towards sourcing sufficient funds for their teams to function well.

A.1.1.3. Quality of science

A total of 62 outputs were published in this PL. The vast majority were without an Impact Factor, but several high impact papers were published and many of the lower impact papers were still in

journals that would attract an appropriate readership and therefore provided an effective route for dissemination of results (Fig A1.1).

Figure A1.1. Publications from PL1 ranked by impact factor of the journals they were published in.



Most publications are from a single centre, with or without non-CGIAR partners, and most of the CIAT publications are single centre single PL whereas IITA included co-operators working in PL5. Links with PL4 were also evident in several publications (Appendix Table A1.1). Authors were affiliated with up to six different CRPs in a single publication, and most linkages were with researchers in CCAFS (11) and A4NH (10) CRPs. Interestingly, 56/84 outputs (67%) had at least one non-CGIAR institution present on the author list. This indicates that there is reasonable collaboration with other global and national research programs but lesser communication within parts of Grain Legumes.

If publications per unit funding are a useful metric, then the cost per publication is high compared to other PLs. But firstly income is not directed solely towards publications, W3 and bilateral income is directed more towards downstream impact seeking activities, hence other metrics that quantify efficiency should be compared, and secondly since the actual CRP nominally allocated funding to each centre and each PL is not audited, the relationship between attribution of publications to centres and funding allocated to centres is perverse. Thirdly, identical publications are 'claimed' by multiple PLs, adding to the attribution conclusions.

Notwithstanding these caveats, this PL achieved a final Output score (Table 5.3.1) of 15, buoyed by the quality rather than the quantity of publications (Table A1.1).

Table A1.1. Quality assessment of nominated papers from PL1.

Output	Synopsis of output	Quality rating out of 15
1	Evaluation of over 1200 cowpea lines for drought tolerance. Identification of six lines that might have useful breeding properties.	10
2	Description and evaluation of a novel strategy for delivering widespread distribution of new bean varieties to smallholders in Sub-Saharan Africa.	12
3	Identification of genetic variation in nitrogen fixation of bean genotypes exposed to soil drying.	10
4	Evaluation of bean genotypes for resistance to aluminium toxicity and soil drying.	10
5	Review of the potential impact of climate change on the imposition of abiotic and biotic stresses on common bean.	8
6	Analyses of photosynthate remobilisation capacity in breeding lines of bean and the interaction of these with drought-adapted lines.	11
7	Identification of genotypes of bean that exhibit drought resistance and the correlation of this trait with pod harvest index.	10
8	Review of issues associated with drought stress in beans and how this interacts with soil fertility and constrains plant breeding.	8
9	Assessment of genetic diversity in cowpea for improved nutrition and seed quality and the potential for introgressing favourable traits.	10
10	SNP genotyping of over 380 cowpea accessions and correlations with delayed senescence, biomass, and grain yield. The study revealed co-location of QTLs for these traits and the potential for developing a rapid screen at an early seedling stage.	11
		Overall quality rating ~ 10

As an aside, we were not made aware of the use of modern data collection techniques, bar-coded plot data collection nor other automated data collection practices, (other than the phenotyping facility at ICRISAT), in this or other field trials visited (but we were not able to view any trial in full swing).

A.1.1.4. Effectiveness

16.8 FTE; 6 female 12 male; 1 university 4 IITA 13 CIAT.

Taking research first, about 80% of the goals set out for the first three years for this PL have been achieved, mainly those relating to the breeding and screening practices.

Large-scale trials have been run to determine phenotypic differences in tolerance in beans to drought, low P, high Al and heat stress under field conditions, and likewise to drought in cowpea, but no use has been made of the phenotyping facility in ICRISAT. Nevertheless, use is being made of ICRISAT-inspired more efficient lattice designs for large-scale screening trials. Training in the USA has supported this research. There is some evidence of sharing of methods (between CIAT, IITA and ICRISAT and USDA) for evaluating different expressions of drought tolerance mechanisms (e.g. canopy temperature depression) and root traits imparting tolerance to unfavourable edaphic conditions in species. However, joint publications on the comparisons of methodologies and on common screening approaches do not exist. Since in some species there is progress in identifying root traits linked with drought tolerance, with time there may be similar opportunities to identify striking effects of single root trait, for example for beans.

Dissection of traits imparting tolerance to drought and low P tolerance and their inheritances (e.g. pod harvest index, pollen viability) is needed, and must make use of phenotyping and genomics support. As an example, use of a mini-core collection of cowpea has allowed for identification of intra- and interspecific diversity for growth traits, including plant transpiration in response to VPD, and this work should be further conducted at the ICRISAT genotyping facility (reported in PL2). Indeed, there is a need to coordinate the phenotyping activities (i.e. conducted on the same populations), both those with large and small populations, to ensure that they are objectively linked with relevant genomics activity

Research on genotypic variation in N2 fixing ability in cowpea under low P is inconclusive, and unfortunately this research effort does not appear to link with research in PL4.

Past evidence of adoption of improved bean varieties with higher micronutrient contents is substantiated by current expert estimates of further adoption, made possible through the release of further improved varieties and the use of the different modalities for seed dissemination carried out in an “action research” mode (e.g. marketing in small seed packets at low cost and permitting farmers to experiment with low risk; seed-for-grain models; standard private sector production; decentralised local production of Quality Declared Seed (QDS) with small NGOs and CBOs, value-chain development). This work has revolutionised the impact pathway and opened multiple channels to reach farmers, both outcomes of the effective partnerships within the Pan-Africa Bean Research Alliance (PABRA). A total of 16 new varieties of cowpea and 18 varieties of soybeans have been released in Africa, and 134 abiotic and biotic stress tolerant bush bean varieties were released across 16 countries in East-Southern Africa since 2010. Farmer Participatory Varietal Selection (FPVS) conducted in 7 African countries involved in TL II and PABRA has underpinned this success. Several segregating populations for example of cowpea in different generations are being advanced indicating that more improved varieties with better performances are in the breeding pipeline with the potential to be released in due course. Likewise in Ethiopia 7 varieties are under pre-release stage, including two introduced via Brazil.

Besides varietal release, soil pathology and soil quality (through composing and green manures) has received research attention within this PL.

The underlying baseline information on the consumption patterns of beans for women and children is still lacking; one country study only (Uganda) has been completed, but this falls far short of the number required to justify the research investment in grain legumes. Informal cross-border trade (e.g. of beans in Eastern Africa) may distort statistics on grain legume availability, for a country that based upon production statistics is self-sufficient, may indeed be deficit once exports have been subtracted from production data. With demand expected to grow with high

rates of urbanisation into the future, entraining of production-market corridors to ensure flow of product from surplus to deficit areas is essential.

A.1.1.5. Impact

This PL and particularly that relating to common bean is backstopped with a strong theory of change, developed pre-CRP by CIAT social science researchers. It champions the diffusion of new and improved varieties, and involves developing seed system innovation platforms in multiple countries and has reached an estimated 4 million farmers and their households. Two of its major achievements include marketing seed in small packs for on-farm trialling by farmers, and contributing to the policy recognising QDS as a viable class of seed, thus permitting decentralised seed production. It has been shown that bean markets, marketing and gender mainstreaming in the bean value chain are executed best through the bean platforms where multiple partners in the value chain develop an operational framework. Nevertheless, adoption of newly released seed varieties remains modest hence more emphasis is necessary on seed multiplication and dissemination.

A mix of seed systems approaches is needed to serve the needs of different target groups. It is indispensable to study and differentiate seed demand in a country first before initiating seed systems activities, and it is essential that this be followed up by a suitable policy framework for production and management of QDS.

In terms of areas sown to improved varieties, 2014 estimates for the spread of improved varieties of bean reached >430,000 ha in six African countries (Ethiopia, Uganda, Zimbabwe, Malawi, Tanzania and Kenya). Such data should be treated with caution, area does not translate into actual impact, although there is a close relationship between the two when new area is cultivated and new varieties contribute to productivity increases. Improved productivity in improved varieties has a significant impact on marketed surplus, and on market integration among rural households.

In Ethiopia a process was set in motion to improve productivity, combining seed delivery, agronomic practices, extension and marketing. Between 2009 and 2014 access of seeds of market-demanded varieties increased from less than 20% to about 75%, with area planted increasing from 245,000 to 326,000 ha from 2004 to 2014 (an increase of 33%) and total production doubled from 211,000 to 455,000 tons. In Zambia, an ex-post impact study estimated adoption of improved varieties to be 26.3% of the cultivated area. In Southern Tanzania, a similar study revealed that only 15.9% area was planted with new improved varieties and, in Uganda, improved bean varieties supply 40 kg more per household than if not adopted.

As another development, aimed at expanding market capture for beans in East Africa, pre-cooked biofortified beans (developed in association with A4NH) should be on the market by 2017, availing these to peri-urban consumers, increasing leisure time of women, and reducing energy expenditure and firewood consumption. Burundi, Madagascar, and Uganda have adopted a 3 tier product development approach focus to achieve this – defining the product based on market opportunities (2014); developing the prototype and testing the market (2015) with product launch (2016).

The impact statements in the self assessment document were numerous and extremely strongly evidenced, with the result that the score for this PL (and PL6) was the highest of all the PLs which were assessed.

A.1.1.6. Sustainability

Table A1.1.6. Funding sources for PLs in Grain Legumes

	Actual Budget																Total
	Windows 1 & 2 funds				Window 3				Bilateral funding				Total Funds spent				
PL	2012	2013	2014	Total	2012	2013	2014	Total	2012	2013	2014	Total	2012	2013	2014	Total	
1	1514	4152	2896	8562	516	2651	3052	6219	3134	4132	3921	11187	5164	10935	9869	25968	
2	774	2086	1590	4450	514	1647	2276	4437	800	2006	1688	4494	2088	5739	5554	13381	
3	1049	2178	1828	5055	1619	2775	3628	8022	1680	2325	2164	6169	4348	7278	7620	19246	
4	1194	3849	2433	7476	338	1562	1841	3741	1993	3975	3955	9923	3525	9386	8229	21140	
5	824	2725	1526	5075	691	1226	1581	3498	937	1500	1551	3988	2452	5451	4658	12561	
6	680	1085	805	2570	517	837	1147	2501	945	1257	886	3088	2142	3179	2838	8159	
7	651	1617	1322	3590	514	839	1079	2432	607	776	761	2144	1772	3232	3162	8166	
8	509	1120	940	2569	786	1427	1866	4079	816	1196	1193	3205	2111	3743	3999	9853	
ME	10	603	3174	3787	0	0	0	0	0	0	0	0	10	603	3174	3787	
Gender	262	318	422	1002	170	317	494	981	260	478	339	1077	692	1113	1255	3060	
TOTAL	7467	19733	16934	44134	5665	13281	16963	35909	11172	17645	16378	45195	24304	50659	50275	125238	

Source: As supplied by GG Koppa on 220715.

Inasmuch as no funding source is sustainable, while the activities of this PL depend upon external funding the future is decidedly unsustainable (Table A1.1.6). A steady decline has been evident in the proportion of W1/W2 funding, which in 2015 was 26.5%. Fixed costs consume about two thirds of W1/W2 income the remainder is used for operational costs, which include the funding for partners. This is particularly vulnerable to uncontrollable budget fluctuations. As a consequence, it has not been possible to hire new staff in Colombia (CIAT) to create a critical mass due to the unstable nature of W1/W2 funding.

For PL1 33% of received funding from 2012-2014 was from W1/W2, PABRA is one of the major contributors to PL1, and a new contract (covering only ECABRN/SABREN) has been signed with the Swiss Development Corporation effective from 1st January, 2015. TL III, the continuation of TL I and II, funded by Gates Foundation, although reduced in number of crops, still retains common bean and cowpea, although the country focus is reduced from 15 countries to 7 African and one Indian state (Uttar Pradesh).

The focus of the bilateral projects is more towards the downstream end of the delivery chain, that appealing to funding agencies wishing for reasonably quick impact. There are always fewer funds available for equipping laboratories and upstream research.

A.1.1.7. Gender

Within the PL there is a reasonable balance of gender, 2:1 male to female, but for students it is 3.5:1. In broad terms, much of the activity of CIAT is within this PL and the male to female ratio of training course attendees is 1:1, the highest proportion of females across the four centres.

Survey tools for monitoring, evaluation as well as impact assessment studies are increasingly collecting gender desegregated data. Though this effort is still in its infancy, it has created significant awareness among NARS and PL researchers and to a good extent had influence on their research focus. All-important decision-making bodies of PABRA have achieved mandatory 40 percent women representation by 2014.

The most important action at Grain Legumes level has been the hiring of a gender expert (a women, in fact two, one in East Africa and one in West Africa, sharing roles across two CRPs) which of course addresses gender issues beyond that of diversity per se. however, one of the positions, that in West Africa, is now vacant.

A.1.1.8. Capacity building

There are quite a number of PhD students in the PL, compared to other PLs, but due to the high number of FTEs only 2 students per FTE [Table 9.2.1] and capacity in this area should be doubled in line with the higher performing PLs. It is notable that most students are located in Nigeria, a couple are registered in Europe but there is an absence of students in Latin America. The PL accesses a range of high-class facilities and has plenty to offer collaborators in universities throughout the world.

Research capacity is lacking in CIAT due to insecure funding, and in IITA simply due to non-availability of some needed specialism (such as biometricians, host plant resistance entomologists, pathologist).

At the downstream level, training has been notable, with >130,000 persons trained, but numbers conceal the quality of the training and the likely impacts that such training might have on production, and post-harvest practices.

A.1.1.9. Partnerships

Continuous growth and success of national partner efforts is possible by taking into consideration the whole value chain; strengthening private and public partnerships, and building skills across a wide range of areas across the bean and cowpea value chains.

The major partnerships that have led to successful seed delivery systems in East Africa are those through PABRA. This is a fine example of a well-focused and efficiently managed network that has been notable in helping overcome local bottlenecks for breeder and foundation seed delivery, subsequently catalysing delivery of seed further along the chain.

Efforts in biofortification figure prominently in this focus, but these efforts are housed under CRP 4, A4NH. There is, however, integration of breeding objectives for nutritional and agronomic outcomes. Apart from biofortification, research on utilisation of beans in diets has been advanced with the demonstration of effectiveness of beans in school feeding programs, and with the development of bean-based flours and a porridge for under-5's employing high iron beans and in collaboration with the private sector which, as mentioned above, is expected to enter upon production in 2017. On-going research on improved protein digestibility could eventually feed into this line of work, hopefully by 2017.

The biggest single restriction in capitalising upon partnerships has been funding to permit a viable interaction (e.g. joint field visits) as a Product Line. Only one technical interchange has been effected in 2.5 years (a course on phenotyping in 2014, held in collaboration with Penn State University and USDA). And in the words of the PLC, 'Instability of funding has forced us to recede into a defensive mode'.

A.1.1.10. Overall score

Table A1.1.10 summary of PL1 scores.

Category	Maximum score	PL1
Outputs	30	15
Impact	35	30
Environment, coordination, and capacity building	20	18
Gender balance and sensitivity	15	13
Total	**100**	**76**

A.1.1.11. Conclusions and recommendations

Collaboration with other centres and institutions is good in this PL, but high profile publications are few. Opportunity for sharing of protocols between CGIAR centres in searching for tolerances to drought and other abiotic stresses has been lost, although the phenotyping facility at ICRISAT should lead to greater synergy in research outcomes between grain legume species. We did note some weak data collection methods, and recommend that data collection adopt available digital technologies. Nevertheless, this PL has been highly effective in meeting its goals; impact is high, with adoption of new varieties resulting from earlier investment in their development and that of effective seed distribution systems. The latter has benefited from the PABRA partnership, which has been exemplary, both in terms of seed system innovation platforms and the inclusiveness with which it embraces gender equity.

A.1.2. Product Line 2: Heat-tolerant chickpea, common bean, faba bean and lentil

A.1.2.1. Relevance

The narrow focus of the title does not capture the extent of research and development undertaken in this PL. It stretches beyond heat-tolerance, into drought, and hosts much of the genomics and phenotyping activities of, in particular, ICRISAT. Drought and heat as stresses are closely linked, therefore the inclusion of drought tolerance research in this PL is well justified, although the genetic bases for tolerances will differ markedly. Close research links should exist between PL1 and PL2, and there is evidence for some of these, especially in common bean research.

Incorporation of heat tolerance in all four species, with the focus on setting of viable pods, will increase yield stability, and protect against global warming. It will also permit the extension of cultivation into regions experiencing temperatures higher than in current production zones (of particular relevance to production of chickpea in India. This and the introduction of short-season adapted chickpea varieties have supported the successful shift of chickpea production southwards. The popular variety JG 11 has underpinned the recent doubling of chickpea area in south and central India to 4.5 m ha over the past decade (see PL6 for some of these data).

Identification of impact domains for dissemination of heat and drought tolerant genotypes though the use of crop modelling is key to directing geographic attention to upscaling activities. An estimate of areas in high temperature production areas for common bean would for example facilitate targeting of improved germplasm of common bean.

Although the proposed emphasis was to have been on heat tolerance and use of marker assisted selection and other advanced genomics techniques (and identification of homologous genes for heat tolerance across species), these approaches have been diverted towards identification and introduction of drought tolerance, with heat tolerance still using traditional screening protocols (such as plant survival, pod set, and pod yield), at the field and controlled environment level.

A.1.2.2. Efficiency

There appears to be little evidence of sharing of facilities and expertise between partners in this PL. However, the basic science underpinning research in genomic and molecular aspects of chickpea heat tolerance is employed in PL6 (extra-early chickpea and lentil varieties), indeed a number of publications attributed to PL2 are also attributed to PL6 by staff at ICRISAT.

A.1.2.3. Quality of science

This PL has produced a number of high quality publications, in journals with high impact factors, for example on the chickpea genome (added to that of pigeonpea), but such publications are

routinely expected when one has access to such types of facilities as the CEG. Publications are almost entirely from single centres, although many have multiple authorship with a range of partners in ARI (43/100) and developing countries (28/100), showing the basic and applied nature of the PL2 research. The only cross centre and cross species publication, on protocols for screening for high temperature tolerance, does nothing more than talk of approaches in the separate species. There is therefore very little evidence of collaboration between individual centres that results in intellectual stimulation and co-publications.

This PL achieved a final Output score (Table 5.3.1) of 21, buoyed by the quantity rather than the quality of publications (Table A1.2) with nearly 8 papers published per FTE.

Table A1.2. Quality assessment of nominated papers from PL2.

Output	Synopsis of output	Quality rating out of 15
1	A study to assess the genetic variability in heat tolerance of chickpea revealing an extensive range in genetic variation for components of yield. Days to first pod and pod number per plant, were correlated with grain yield whereas canopy temperature depression was generally not correlated. Breeding material exhibiting a range of heat tolerances was identified	11
2	Use of SNP markers to further define a QTL hotspot for drought resistance in chickpea for use in marker assisted breeding.	11
3	Use of DArTs, SNPs, and SSRs to assists in marker-trait association mapping in chickpea to developing superior varieties with enhanced drought and heat tolerance.	12
4	Screening of chickpea collections against heat stress identified two heat-tolerant and two heat-sensitive genotypes. Pod set was reduced in the heat sensitive genotypes due to reduced pollen viability. Heat stress also significantly reduced stomatal conductance, leaf water content, chlorophyll, membrane integrity and photochemical efficiency with a larger effect on heat-sensitive genotypes.	12
5	Further analysis of heat tolerant and heat sensitive genotypes both in field and under controlled conditions revealed structural abnormalities in anthers and pollen function.	11
6	An analysis of the role of ABA and osmolytes in regulating the response of chickpea to heat stress.	11
7	Screening of chickpea germplasm for tolerance to high temperatures at two locations in India (Patancheru and Kanpur) by delayed sowing and synchronising of the reproductive phase of the crop. Many heat-tolerant genotypes identified also exhibited drought tolerance.	12
8	A study to assess the genetic variation for 12 traits among 43 lentil genotypes. Under drought stress, early flowering and maturity and	12

	seedling vigour were identified as key traits for higher seed yield in lentil and these traits can be utilised for the development of mapping populations to identify QTLs for marker-assisted breeding.	
9	Description of QTL analyses for drought resistance traits in recombinant inbred lines of chickpea.	11
10	A review of the role of high throughput phenotyping systems for crop screening and the importance of complementing initial analyses with more directed approaches.	9
		Overall quality rating ~ 11

A.1.2.4. Effectiveness

9.5 FTE; 8 female, 37 male; 8 from NARS, 19 from ICRISAT, 15 from ICARDA and 3 from CIAT.

This section is separated into three major activities, that of crop simulation modelling, of phenotyping and of genotyping.

Crop simulation modelling figures quite strongly in this PL – being used both for mapping of domains for varietal release (especially under changing climates), for identification of traits, or combinations of traits, leading to yield improvements under high temperature and drought stresses, and for direction in agronomy research. These are sensible activities for international centres. The drawback is the lack of compatibility between the various models used, Simulations use various models: SSM (simple simulation modelling) is referred to for use with groundnut and chickpea (in the former, predicted yield increases with higher plant population is now implemented in Malawi) and lentil in PL6, Ecocrop in bean (modelling the benefit of adaption to a 3 C maximum optimum and maximum absolute temperature rise and climate suitability of improved heat tolerant varieties), and CROPGRO for chickpea by ICRISAT (investigations of incorporation of drought and heat tolerance directed attention to prioritising plant traits for location-specific breeding). The approach of homologous research domains is also being used by ICRISAT for targeting suitable genotype by environment combinations for beneficial/potential use, for measuring spill-over domains and to estimate potential welfare benefits. The rather simplistic assertion that genotypes collected in areas where abiotic stress is endemic will have useful variability for conditioned tolerance to that stress (i.e. the FIGS approach) is being used effectively to identify useful germplasm tolerant to drought in lentil in small collections, and is being used for other species. However, the effectiveness of the approach, as opposed to choice of sets based on chance alone, is still to be proven.

Both large- and small-scale phenotyping is underway. Small-scale is with lentil and chickpea in N Africa searching for direct heat tolerance in these crops. Progress on identification of field based genetic differences in heat tolerance in common bean in Colombia has not advanced much beyond earlier research, a degree of gradualism, necessary but not remarkable. As with non-leguminous species, pollen fertility is a critical trait susceptible to high temperature and interspecific crosses with tepary bean (*Phaseolus acutifolius*) have raised tolerance to higher than normal temperatures. Pollen viability was confirmed to be a primary mechanism of heat tolerance in common bean, although it explains only part of the observed tolerance. The effect negative effect of high temperature is on pollen survival not formation, and tolerant tepary bean crosses have additional direct benefits on growth under higher temperatures. These effects of high

temperature on metabolism deserve more research attention, as those relating to fertility are overcome. Grain filling is similarly important, and probably other mechanisms, including carbohydrate metabolism in the flower, are significant too.

For example, sucrose metabolism appears related to heat tolerance in lentil. In Africa and India heat tolerance in faba beans and lentil germplasm is being field-evaluated (and one variety released in Sudan). Development of common sites and protocols for identification of heat tolerance have not been forthcoming, although the key physiological trait imparting heat tolerance, that of pollen fertility, is key across legume species. Grain filling is similarly important, and probably other mechanisms, including carbohydrate metabolism in the flower, are significant too.

Large-scale phenotyping is undertaken at the new Leasyscan facility in ICRISAT headquarters, where the physiological basis of traits imparting tolerance to drought and heat are being unravelled. Novel research on the role of water channel proteins imparting drought tolerance is exciting. Research in the Leasyscan facility is underway not only on crops under the ICRISAT mandate, but also including others crops in Grain Legumes, cowpea, and beans, and several other orphan legumes. Water saving traits, real-time measures of transpiration rates, transpiration to high vpd. Some research is investigating the benefits of tolerance to one stress providing tolerance to at least one other stress (between heat, drought and salinity), with some promising results (as has been found in other species, e.g. *Solanum*) and phenotyping of various physiological parameters in heat tolerant bean genotypes to field level drought tolerance is underway, but nothing is forthcoming on the proposed (the original proposal) studies on relatedness of genes of value in the search for heat tolerance across genomes of pigeonpea, chickpea and groundnut (and soybean).

With genotyping, candidate genes and whole genome sequencing has been used for investigating heat tolerance in chickpea, but outcomes have not been specified. Candidate genes (QTLs) for heat tolerance have been identified in chickpea (and for tolerance to *Fusarium, Ascochyta* and *Rhizoctonia*) and are discussed in Impact below. A password-protected repository has been established to manage next generation sequencing data for heat tolerance and other traits in chickpea.

Clear argument as to the comparative improved efficiencies (in terms of time and costs) in enhancing genetic gain using the marker assisted selection (MAS) approach are still to be penned, although the genomics team at ICRISAT is convinced of the MAS superiority and has presented evidence to the CCEE that the best performing selections from 20 MAS-derived lines in chickpea grown at four locations in India under two growing conditions (rainfed and irrigated) produced a 12 % increase in yield under rainfed conditions and 24 % increase in yield under irrigated conditions.

A.1.2.5. Impact

Immediate impact from the 2.5 years research is not possible, but funded CRP activities building upon earlier research has led to impacts. From pre-CRP research, heat tolerant chickpea variety JG 14 (ICCV 92944) released in India in 2009 for late sowings (experiencing higher than normal temperatures) was also released as Yezin 6 covering over 40,000 ha in Myanmar during the 2012-13 crop season. This variety was released as Chania Desi 2 in Kenya during 2013. In India according to a baseline study slow adoption of JG 14 is reputedly due to lack of seed, despite farmers always choosing JG 14 in farmer selection trials. Better adoption is taking place in Bangladesh, together with other varieties developed under TL II. Likewise in bean, one line in Nicaragua has been

released as being heat tolerant, with pod formation when night temperatures exceed 22 C. and with faba beans, tolerance to temperatures up to 35 C at flowering in the Sudan have led to one variety being released, responsible for adoption by 25, 000 farmers on 50, 000 ha, with income increases of $4000 per family.

Areas of near-impact include the following: identification of pleiotropic QTLs (QTL-hotspots) related to drought tolerance in chickpea has allowed for MAS with introgression of the QTLs into a broadly adapted and well-adopted variety JG 11 in India. This set of MAS backcrossed lines has performed well in all-India trials and at least one selection is set for release in a couple of years. This represents a strong example of the benefits of investment in genomics research at ICRISAT. Another is with MABC to introgress resistance to *Fusarium* wilt race 1 and *Asochyta* blight into an elite chickpea cultivar. Further likely impact is to be gained by trying to pyramid disease resistance genes by intercrossing resistances and selfing to gain homozygous lines for introduction of genes to elite cultivars.

Extent of potential impacts has been supported by ex-ante simulation modelling, showing that in the face of a 3 C temperature rise incorporation of tolerance to such temperature will [not surprisingly] obviate global warming reductions of area suitable for beans, so that reduction in area will only be c. 10% in 2100, compared to a loss of 20-50% with regular cultivars. Likewise, the CROPGRO-Chickpea model also shows benefits for incorporated heat tolerance under warmer climates in the future, and benefits due to drought tolerance up to 22% in both baseline and climate change scenarios. Nevertheless, the predictions of climate change on yields are inconsistent across models, and climate models must be improved upon before sensible predictions for extent of geographic suitability of improved varieties are forthcoming.

Unfortunately PL2 did provided only two impact cases in the self-assessment document, which were not well evidenced, so it was not possible to award a high score for this section.

A.1.2.6. Sustainability

Funding for this PL comprised one third W1/W2 and the remainder W3 and bilateral. Total funding of *c.* $13.5 million was spent in the ratio 2.8:5.2:5.5 between CIAT, ICARDA and ICRISAT, with almost equally amounts in bilateral funding, but larger sums for ICARDA from W1/W2 and from W3 for ICRISAT. Averaged across the three centres, W1/W2 declined from 36.3% of funding in 2013 to 28.6% of funding in 2014. All three research strands in this PL attract funders' attention, whether for the right or wrong reasons (new technologies, promise of spectacular results, and fear of global warming), so in the short term this PL will likely be sustainable in terms of funding.

A.1.2.7. Gender

Of the 45 staff members aligned with PL 2, spending the equivalent of 9.5 EFTE, 21% are female. Four of the nine postgrads are also female.

Most of the information related to gender in PL2 is similar to that provided in other product lines. There is a proposal to bring on board a women PLO (Product Line Organizer) for PL2. Efforts have been made to ensure greater participation of women in training programs at all the levels. One shining example, a PhD student (Viola Devasirvatham) at ICRISAT, worked on heat tolerance in chickpea, albeit completing soon after Grain Legumes began. She made excellent progress and published 3 research articles (two in Field Crops Research and one in Functional Plant Biology), one review article (in Crop and Pasture Science) and one book chapter.

A.1.2.8. Capacity building

Long term research capacity building in this PL is poor, only 4 out of the low number 10 students enrolled in post-graduate degrees are registered for PhD degrees. There seems to be little incentive to supervise PhD or MSc students since the student:staff ratio is very low, particularly so for CIAT. In recompense, national programmes are benefiting from training of their staff in molecular breeding, although this was apparently only for MAS. Training on 'grain legume improvement' for plant breeders took place in 2014 in Lebanon for 22 NARS partners (including 9 researchers from South Asia, 3 researchers from Sub Saharan Africa and 10 researchers from CWANA) and another was held in ICRISAT on "Pre-breeding and crop improvement in legumes" but there does not seem to be a master plan that links training needs with training activities.

A.1.2.9. Partnerships

The list of publications and co-authorship indicates a wide range of research associations, not necessarily partnerships, in the three discipline areas, modelling, phenotyping and genomics. Spread across ARI and national programmes, there appears to be a sensible balance. To promote and facilitate discussions on modern genomics and biology, Critical Focus Area meetings, for cross fertilisation of ideas, have been organised by the genomics group at ICRISAT. At the other end of the spectrum, close links with NARS in Bangladesh and India, for example with farmer participatory varietal selection and genotyping services are well received.

A.1.2.10. Overall score

Table A1.2.10 summary of PL2 scores.

Category	Maximum score	PL2
Outputs	30	21
Impact	35	15
Environment, coordination, and capacity building	20	12
Gender balance and sensitivity	15	4
Total	**100**	**52**

A.1.2.11. Conclusions and recommendations

Although the PL highlights research into heat tolerance across species, much effort is directed towards drought tolerance. Where there is concerted effort towards heat tolerance, such as with common beans, the research links well with that of PL1. Simulation modelling underpins much of the domain focus across species, and quantification of potential introductions of tolerance traits into the various grain legume species. Molecular approaches to drought tolerance are emphasised more than for heat tolerance (although QTLs for heat tolerance in chickpea gain much attention), and many high quality publications have been forthcoming, although with negligible cross-CGIAR centre authorship. Phenotyping, both in the field and the specialised Leasyscan facility at ICRISAT, takes many resources, and could be better linked to molecular selection protocols. Good impact of past research into heat tolerant selections in chickpea is commendable, and near-impact of ongoing research using MAS and introgression of tolerance genes into popular varieties is notable. Partnerships with ARIs and national programmes is of good quality, but capacity building and postgraduate trainings require greater degree of coordination for effective outcomes

A.1.3. Product Line 3: Short-duration, drought tolerant and aflatoxin-free groundnut

A.1.3.1. Relevance

This Product Line has two main focal areas; firstly the upstream implementation of a breeding programme for short-duration, drought-tolerant and aflatoxin-free groundnut and, secondly, intensive promotion and upscaling of new and improved varieties to farming communities across a number of countries. These targets rely on a good network of screening sites and engagement with the user communities. The PL has an acute awareness of the importance that is being placed on the nutritional properties of groundnut and its potential for delivering high energy, calorie dense products in a form that has good postharvest shelf life and processing characteristics. The use of groundnut as a source of oil has therefore become secondary and thus new varieties are required with a far greater range of quality parameters. The increased potential of groundnut as a crop enables the PL to address challenges connected with the effort required in production and therefore work relating to reducing the drudgery and increasing mechanisation of production, particularly in relation to promoting gender balance. The problem of aflatoxin contamination has been a major disincentive to the development of the groundnut crop and this PL represents a unique and coordinated effort to reduce aflatoxin contamination through a breeding approach.

A.1.3.2. Efficiency

PL3 has good integrative networks within India, West and Central Africa, and East and Southern Africa respectively. The networks appear to work in isolation, but are efficient in their own right. The PL recognises that access to seed remains a challenge in most countries and that informal systems for scaling out, such as community seed banks, work best. Innovation platforms have been established, the most recent in Tanzania. One innovation platform aims at management of Aflatoxin and the other two aim to improve cereal legume crop productivity as well as crop livestock productivity for semi-arid zones. Activity is centred around meetings, but these integrate well across the food supply chain. Women based community groups appear to be more efficient at scaling out of technologies to fellow women and keeping technologies within communities.

A.1.3.3. Quality of science

PL3 has produced some notable outputs that do not take the form of publications e.g. seven new groundnut varieties released in Malawi, three varieties identified for release in India. Deployment of seed throughout Asia and Africa is impressive. Breeding programmes are using marker-based approaches and the traits target are nutritional (oil quality, identification of toxigenic *Aspergillus flavus* strains), biotic (rust resistance and rosette disease) and abiotic (drought tolerance). The importance of genetic diversity is recognised in the PL and synthetic tetraploid groundnut has been developed and are being used in groundnut breeding although the benefits from the work were not described. New sources of drought and low P tolerance were identified within existing germplasm collections, again the pathway to impact of their use has not been described.

The publication record of the PL is not extensive with just 26 outputs in total, just 1.6 per FTE, although most were in journals with impact factors. Only six papers were submitted for consideration of quality and not all of these were peer reviewed articles (Table A1.3).

Table A1.3. Quality assessment of nominated papers from PL3.

Output	Synopsis of output	Quality rating out of 15
1	A descriptive summary of a collection of articles that outline the involvement of a variety of genes/pathways and regulatory networks in the responses of crops to abiotic stress.	2
2	Description of the use of a multiplex PCR-based approach to detect groundnut rosette assistor virus (GRAV), groundnut rosette virus (GRV) and a satellite RNA (satRNA) to assist plant breeding strategies.	9
3	Report outlining the positive impact of over expressing the DREB1A group of transcription factors on drought tolerance of peanut (*Arachis hypogaea* L.) under field conditions	11
4	A study of the use of allelic diversity, population structure, linkage disequilibrium decay and marker-trait association (MTA) in peanut. The conclusions from the work are that MTAs can be deployed to improve traits such as: biotic resistance, oil/ seed/ nutritional quality, and drought tolerance.	12
5	Demonstration that while drought stress can increase the concentration of aflatoxins in seeds of groundnut there is no correlation of this with the tolerance of genotypes to water deficit.	10
6	A report of the impact of gene pool diversification in groundnut using a backcross breeding approach to generate material exhibiting a wide variation for several morphological and agronomic traits including resistance to foliar diseases such as rust and late leaf spot.	10
		Overall quality rating ~ 9

A.1.3.4. Effectiveness

Staff on PL3 consist of 16.2 FTE; 5 female 16 male; 9 based in India and 12 in Africa.

PL3 has put together an excellent network of participatory variety selection and on-farm research activities that spans 1500 farmers in Zambia and Malawi. The evaluation of trait preference by farmers is revealing e.g. disease resistance is not actively selected, men prefer traits linked to market value, women prefer traits linked to processing, but how this information is used to further direct the breeding programme is not clear.

The first diploid genome sequence for groundnut has been generated, but detail on the quality of the assembly and whether the tetraploid genome assembly has made any meaningful progress is not provided. GWAS in multiple seasons is complete and has been used in conjunction with DArT and SSR markers to provide some high quality data which have been published in PLoS ONE

(Pandey et al., 2014). Genomic selection models for drought tolerance and QTL-based approaches to identify and eventually introgress useful alleles from wild relatives is making good progress and have been published in The Crop Journal (Kumari et al., 2014). The scientific approaches are sound and high quality, but an indication on how this work will be translated into impact for breeders working in target countries is required. The breeding programme for high oleate accessions is progressing slowly, the extent of evaluation is not clear and it appears that this project has been given less attention than others, probably with some justification, as other yield and quality traits are more important.

Breeding work between NARS and ICRISAT to use better genetic sources for high drought tolerance, better nutritional quality and low or no aflatoxin is well replicated and thorough in terms of the range of nutritional and biotic traits, including postharvest traits, tested in multiple locations in Asia. The work has been published in TAG in a good quality publication (Varshney et al., 2014). Useful metrics are provided in the 2014 annual report to evidence the progress being made at developing more resilient and nutritionally-dense varieties. The breeding work in Africa is described in less detail and appears to be progressing through successive generations without a concentrated effort at evaluation of the progeny. The development of advanced genetic resources e.g. TILLING populations, stacked traits, mutagenised populations is welcomed, but detail is required on how these are made accessible to interested parties and how much use there has been of them outside of the immediate research consortia. Likewise, in the mutant populations described as 'TILLING' within the Grain Legumes there has been no recorded identification of a mutant individual that has been analysed with respect to the predicted phenotype. There has been some DNA analysis, but the loop has never been closed.

Candidate (transgenic) lines which have low accumulation of aflatoxin have been achieved and the PL is making good use of collaborations with Louisiana State University and the Danforth Plant Science Centre, both USA. High quality science is certainly in progress, but evidence is needed to show how this will be translated into a resource that can be used in the local breeding and farming communities.

Four different projects to underpin drought tolerance and low aflatoxin breeding, are in progress and if all are to be continued they would need a lot of work to see to fruition. For example, generating MAGIC populations is time consuming and may not be worth the investment. The recommendation is to focus on the areas that are best developed e.g. polymorphism study on parental lines of root nodules and seed dormancy, polymorphism study on parental lines of aflatoxin resistance.

The situation in Asia for scaling up of national seed systems is promising, with 13.8 t of seed distributed to different agencies that will take care of multiplication and distribution under a certified programme in India. The amount of seed distributed in Africa (Malawi and Tanzania) is much larger, but the PL does not seem to have as firm an understanding of how much seed this will generate and whether it will be enough compared to the situation in India.

A.1.3.5. Impact

This product line addresses the most important abiotic stress (drought) and an important factor that affects quality of the produce (aflatoxin contamination) in groundnut. The biggest bottleneck in adoption of improved cultivars is the availability of quality seed. This will be addressed by strengthening both formal and informal seed systems. Enhanced adoption of improved cultivars and integrated crop management practices will lead to improved groundnut productivity and quality in drought prone environments. The Impact target is to produce groundnut in 0.5M ha

with a 15% yield increase in Asia. ICRISAT has produced 29 t of breeder seeds which are now with private companies for further multiplication. However, the picture in Africa shows that seed production is still falling short of demand with an eight-fold increase required in Malawi to meet demand. This is unfortunate for impact studies conducted by ICRISAT show a doubling of productivity due to new varieties and allied technologies. Efforts to address this seed-shortfall are rather small-scale and may make individual pockets of difference but not necessarily the magnitude required. The recommendation is that investment is concentrated on scaling up production of varieties with the most promising trait profiles to meet the basic seed requirement.

Metrics are provided that indicate that knowledge dissemination through farmer training schools is very effective and reaches both genders. An estimated 286 farmers are reached for every farmer trained through a variety of media and face-to-face dissemination activities. This was linked directly to a 10% increase in production area in Malawi and work is ongoing to achieve similar outcomes in other Eastern and Southern African Countries. West and Central Africa is struggling to develop such good training networks and will need more investment to achieve the yield increases sought.

Considerable progress has been made in terms of developing and utilising labour saving equipment. Whist this has undoubtedly relieved women of much of the drudgery associated with groundnut production it is not clear if the new machinery is being used by women or if their jobs have disappeared. The provision of mechanical shellers has relieved women of this onerous task and it was reported that this enabled women to control more of the decision making process in the crop cycle although concrete evidence was not available to support this statement. It would appear that each sheller would leave 19 women displaced from work and that men in the community retained control of transport of the crop to market, seed sourcing and planning the crop cycle. Whilst running the shelling machine is good for the woman with that responsibility it is far from clear what her former colleagues will be doing instead.

Metrics are provided that indicate that a surplus of groundnut is produced, even in a poor harvest year, and that this is sold and providing a significant proportion of household income. Whether this income is considered sufficient, and whether a profit of $180 per acre USD in Malawi is sustainable when new technologies and seed varieties are recommended is not clear. However, the data provided by PL3 show that groundnut is a significant contributor to Malawi's economy and growing rapidly, but the organisation of groundnut marketing and processing is not keeping pace.

Assessment of aflatoxin contamination of grain legumes showed that the major impact target of PL3 – to reduce aflatoxin contamination – is still far from being met. A contamination rate of 95% was reported (over 20 ppb) and although further mitigation efforts are planned there was no detail of these presented.

A.1.3.6. Sustainability

Between the PLs, PL3 is one of those with the smallest proportion of the budget from W1/W2 funds, receiving 30% in 2013 and 24% in 2014. ICRISAT is the training hub for PL3 and is training reasonably equal numbers of men and women. However, the network of breeders, seed producers and farmers is much more extensive and better connected in Africa, particularly in East and South Africa. The recommendation is for much more integration between research and knowledge exchange across both continents so that the best aspects of both can be shared. This will not be possible without significant further investment and it is important that funding is obtained for building infrastructure, increasing training capacity, and testing varieties in multiple

seasons and locations as well as for the more pure R&D work around breeding. Breeding efforts in Africa are scattered and are not structured, therefore much of the genetic resources and expertise resident in ICRISAT is not being translated into impact on the ground. Much of the training capacity in Africa at present centres around farmer schools to demonstrate new varieties, agronomic practice and technologies. Without an equally vibrant programme directed at breeders the local efforts are unlikely to be sustainable.

A.1.3.7. Gender

A 3:1 ratio of males to females is to be found in the staffing of the PL, but for students the ratio is 10:13.

A.1.3.8. Capacity building

Post-graduate training is a must for strengthening NARS and international centre work forces. This PL is weak in PHD training; most postgraduates are at the Masters level. In all target regions there has been capacity strengthening from two fronts; i) access to breeding lines by NARS has expanded the genetic diversity of material available, leading to new variety release; ii) Capacity strengthening of breeders has improved capability to breed groundnuts. Today in Africa, for example, each of the target countries has a full time equivalent of groundnut breeder trained on basics of breeding and delivery.

A.1.3.9. Partnerships

The PL planned good engagement with partners within and outside CGIAR including ICRISAT, ICARDA, ARIs, Peanut CRSP, CIRAD (France), USDA and Louisiana State University (USA), Catholic University of Brasília (Brazil) and NARES, government and non-government extension agencies, NGOs, Farmers' groups and farmers in target countries. But we were unable to determine the outcomes of such partnerships. The translation of transgenic work was planned with the Indian NARS and the PL has coherent reach across Indian and African continents. In Malawi, for example, impact studies conducted by ICRISAT show a doubling of productivity due to new varieties and allied technologies. Ultimate benefits from income and nutrition however require leverage of aflatoxin mitigation and value addition, key aspects of the CRP A4NH.

A.1.3.10. Overall score

Table A1.3.10 summary of PL3 scores.

Category	Maximum score	PL3
Outputs	30	12
Impact	35	15
Environment, coordination, and capacity building	20	14
Gender balance and sensitivity	15	9
Total	**100**	**50**

A.1.3.11. Conclusions and recommendations

The aims of PL3 to reduce aflatoxin contamination and improve drought resistance are still extremely important, but actually the major success of this PL has been in reducing drudgery of crop production and developing valuable genetic resources that are applicable to a wider range of crop improvement goals. There is recognition that the landscape of how the crop is used has changed significantly over the life of the projects such that the processed crop is now

economically important as confectionary, snack food, providing nutritionally dense food in a preserved form. The PL should adapt its aims in line with the shift in market that it has already identified and particular attention needs to be paid to how aflatoxin contamination can be significantly reduced. Without concerted effort in this direction the nutritional benefits of the crop cannot be utilised and a multidisciplinary approach is recommended that considers processing solutions as well as breeding solutions**.** In terms of breeding then the diversity of genetic resources in development is to be commended, but the recommendation is to prioritise genetic resources that offer the most immediate utility for fast tracking breeding targets with the aim of delivering a significant improvement in a few traits that can be adopted by the farming communities. Two such areas are the markers for root nodulation and seed dormancy, and the study on parental lines of aflatoxin resistance which now needs to be expanded to characterising whole populations. Success of pre-breeding programmes and translation into cultivated lines will bring with it a need for increased seed production which is already stretched. It is therefore recommended that investment is concentrated on provision of an infrastructure for scaling up production of varieties with the most promising trait profiles to meet the basic seed requirement. There are excellent aspects to the work done in both India and Africa in PL3, with the different communities having distinct strengths. A call and recommendation is made for far more extensive integration of research and knowledge exchange across both continents so that the best aspects of both can be shared. This should be developed through training of researchers, extension specialists, farmers and food processors and facilitated through exchange programmes and joint funding applications.

A.1.4. Product Line 4: High nitrogen-fixing chickpea, common bean, faba bean and soybean

A.1.4.1. Relevance

This PL has broad and generic relevance to all legume crops, and therefore to all countries where such crops are grown. It aims to improve the contribution made by biological nitrogen fixation to the yield of legumes and is of particular importance. We were told by the MU that, from 2015, greater integration will take place with N2Africa.

The target countries are Ethiopia, India, Kenya, Malawi, Morocco, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia, plus some Global activities.

The PL relates to **IDO4 and 5** which are:-

IDO4 Productivity: Improved productivity of farming systems, especially among smallholder farmers

IDO5 Environment: Minimized adverse environmental effects of increased production and intensification of grain legumes.

The value of biological (or symbiotic) nitrogen fixation (BNF) lies not only in the potential improvement in the yield of the specific legume under consideration, but also in the overall improvement of the nitrogen status of the soil. For example, it is estimated that 50% of the nitrogen fixed by a chickpea crop remains in the soil and is available for the next crop. This benefit is exemplified by data which show a 1.2 to 2.3 fold increase in the yield of maize grown after soybean, compared with maize control.

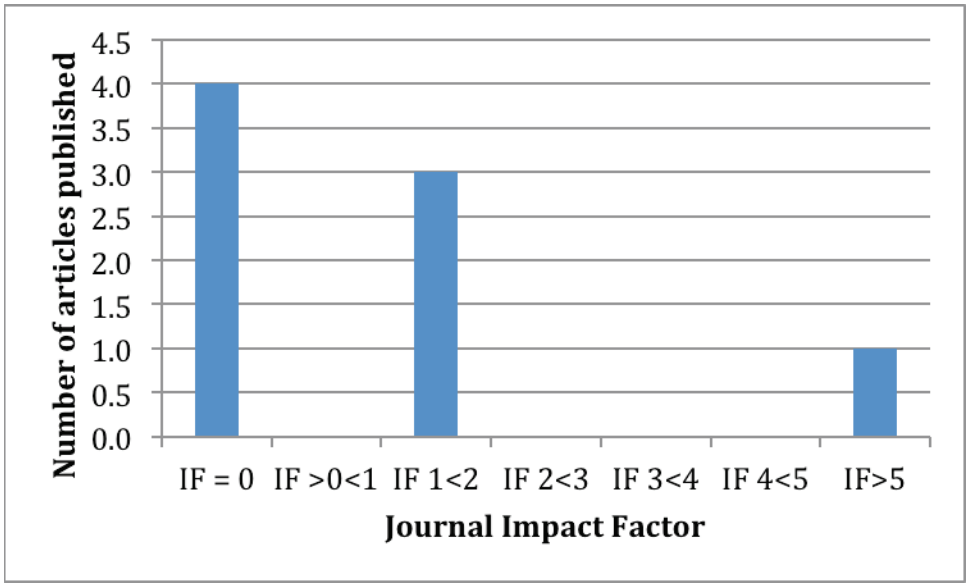
A.1.4.2. Efficiency

In addition to from the general lack of research output referred to below, the coordination of the project has not been effective. Specifically, there has not been a PL4 global meeting. This probably explains the overall lack of integration and the absence of any cross-centre communal spirit in this PL.

In the various discussions the PL participants were asked about any factors that might have restricted the successful implementation of pipelines and programmes of research due to communication or management procedures. The response included the suggestion that this PL 4 should have been given top priority by way of providing dedicated funds and scientific manpower. The large size of the total funds for this PL is mentioned below, but despite this it was stated that the allocation of funds at most of the Institutes was not clearly defined, and that there were insufficient dedicated staff to undertake research on BNF at most of the CGIAR Institutes. This was contrasted to the position in other PLs. The lack of dedicated staff was stated to have reduced the development of effective close interactions and inhibited the implementation of pipelines.

A.1.4.3. Quality of science

Figure A1.4. Publications from PL4 ranked by impact factor of the journals they were published in.



During the period from 1st January 2010 to 31st March 2015, a total of 14 publications were reported (Figure A1.4), with only four of these being in journals assigned an impact factor (highest 4.397). There were no publications from more than one centre, though authors on these papers are also affiliated to PL 5, 6, and 7. The quality assessment of the nominated papers gave a score of 9/15, but this was only based on the six nominated publications (Table A1.4).

Table A1.4. Quality assessment of nominated papers from PL4.

Output	Synopsis of output	Quality rating out of 15
1	Study describing how a QTL for leaf shape in cowpea was exploited with syntenic information from *Medicago* to identify candidate genes that might be utilised to improve the quality of cowpea leaves for vegetable and forage markets.	12
2	Conference article reviewing genetic improvement in grain and fodder yield of cowpea in Sudan from 1970-2004.	5
3	Review article that seeks to explore the limitations of strategies to develop cultivars of food legumes for release into tropical/ sub-tropical environments The focus of the analysis is particularly on the identification of crops with tolerance to nutrient deficiency stress.	8
4	A description of a study, carried out in 2000/1 and 2002/3 on the genetic variation of phosphorous use efficiency in Moroccan faba bean varieties under different field conditions.	10
5	A review summarizes research on microbial inoculants and the benefits that organisms belonging to the family Rhizobiaceae, Phyllobacteriaceae and Bradyrhizobiaceae can have on crop species.	8
6	Evaluation of the *in vitro* plant growth-promoting properties of a bacterium, isolated from nodules of chickpea grown in India, on the growth and development of chickpea plants raised under greenhouse, on-station of on-farm field conditions.	10
		Overall quality rating ~ 9

This low level of productivity (c. 0.4 publications per FTE per year) is acknowledged by a member of the PL who commented that the partner Institutes do not have sufficient scientific man power, specifically microbiologists, to carry out activities relating to the PL and that these activities received low priority at the Institute level. It was suggested that this resulted in the generation of a small amount of data and few high impact articles at many of the centres. On a more positive note, it was recognised that the support extended through the short-lived Competitive Grants system allowed more engagement with scientists from the NARS.

It is surprising that to hear that the scientists in this programme apparently consider that those involved in the PL do not have the necessary skills to fulfil all the needs of the project.

This lack of fundamental understanding of some of the basic science principals of nitrogen fixation and how to measure success was exemplified by conflicting comments about whether or not there is a link between nodule number and crop yield. Similarly, there were significant differences in

approach to the selection of the most effective inoculants, with some scientists saying that these differed by crop and specific soil type, whilst others claimed broad general effectiveness across environments. Some argued for use of single strains, whilst others advocated the use of multiple strains. It was also stated by a senior scientist in the project that N fixation would be assessed by use of "radioactive [sic]" compounds (presumably referring to the stable isotope ^{15}N).

The complexity of the interpretation of studies in this PL is demonstrated by results from a single study conducted in Ethiopia. In summary "Interaction effects of varieties, phosphorus and rhizobial inoculation on the seed yield and yield components of chickpea were found to be highly significant. The highest seed yield (4212 kg/ha) of chickpea was obtained from line ICC-4918 with the application of phosphorous at 20 kg/ha and inoculant strain EAL-029. Line ICC-4918 was supplied by ICRISAT-HQ as a non-nodulating genotype. Interestingly, line ICC-5003 supplied as the most highly nodulating gave the lowest chickpea seed yield (1328 kg/ha) with the application of inoculant strain Chickpea-nodulator. More studies on indigenous Rhizobia and their interaction with chickpea varieties and environments should be undertaken to establish the best combinations for enhanced productivity."

Such findings suggest that the multiple interactions between crop genotype, inoculants strain (or strains), soil type (including phosphate content), and climatic factors mitigate against there being a single strategy in this area of research. However it is not clear that there is an effective system in place to target effort towards the most important objective of optimising yields by exploiting the optimum cultivar/inoculum combinations.

A.1.4.4. Effectiveness

Data show a total of 24 staff (~7.2 FTEs), including the PLC, who is located at the Indian Institute of Pulses Research, Kanpur, India. The other 23 contributors are distributed among the CGIAR centres as follows: ICRISAT (3), ICARDA (6), CIAT (12), together with one IITA scientist and one CIAT scientist who left the programme during the period under consideration.

Among the comments was the claim that at most of the of the partner Institutes dedicated programs to improve varieties for higher BNF are not in place (perhaps with the exception of common bean in CIAT), and therefore crop varieties could not be developed with better BNF efficiency.

However, there is evidence of a great deal of activity, mostly at ICRISAT and ICARDA, both in comparing strains of Rhizobia and crop genotypes For example, 50 genotypes of chickpea and 400 mutant lines of faba bean were evaluated for nodulation by ICARDA, and 296 chickpea accessions were screened under glasshouse conditions. In addition, a variety of carrier materials (for inoculants) were compared, and training for inoculant production was provided.

The efficiency of this diverse range of activity is very difficult to assess.

Evidence from PL1 refers to the fact that research on genotypic variation in N_2 fixing ability in cowpea under low P conditions has proved inconclusive: unfortunately this research effort does not appear to link with research in PL4.

A.1.4.5. Impact

It was mentioned in person, and in other communications that this PL demonstrated some "lack of delivery". In discussion it was stated that whilst ICRISAT was supportive, there was less commitment (no individual champion) from ICARDA or CIAT.

In response to the request for details of specific impact cases, the only one related to research output was that efficient strains of Rhizobia for chickpea had been identified, as determined by nodulation, biomass and seed yield.

It can be concluded that to date, there has been no specific and identifiable impact at the farm level. This is in contrast to the claims made by N2Africa.

The impact statements in the Self Assessment document were of variable quality and did not provide strong evidence to support the claims made. More evidence is required to show that the research finding e.g. novel rhizobium strains is being translated into action that will benefit farmers and growers of chickpea. The Ethiopia project is not well described and it is not possible to get a sense of whether the improvement in productivity that is sought is actually being achieved.

A.1.4.6. Sustainability

The funding for this PL is given in PoWB (2014) as $8.684 m, with the great majority of this sum being assigned to activity cluster 2 (SC2), "Improved sources of SNF with tolerance to other stresses" $5.225 m; and activity cluster 3 (SC3) "High nodulating and nitrogen fixing indigenous Rhizobia identified and characterised" $1.162 m. This latter activity has the somewhat curious OT of "Farmers satisfied and regain confidence in SNF technology". The reason for the previous loss of confidence is not clear.

From POWB 2015 "Budget allocations have modified the allocation in Phase I according to a priority setting exercise at the Product Line level, and reflect the holding of $2M for commissioned and competitive grants as outlined in the extension phase proposal. We anticipate that a high proportion of this will be used for gap filling and to avoid redundancies of core personnel."

The 2015 PoWB shows a total budget for Grain Legumes of $13.8 m from W 1&2 and $26.423 m from W3 and bilateral. Within these totals the PL4 activity was given as $1.253 W 1&2, and $1.018 m from W3 & bilateral, giving a total of $2.271. This disparity between years is due to the fact that funding from TL II was included in the 2014 budget, but that from TLI II was not included in the budget for 2015.

The specific element of TL III associated with PL4 was *Objective 7: Enhancing promiscuous, multipurpose soybean productivity and production in drought-prone areas of sub-Saharan Africa.*

Future funding issues include uncertainty about the potential contribution from TL III to the successor of Grain Legumes.

A.1.4.7. Gender

This issue is given high priority within the aims of Grain Legumes, as part of CGIAR policy. As an example, from PoWB 2015 PL4 is allocated $106 k for gender activities; this is the highest amount of any PLs, and can be compared to just $7 k for PL5. In the POWB for 2014, the PL 4 gender budget was $209 k.

There were multiple encouraging comments from all parts of the PL about the attention that is paid to gender during both project design but particularly to aspects of training.

The M/F ratio of staff in this PL is 4.8/1 while the ratio of research students was 0.7/1.

A.1.4.8. Capacity building

The 20 PhD and 3 MSc students involved in this project represent a large number of potentially valuable sources of new energy and future skills. It is regrettable that this cohort of students did

need not seem to be organised into, or considered as part of, any coherent research community. There is an apparent overall lack of cohesion about PhD students within a single centre (ICRISAT).

Training activities were described by many contributors. Such training often had a notional gender component.

A.1.4.9. Partnerships

In terms of developing partnerships, it was stated in some responses that within Grain Legumes there is ample scope to develop partnerships to carry out activities relating to PL4. It was also suggested that once impact can be demonstrated through R4D and training of partners, the research will certainly help in maximising yields of the targeted crops under harsh environmental conditions where most legumes are known to grow. These comments may be largely aspirational.

Specific comment must be made about the relationship to N2Africa. It is stated in the Extension Proposal that "The BMGF projects Tropical Legumes and N2Africa are strongly aligned with the CRP Grain Legumes, …."

According to POWB (2014) "We will build on databases, information, knowledge and resources developed…..In association with the N2Africa program and other partners, to identify suitable genotypes of grain legumes that can best benefit from (Brady)rhizobial inoculants and improve the nitrogen balance of the soil. (PL4)". The POWB 2015 states "In 2014 there were several discussions with the BMGF funded N2Africa project and some of this work has been re-assigned to Grain Legumes, reflecting the common interests and areas of work."

At most of the of the partner Institutes dedicated programmes to improve varieties for higher BNF are not in place (excluding common bean in CIAT by Steve Beebe), therefore crop varieties could not be developed with better BNF efficiency.

However, at a more recent stage in Grain Legumes, involvement of more partners (by way of dedicated competitive grants involvement of NARS) and support from N2Africa and University of California, Davis has opened new doors for concentrating research for PL4.

Despite this avowed intention to exploit joint approaches, and the fact that during some discussions there was mention of constructive contacts with N2A, there is no evidence of any real collaboration. Also any awareness is much more evident at the senior level of the PL. By contrast, junior scientists in India were unaware of N2A, and conversely, within Africa we found a number of members of N2A who were unaware of the PL, its function and its leadership. This independence of action is exemplified by the fact that the N2Africa January 2015 annual progress report on Phase II, Year 1, makes no mention of Grain Legumes (http://www.n2africa.org/sites/n2africa.org/files/images/images/N2Africa%20annual%20report%20Phase%20II%20Yr%201%20%28narrative%20and%20Key%20Milestone%20tab%29.pdf).

In a different context, there was mention within India of the positive role of NGOs in providing support for the demonstrations of BNF, but the overall value of NGOs did not figure in many discussions.

A.1.4.10. Overall score

Table A1.4.10 summary of PL4 scores.

Category	Maximum score	PL4
Outputs	30	10
Impact	35	10
Environment, coordination, and capacity building	20	10
Gender balance and sensitivity	15	8
Total	**100**	**38**

A.1.4.11. Conclusions and recommendations

Despite the recognised importance of biological nitrogen fixation to the environmental and economic sustainability of cropping systems that include grain legumes, the potential for achieving notable improvements and impact is distant. There is poor coordination of the activities within the PL, especially across continents with the major players in research not acknowledging each other. For example at the senior level there is recognition of ongoing activities across continents, but at the scientist level this is not so; research is undertaken oblivious of similar activities on other continents. Additionally, the strong interactions between crop variety, inoculant strain, soil type and climate augur for site specific, rather than generalised recommendations. This is reflected in part by the low number of publication, almost all with no impact, and the lack of impact at the farm level; although N2Africa claims impact in its publications that impact was not claimed by the GL CRP. The lack of overalls uses in the PL was also attributed to the lack of qualified staff, particularly microbiologists, to direct and undertake the research, and we recommend that this be addressed in the short-term. On the positive side, gender equity is good in the PL as is the number of students being trained for PhDs, but the cohort does not represent a coherent group able to create synergies across activities.

A.1.5. Product Line 5: Insect-smart chickpea, cowpea, and Pigeonpea production systems

The target countries are Benin, Burkina Faso, Ghana, India, Morocco, Nigeria.

The PL relates to **IDO 2, 4 and 5** which are:-

- **IDO2** Income: Increased and more equitable income from grain legumes by low income value chain actors, especially women
- **IDO4** Productivity: Improved productivity of farming systems, especially among smallholder farmers
- **IDO5** Environment: Minimized adverse environmental effects of increased production and intensification of grain legumes.

A.1.5.1. Relevance

This PL has relevance to a subset (chickpea, cowpea and pigeon pea) of the 8 CRP legumes. It aims to use a variety of approaches to improve the resistance of these selected crops to important insect pests, one of the key biotic stresses. For example, it is quoted in the Grain Legumes proposal that such pests, in particular the pod borers *Helicoverpa armigera* and *Maruca vitrata* cause an

estimated loss of over $1 billion annually. We were informed during our visits that the average annual losses of cowpea due to insect pests amount to 3.8 m tons which equates to ca. $3 billion.

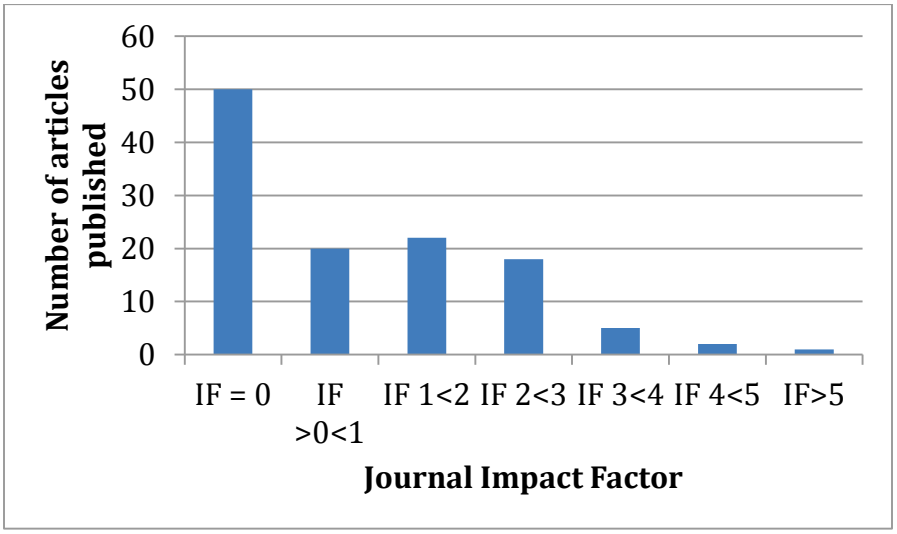
There are also undoubted environmental and possibly health problems associated with the unregulated market of agrochemical imports from the Asian market into West Africa. When in Benin we were shown an empty container of Chinese manufactured generic glyphosate imported unofficially from Nigeria. Although nothing to do with insect pests, this simply illustrates the poor control over any agricultural inputs. This container had application details in English, which could not be understood by farmers, and was used with the help of extension specialist who have to accept such trade in unlicensed products.

A.1.5.2. Efficiency

From all available sources of information this PL seems to be organised in a coherent and efficient manner, which combines high quality science with a practical and effective link to the farming sector. Obviously the change in status and loss of the ICARDA facility in Syria may have affected performance but there is confidence that this will improve when the new facilities in Morocco are established.

A.1.5.3. Quality of science

Figure A1.5. Publications from PL5 ranked by impact factor of the journals they were published in.



The majority of papers in this PL were without an impact factor (Figure A1.5). An evaluation of the top 10 outputs by PL5 is given in Table A1.5.

Table A1.5. Quality assessment of nominated papers from PL5.

Output	Synopsis of output	Quality rating out of 15
1	Identification of a viral/botanical insecticide treatment that protects cowpea from insect attack in the laboratory and under field conditions. May provide a useful approach for integrated pest management.	11
2	Evidence is presented using sequence and microsatellite marker data to indicate that variation in host plants does not influence the genetic variation of the insect pest *Maruca vitrata*. This observation has implications for insect resistance management practices and the application of biocontrol agents.	11
3	A laboratory evaluation of the effects of host specificity and competitive ability of the parasitoid *Apanteles taragamae* on *Maruca vitrata*. The data may be useful in assessing intrinsic completion between parasitoid species.	10
4	The paper describes the deliberations of an expert panel convened in 2009 on the environmental risk of the use of Bt-cowpea and specific issues related to gene flow, the impact on non-target organisms, and the management of insect resistance using GM crops.	12
5	A study to assess the capacity of cultivated pigeon pea accessions and its wild relative to host the pod borer parasitoid and their use in integrated host management strategies.	10
6	Study to determine if oxalic and malic acids present in chickpea leaves might affect the biological activity of Cry1Ac toxin protein and reduce the efficacy of Bt-cowpea as a strategy to control the pod borer *Helicoverpa armigera.*	10
7	A range of flavonoids such as chlorogenic acid, caffeic acid, gentisic acid, trihydroxyflavone, catechin and protocatechuic acid, in addition to the lectins, GLL and ConA were analysed to determine their potential use in insect control programs.	9
8	Demonstration that gut microflora of *Helicoverpa armigera* can influence toxicity to Bt and the consequence of this on the use of foliar sprays or GM strategies to control the pod borer.	10
9	Review of the impact of global warming on pest control strategies and the use of long term monitoring of insect populations as an 'early warning' indicator to assess environmental risk.	9
10	Not identified	-
		Overall quality rating ~ 10

During the period from 1st January 2010 to 31st March 2015, a total of 118 publications were reported, with 68 of these being in journals assigned an impact factor (highest 9.81). There was one publication with authors from IITA and ICRISAT and one review article which had authors from three centres. There were several papers from ICRISAT that had co-authors from a range of India universities and other NARS partners.

Investigation after the receipt of data from the PL revealed several publications not included in the submitted list and emphasises the difficulty in establishing the actual output from this (and other PLs) in the absence of a centralised and up to date archive of publications. It should be noted that regrettably the Grain Legumes site for publications for 2014 (http://grainlegumes.cgiar.org/products/publications/research-publications/) is not working.

This high level of overall publishing productivity (c. 5.2 publications per FTE per year) provides strong evidence of a flourishing programme with strong leadership and a good international impact that is widely recognised. For example, the PLC is a member of the committee for the XVIII International Plant Protection Congress, and Hari Sharma is a former president and present council member of the International Congress of Entomology.

A.1.5.4. Effectiveness

Data show a total of 11 staff (~4.5 FTEs). The PLC is based in IITA in Benin with other participants based in ICRISAT and ICARDA. There appears to be good communication and knowledge of mutual activities.

A.1.5.5. Impact

This PL has developed effective methods for the biocontrol of insects. These methods also have the additional value of promoting a "cottage industry" of women groups and/or unemployed youths to create a steady supply of biological control products and thereby provide an additional source of household income.

At a commercial level an exclusive MOU is in place between the Government of Benin, IITA and the company Elephant Vert for exploiting a fungal strain of the entomopathogen *Beauvaria bassiana* in the world's largest production unit in Meknès (Morocco). Surprisingly, neither this project nor the facility was mentioned during our visit to this location in Morocco.

The impact statement in the Self Assessment document was very poor, only one example was provided of biological control of the pod borer *Maruca vitrata*, and no detail was provided to evidence the impact or to describe what the nature of the field data were or how they achieved pest control and if/how recommended practices were being disseminated or adopted by local farmers.

Screening trials have yielded extremely positive results and there is a clear plan of the next steps to rolling out the parasitiod release to the wider community. One of the other impact cases presented (commercial formulations of bio-pesticides) used research-based evidence to show the efficacy of the new products over existing alternatives and demonstrated that private partnerships had already been established to provide a route to commercialisation.

A.1.5.6. Sustainability

The funding for this PL is given in PoWB (2014) as $4.821 m, with the majority of this sum being assigned to activity cluster 2 (SC2), "Developing and deploying durable insect-resistant traits" $3.009 m with the OT being "Breeders have access to new sources of durable resistance to key

insect pests which can produce in average 30% more yield and need 50% less insecticide sprays". The budget for activity cluster 3 (SC3) "Developing and deploying sustainable IPM systems" received $537 k. This latter activity has the OT of "Farmers can make informed decisions about IPM options to be deployed depending on a variety of agronomic and environmental factors".

From POWB 2015 "Budget allocations have modified the allocation in Phase I according to a priority setting exercise at the Product Line level, and reflect the holding of $2M for commissioned and competitive grants as outlined in the extension phase proposal. We anticipate that a high proportion of this will be used for gap filling and to avoid redundancies of core personnel."

The 2015 PoWB shows a total budget for Grain Legumes of $13.8 m from W 1&2 and $26.423 m from W3 and bilateral. Within these totals the PL5 activity was given as $1.367 W 1&2, and $714 k from W3 & bilateral, giving a total of $2.018.

Future funding issues include uncertainty about the potential contribution from TL III to the successor of Grain Legumes. Also there is concern within IITA that the aging buildings and equipment will need to be replaced and this seems only to be possible through W3 and bilateral projects. Comment may be made to the extract from the document describing the key assets and benefits of CGIAR "The multi-donor trust fund provides reliable and predictable financing to enable long-term planning and pools resources to support big-ticket research that aims to deliver step change."

A.1.5.7. Gender

Overall, this issue is given high priority within the aims of Grain Legumes, as part of CGIAR policy.

However, from PoWB 2015 PL4 is allocated only $7 k for gender activities; this is the lowest amount of any PLs, and can be compared to $106 k for PL4

There was evidence from many presentations and from personal contact, for example with groups of women farmers in Benin, that gender is not only considered but is also central to both extension and training programmes.

The M/F ratio of staff in this PL is 10/1 while the ratio of research students was 1.8/1.

A.1.5.8. Capacity building

The 33 PhD and 3 MSc students involved in this project cover a wide range of disciplines and hopefully will provide a large number of well-trained personnel.

Other improvements in human capital will be provided by expert training being provided to many farmers, many female, in techniques for production of biopesticides and natural IPM-compatible compounds such as neem oil.

A.1.5.9. Partnerships

It was stated in the original proposal that the main R4D partners would be NARS in the prominent chickpea, cowpea, and pigeonpea growing countries. In addition, "NGOs and farmer groups will participate in on-farm evaluation and dissemination of information." From evidence presented on wide scale farmer participation in many countries it seems that this ambition has been met.

Likewise there has been constructive research interaction with other partners exemplified by participation in the GIZ-project on parasitoids with AVDRC.

There was less evidence of a strategic approach to the integration of the Bt cowpea available from AATF and also no apparent policy on whether to produce and test other insect resistant

transgenics. This is despite the section in the proposal "Identifying novel genes and traits to confer resistance to the target pests, and assessing their suitability as candidate genes for genetic engineering in chickpea, cowpea, and pigeonpea will be important for developing a package for sustainable protection of these crops. Platform technologies for resistance to the target insect pests will be developed using novel resistance genes from *Bacillus thuringiensis* in combination with lectin and protease inhibitor genes. Efficient gene-promoter combinations will be the key to develop insect-smart transgenic plants in chickpea, cowpea, and pigeonpea, and for identifying novel genes and traits for insect resistance for sustainable protection of these crops from the ravages of pod borers." Without a change of emphasis and focus it is not likely that the project will meet the five year target, namely "Chickpea, cowpea, and pigeonpea transgenic events with high levels of resistance to pod borers developed and characterized". Similarly the extension proposal states the following objective under *IDO5 Environment: Minimized adverse environmental effects of increased production and intensification of grain legumes:-*

"Reduction of yield losses by 35% in cowpea due to the adoption of IPM innovations based on host plant resistance (including Bt-transgenics), biological control and bio-pesticides, thereby reducing the use of synthetic pesticides by at least 25%."

A.1.5.10. Overall score

Table A1.5.10 summary of PL5 scores.

Category	Maximum score	PL5
Outputs	30	25
Impact	35	25
Environment, coordination, and capacity building	20	18
Gender balance and sensitivity	15	10
Total	**100**	**58**

A.1.5.11. Conclusions and recommendations

Costly losses to insect damage and the negative health and environmental impacts of current chemical control measures strongly justify the search for alternative practices to manage pests in grain legumes. The research and development in this PL is efficiently organised, bringing together research across three centres (illustrated by a three centre co-authored and other high impact publications). The leadership in this PL is internationally recognised, and field-level impact is imminent, building upon investments in gender and age-related training interventions, strengthening of extension services and encouragement of commercial ventures. On-farm dissemination of non-chemical approaches to pest management is exemplary, but efforts to introduce novel genes and traits into grain legume species for host plant resistances are weak, and unless the focus of research is changed significantly will not deliver the projected goals in reduction of synthetic pesticides through development and characterisation of chickpea, cowpea, and pigeonpea transgenic events with high levels of resistance to pod borers.

A.1.6. Product Line 6: Extra-early chickpea and lentil varieties

A.1.6.1. Relevance

Product Line 6 aims to increase the use of chickpea and lentil varieties within intensive cereal cropping systems, thus increasing farm income. Although not stated, this would also improve the nutritional diversity available to people in the target regions of South Asia and Sub-Saharan Africa since the amino acid profile of legume crops is different to that of cereals and the optimum diet contains proteins from both sources. Short season varieties are preferred because in the rice-dominated system the crop is usually grown on residual moisture and needs to mature before terminals tresses associated with temperature which reduces fertility and grain growth. The target areas for chickpea are the Andhra Pradesh and Karnataka states of India and for lentil the project is expanded to include Bangladesh, Nepal and Eastern India. The barriers and requirements for chickpea and lentil variety adoption in Ethiopia, Eritrea and the Sudan are also considered. The adoption of short duration improved cultivars in Indian states is extremely successful, particularly in more southerly Andhra Pradesh where 98% of chickpea grown is short duration, leading to a ten-fold increase in productivity and a consequent commercialisation of the crop. The situation in Karnataka is more risky, since a single variety (JG 11) is used by 65% of the cropping area; reliance on such a narrow genepool gives poor resilience to biotic or abiotic challenges in the future. The PL therefore faces the challenge of developing crop varieties that can reliably mature within a very short season and which can be managed without an enormous change in the agronomic infrastructure available to farmers. This necessitates the development of local-level crop management practices, better developed through bilateral special projects than global CGIAR research projects rather than aiming to provide global recommendations. Activities in the PL span pre-breeding and breeding programmes underpinned by physiological understanding of biotic and abiotic stress, evaluating and demonstrating the impact of season and environment on crop performance and working with the whole supply chain to facilitate adoption of the new varieties.

A.1.6.2. Efficiency

The CGIAR institutes (ICRISAT and ICARDA) and some of the NARS partners (IIPR, IARI) are using both control environment facilities and experimental fields, while other NARS partners are using experimental fields. There is a Center of Excellence in Genomics (CEG) at ICRISAT and also the Platform for Translational Research on Transgenic Crops (PTTC) at ICRISAT. It is unfortunate that these facilities do not get used by many other teams (ICARDA) within the product line, although we are aware that Fida Aloe from ICARDA but based at ICRISAT is engaged in sequencing ICARDA germplasm lines at CEG.

A.1.6.3. Scientific quality

It was not possible to assess the range of output quality as the PL did not supply impact factors, however the top ten publications scored fairly well (Table A1.6). Publications from ICRISAT and ICARDA were completely separate, showing very little cooperation across the PL, but there was good evidence of collaboration with external institutions e.g. IIPR, IARI, BARI, University of

Saskatchewan, PAU, UC Davis, University of Frankfurt. Of the 101 outputs listed only 16 had a female author in first or last position on the author list.

Table A1.6. Quality assessment of nominated papers from PL6.

Output	Synopsis of output	Quality rating out of 15
1	A review of the opportunities of using translational genetic analysis in legume crops to improve crop productivity and enhance food security in developing countries.	9
2	An analysis of allelic variation in early flowering genes in chickpea and their impact on yield under differing environmental conditions with a view to exploiting this information in breeding strategies.	10
3	A field evaluation of F_4 progenies of both *desi* and kabuli lines of chickpea showing that the grain yields were lower in all the kabulis as a consequence of reduced total shoot biomass and harvest index. The conclusion form this study was that introgressions between these breeding lines might improve both the adaptability and yield stability when grown under peninsular Indian environments.	11
4	Use of chromosomal genomics tools to identify misassembly in the draft *desi* genome of chickpea. This approach has value not only to enhance new genome assemblies but also to complement currently applied genome assembly strategies.	11
5	Same publication as 2.	-
6	High profile report of the reference genome sequence of chickpea and an assessment of its value in the identification of the genetic basis for a range of agronomically important traits.	15
7	A report that demonstrates that by using an SNP approach it is possible to demonstrate a high degree of synteny between the chickpea and the *Medicago truncatula* genome , followed by *Glycine max*, *Lotus japonicus* and least with *Vigna unguiculata*. Development of cost-effective CKAMs for SNP genotyping provides a useful approach for crop breeding in chickpea and also in other model legumes.	12
8	Demonstration that folate concentration in lentils shows a significant year × location interaction and that possible location sourcing may be required for future lentil folate research.	10
9	Characterisation of *Lens* taxa, originating from twenty seven counties under two agro-climatic conditions of India. The results showed wide variations for almost all yield attributing traits including multiple disease resistance in the wild species, *L. nigricans* and *L. ervoides* accessions.	11
10	A molecular characterisation of the genetic diversity of 53 Moroccan lentil landraces using simple sequence repeat (SSR) and amplified fragment length polymorphisms (AFLP). Functional grouping according to agro-environmental origins, cycle duration and early vegetative vigour was observed.	11
		Overall quality rating ~ 11

There is evidence of collaboration between PL6 and other PLs that lead to publications, particularly PL2 and PL7, although PL3 and PL8 are also mentioned. There is very little inter-centre collaboration although the group works well with several institutes outside of the PL.

A.1.6.4. Effectiveness

The staff on PL6 constitute 7.3 FTE; with 8 females and 38 males; 19 are based at NARS, 16 ICRISAT, 9 ICARDA and 2 at an ARI university.

As with PL7, constraints and opportunities for extra-early chickpea and lentil varieties in target areas and their respective cropping systems have to be identified. Collaboration with North Carolina University has the potential to address this by modelling development, growth and yield of lentil in different environments and could be integrated better with other projects. Additional development of the GIS mapping activity with ICAR has helped to ensure that appropriate areas are used for lentil crop cultivation. Adoption of new varieties in African countries is clearly much slower (some exceptions do exist, e.g. in target countries such as Ethiopia) and a clear pathway to define how this effort will be intensified is required. The work in this PL to develop a Breeding Management System under the programme coordinated by the Global Challenge Programme, ICARDA and Bioversity International is to be applauded and really should be taken as an example of best practice of how other types of germplasm across Grain Legumes should be recorded in a standardised way.

There is an intensive breeding programme aimed at identifying extra-early germplasm with resistance to key biotic and abiotic stresses. Populations for *Fusarium* resistance are down to F7 generation in some cases which means that they should be homozygous at nearly every locus; however it appears that there is no sequence information underpinning this project and all selection is on the basis of phenotypic performance in the field. Whilst this phenotyping is essential and important, the use of this genetic resource could be greatly improved if markers were available and scored across the populations. A marker-assisted breeding approach could then be implemented which would fast-track the development of new varieties. There is a considerable sequencing effort underway of the 3000 accessions in the chickpea composite collection. It is not clear if these included the parents of the mapping populations described in this PL but if not then these two activities need to work with greater synergy. There also needs to be a greater transparency of how the HiSeq data will be processed and used and whether adequate informatics human and financial resources exist to capitalise on these data. Similar conclusions can be reached for programmes which are addressing *Ascochyta* blight (PL 2) and *Stemphylium* blight; some extremely valuable populations and phenotyping data are available and these need to be underpinned by molecular marker development.

In contrast to the comments above about disease resistance programmes, the early flowering activities have taken a molecular approach from inception so that SNP and SSR markers are in place for a number of genes linked to early flowering. Whilst only at F2 stage these populations will have a wide utility and the recommendation is to assess whether they capture diversity for other traits of agronomic importance. The activity is generating quality publications and the availability of the chickpea reference genome published in Nature Biotechnology by ICRISAT staff is helping to fast track this programme. A trait to gene approach is being used to underpin the selection of candidate resistance genes for *Fusarium* wilt and this work needs to be joined up with the phenotyping activities mentioned earlier. The results illustrated from introgression lines are looking very promising in the laboratory and a clear plan for how translation to the field and uptake of the new germplasm is required. Other genetic resources for chickpea and lentil include TILLING and RIL populations, the latter having been trialled in ten different environments. Good

evidence is provided to support the value of these populations e.g. a marker for rust resistance has been identified in lentil through screening of the RIL population; there now needs to be a refinement of the markers in this region of the genome so that one can be identified that is more closely associated with the trait and which cannot be disassociated through a recombination event in a breeding programme.

Activities that evaluate environmental effects on extra-early germplasm performance with adaptation to different short season environments and improved grain quality are thorough in this PL for Indian locations. Unsurprisingly, the G x E effect is significant and different varieties performed better in different locations. Multi-season analysis is required in the following years to gain a true understanding of performance of these lines. Evaluation of introgression lines of chickpea formed from introgression of a QTL hotspot relating to drought tolerance related traits from ICC 4958 into the cultivar ICCV 10 (widely adapted desi chickpea variety grown in India) through marker assisted backcrossing (MABC) produced similar results with very few lines showing good performance at three or more locations. Stacking of traits conferring resistance to multiple biotic stresses is extremely important to increase overall resilience of the germplasm in this regard. Chickpea lines (300) have also been evaluated in multiple sites in Lebanon and Morocco by ICARDA. Fewer data are reported and links to markers do not seem to exist**.** Lentil screening programmes are also extensive in these countries and useful lines for future introgression programmes were identified; the range of traits screened which span flowering time, nutritional value, cooking traits and yield is to be commended, but again this needs to be underpinned by marker development. Greater interaction between ICARDA and ICRISAT is required to produce a coordinated research programme.

Activity for integrated crop management practices for extra-early varieties of chickpea and lentil for short season environments includes the development of novel biocontrol material in an interesting project to use microbial-derived metabolites as antagonists to fungal diseases. This is early stage research and needs a clear plan for how it will be taken forward. Commercially available fungicides were also evaluated, without great differentiation between the performances of each. There is a lack of value in assessing fungicide performance (however the chemical is derived) on its own; researchers pointed out that in some cases development of the target disease was poor so the chemical performance could not be properly evaluated. This type of research must be conducted in association with the agrochemical industry to maximise research gains. A more holistic approach is required that coordinates an understanding of the disease pathology and epidemiology, new chemicals before they become commercially available, together with agronomic practice such that recommendations can be made for how best to avoid disease development and what treatments confer maximum efficacy of chemical treatments e.g. time of day of application, crop water status, plant developmental stage.

The seed systems are well described and supported by metrics. However, it is not clear if the numbers represent sufficient seed supply and what proportion is used for domestic use and what is available for the commercial market and farmer profit. The PL recommends the development of an alternative seed systems model based on local village based seed enterprises (VBSE) which suggests that the current model is not ideal. There is good vision associated with the VBSE, but a lack of clarity about how the structure would be developed and adopted from first principles. A coordinated project to survey farmers' needs and to evaluate the performance of new crop varieties was undertaken through ICARDA, ICRISAT and the M. S. Swaminathan Research Foundation. The data supplied suggest that this approach yielded promising results but not enough detail was provided to understand if the training activities resulted in efficient and wide

dissemination of knowledge and uptake of best practice beyond those who were trained directly. Better data were provided to support the success of adoption of new chickpea varieties in India in Rainfed Rice Fallow Lands and on-farm demonstrations are an effective way of transferring knowledge into practice. It also appears that the additional demand for new seed (30 tons) was met. Lentil production technologies were also successfully demonstrated in SE Asia and SS Africa. Metrics were provided to indicate how many women farmers were trained in each location. The proportions are not high and an indication is required for how that can be improved, but the provision of the metrics at this stage is welcomed.

A.1.6.5. Impact

The data provided to describe impact in this programme within the annual report were very poor. Quantity of seed produced and distributed at a statement that varieties have been adopted does not constitute evidence of an impact. However, the information provided in the Self Assessment document by the CCEE was far more extensive and shows that this PL is reaching its target audiences and making a difference to the farming communities, the resilience, utility and quality of the crops they work with.

The major example of documented uptake of lentil varieties was in Bangladesh, which grows about 165,000 ha of lentil and has traditionally imported more than half of its consumption. Key scientific enablers in establishing a thriving rice-lentil system Bangladesh are the new higher-yielding short duration lentil varieties (BARI Masur 4, BARI Masur 5, BARI Masur 6 and BARI Masur 7 which draw on ICARDA breeding lines) resistant to common diseases (rust and *Stemphylium* blight). Extensive training of rice farmers underpinned their managing of the new lentil crops. This has led to increase in lentil production from 126,000 tonnes in 2001 to 210,000 t at present, mainly because of yield increase from 790 kg/ha in 2001 to 1270 kg per ha. Grain Legumes W1/W2 funding from ICARDA has enabled this work to continue following on from HarvestPlus and Australian funding. The improved technology has spread to more than 85 percent of the lentil area in Bangladesh alone, bringing in an additional annual income of US $26.6 million. For small-scale farmers numbering ~ 1 million, obtaining a harvest of lentils from the piece of land that formerly only produced rice, has not only improved their livelihood but also nutrition for their families.

Distribution of ca. 66,000 t of quality chickpea seeds (breeder, foundation, certified and truthfully labelled) in East Africa and South Asia. Some ‘back-of-the-envelope’ estimations put this in context: this is approximately 15% of the total seed production for this region according to the 2012 FAO statistics. Assuming a seeding rate of ca. 100 kg seed per ha this corresponds to an area of 660,000 ha under cultivation from seed directly attributable to this programme (approximately 6.5% of the c. 10 million ha cultivated in 2012). Note that adoption rates of the improved seed must be higher because some seed from our activities is already in the seed system (both formal and informal). A conservative estimate is that chickpea fixes >50 kg N /ha, and the price of urea (a cheap source of nitrogen) is $340/t (urea is about 50% N), so the area of cultivation of these seed alone would alone contribute about $23 million from N fixation.

A.1.6.6. Sustainability

Work in this product line is far-reaching and generally well-coordinated. It relies on activities across two institutes, ICRISAT and ICARDA, and particularly on good coordination between Dr Pooran Gaur and Dr Shiv Kumar Agrawal. The small numbers of people and institutes involved have resulted in efficient working practice and this PL was the most productive from the whole CRP, despite having the smallest number of FTE staff. The PL is sustainable and the majority of the

activities within it are delivering good results, with some areas requiring better coordination of activity (or reporting of activity), perhaps achieved by merging some of the activities around the development of genetic resources and molecular markers with the activities to evaluate and phenotype populations.

A.1.6.7. Gender

Gender practice aligns with CGIAR policy, although the implementation of the new policies is not yet being felt throughout the PL. Postgraduate representation is poor with only two females in the cohort of nine. Only a third of farmers trained in Nepal were women, although a far higher proportion of women attended training or took part in demonstration trials. Women from ICRISAT or ICARDA are rarely occupy first or last author positions on the publications listed and only 8 women work on PL6 compared to 38 men.

A.1.6.8. Capacity building

Six PhD students and 3 Masters are low numbers for postgraduate training, in fact the lowest of all PLs, and are biased away from female representation (7 males: 2 females). Capacity of stakeholders related to development and cultivation of extra-early legumes strengthened. But this activity appears to be a rather patchy collection of isolated activities to train individual researchers. Whilst good for individual career development the registration for a PhD or attendance at a training programme/conference is not indicative of strengthening capacity on its own.

Massive training of farmers, by partners, is impressive, with a total of 1535 farmers including 494 women farmers in Nepal, 2255 farmers in Bangladesh and 3930 farmers in India through organisation of field days and training programs on lentil improved technologies. **There needs to be a clear pathway to show how training received will be disseminated to a wider audience so that knowledge can be pyramided throughout institutions and communities.**

A.1.6.9. Partnerships

The majority of the work is taking place in India, although Sub-Saharan Africa is a major user of the crops developed. CGIAR centers (ICARDA and ICRISAT) and NARS are involved in development of technologies, while NARS, government and non-government extension agencies, NGOs, public and private seed agencies, and farmers in target countries (India, Bangladesh, and Nepal) are involved in final evaluation and dissemination of technologies. Various ARIs are involved in cooperative research: ICRISAT has signed an agreement with Punjab Agricultural University, Ludhiana, India for screening of chickpea breeding materials for resistance to AB under field conditions at Ludhiana. ICARDA has signed MOAs with University of California-Davis and University of Saskatoon–Canada for lentil genome sequencing, North Carolina State University-Raleigh for development of a lentil growth and development model, Washington State University-Pullman for development and validation of EST-SSR markers, and North Dakota State University-Fargo for bio-fortification of short duration varieties of lentil with Fe and Zn. Similarly, ICARDA has carried out some activities through MOAs with national partners in India (IIPR, Kanpur; PAU, Ludhiana; BCKV, WB; JNKVV, MP), Sudan, Egypt, Morocco and Ethiopia.

A.1.6.10. Overall score

Table A1.6.10 summary of PL6 scores.

Category	Maximum score	PL6
Outputs	30	10
Impact	35	30
Environment, coordination, and capacity building	20	12
Gender balance and sensitivity	15	8
Total	**100**	**60**

A.1.6.11. Conclusions and recommendations

This is a strong Product Line, delivering high quality outputs in terms of academic significance and the difference that is being made to target communities. There is a strong recommendation to use the example from this PL of how new germplasm is recorded in the Breeding Management System (coordinated by GCP, ICARDA and Bioversity International) and to expand across all other PLs and grain legume crops. The Product Line has generated some excellent genetic resources in terms of different types of mapping populations and germplasm collections. Many of these are underpinned by excellent phenotyping data in different locations and seasons whereas others have been associated with considerable effort to provide a good genetic marker framework. However, there is a need for greater coordination so that a more effective programme of marker assisted breeding can be developed across the range of populations and traits of interest so that ultimately the development of new varieties and introgression into elite commercial lines can be fast tracked. Although coordination between ICARDA and ICRISAT is good this is an area which requires considerable strengthening of that relationship and more joint programmes. It would also be useful to coordinate and expand phenotyping efforts so that multiple traits of interest e.g. flowering time, nutritional value, cooking traits and yield are assessed simultaneously and in parallel to disease incidence. There are some interesting developments in terms of tackling fungal disease but the approach is too fragmented at present. A more holistic approach is required that coordinates an understanding of the disease pathology and epidemiology, together with agronomic practice such that recommendations can be made for how best to avoid disease development and what treatments confer maximum efficacy of chemical treatments e.g. time of day of application, crop water status, plant developmental stage. There needs to be a clear pathway to show how training received by individuals will be disseminated to a wider audience so that knowledge can be pyramided throughout institutions and communities.

A.1.7. Product Line 7: Herbicide-tolerant, machine-harvestable chickpea, faba bean and lentil varieties

A.1.7.1. Relevance

Parasitic and non-parasitic weeds continue to be a major production constraint to grain legume production, competing with crops and often leading to significant yield losses of up to 40% in legume crops. Manual weeding has become uneconomical and impractical for many smallholder farmers and effective herbicides are not yet available.

The rather disparate goals of generating herbicide tolerant grain legumes and improving varieties so that harvest can be mechanised were combined in a single Product Line as both are viewed as labour saving. Farmers, mostly women, are presently subjected to the drudgery of hand weeding and hand harvesting the crops and provision of new varieties that lessen these requirements will be most welcome. A range of approaches are taken, including traditional and mutagenesis breeding methods. This is coupled with *in silico* mapping of candidate genes, development and evaluation of agronomic practice to adapt to mechanisation and a series of training courses to disseminate the work.

A.7.2. Efficiency

The PL sets out to address some important goals but at present falls short of working efficiently with other PLs and in coordinating projects within its own PL. There is little evidence of coordination of activity across continents and whether findings such as genes encoding herbicide tolerance or resistance to parasitic weeds could usefully be shared across projects working on the same type of crop. Training courses are more efficiently organised; in 2014 a training course on "Pre-breeding and crop improvement in legumes" was organised at ICRISAT-Patancheru in which 25 scientists (23 men + 3 women) from 14 countries of South and Southeast Asia and Eastern and Southern Africa. Similarly, a training course on "grain legume improvement was organised by ICARDA in Terbol, Lebanon in which 22 NARS partners (4 women) including 9 researchers from South Asia, 3 researchers from Sub Saharan Africa and 10 researchers from CWANA participated. Five trainees (1 female) participated in the course on variety maintenance and village based seed enterprise in Morocco.

A.1.7.3. Scientific quality

This product line produced 13 outputs per FTE over the assessment period, although less than half of these were in journals with an impact factor on average. Good quality outputs were identified in the top ten from the PL (Table A1.7) and many were in high-ranking journals. Very few publications had female first or last authors from the product line. Journal impact factors were not provided for each of the publications so it was not possible to do a broad analysis of publication quality from all those listed. A good spread of PLs were co-authors on publications, although usually within the same CGIAR institute. Only one conference paper has authors from ICRISAT and ICARDA, but many (33) are produced in cooperation with NARS, 10 with ARIs and 4 with developing country universities, out of a total of 91 published outputs.

Table A1.7. Quality assessment of nominated papers from PL7.

Output	Synopsis of output	Quality rating out of 15
1	Use of chromosomal genomics analysis to validate the quality of genome sequencing in chickpea. The data show that integration of chromosomal and genome sequencing could improve the quality of new and published assemblies.	12
2	High profile report of the reference genome sequence of chickpea and an assessment of its value in the identification of the genetic basis for a range of agronomically important traits.	15

3	Critical review of the use of contemporary breeding approaches such as marker-assisted recurrent selection and genomic selection to develop legume crops that show enhanced tolerance to environmental stresses.	12
4	Description of how genic markers on a large-scale can be employed, together with easily assayable markers, and a transcript map to analyse the genome of chickpea and provide opportunities to optimise plant breeding strategies.	12
5	Description of the establishment of novel molecular markers such SSR and DArT to construct a high density map in RILs of Chickpea	11
6	A study to confirm the presence of a new and highly virulent pathotype of Ascochyta blight disease of chickpea.	11
7	Analysis of yield stability of hybrid bulk populations of Faba beans to *Orobanche* infection. Although some populations exhibited resistance/tolerance their yield potential in non-infested soils was low.	11
8	Identification of 7 QTLs related to *Orobanche* resistance in faba bean and genetic demonstration that a single QTL may provide resistance to both *O. crenata* and *O. foetida*	11
9	The report of a field experiment to identify faba bean germplasm exhibiting resistance to Orobanche. The study revealed that a significant genotype × environment interaction exits in the legume material and that some accessions showed significant levels of resistance that were stable across environments.	11
10	Validation of the use of syntenically anchored polymorphisms from Medicago and faba bean to map a flower colour gene.	13
		Overall quality rating ~ 12

A.1.7.4. Effectiveness

Staff in PL7 constitute 6.7 FTE, comprised of 7 females and 32 males, of which 17 are from NARS, 6 ICRISAT and 16 ICARDA.

A report on scope and implications of the cultivation of herbicide tolerant legume cultivars and mechanical harvesting of legumes, including potential impacts on farm women is still a work in progress. It would have been better to complete this ahead of progressing the research programme.

Quantification of the gains provided by mechanisation of harvest needs better definition and comparison between harvest methods in terms of efficiencies and crop losses is needed. Availability of suitable varieties of chickpea and availability of machines constrain the mechanisation of harvest. Although the private sector will, in some countries, step in to fill the harvester gaps (as seen with the shift southwards of harvesting machinery in India for the some

crops) promotion of community-based harvesting cooperatives will be required since outright purchase of harvesters by individual farmers will be impossible. Given such problems with the overall delivery it is important to identify the PL targets, but this work does not extend to providing a roadmap of how to solve the issues.

A relatively traditional breeding programme has been used to isolate herbicide tolerant chickpea lines in India. However, very few data are presented and it appears that the trial was not properly replicated i.e. there are no accessions grown in all four locations studied. Control data for crops not sprayed with herbicide are omitted. There is a suggestion that herbicide tolerant crops from this programme were also high yielding, however, insufficient evidence was presented to make this conclusion. An experiment in Terbol, Lebanon on chickpea also claimed significant differences between different herbicide doses, but since the amount of crop damage was still nearly 100% in some cases then it is doubtful if the herbicides exerted any efficacy relative to the unsprayed control. There were several experiments testing different herbicides in different locations on different crops, ranging from Morocco to Lebanon and India. Some mutagenised faba bean lines were also subjected to glyphosate and two lines were found to be tolerant. This line of research is rather touch and go. The focus on herbicides such as imazethapyr, glyphosate, pendamethalin and Aclonfen is worrisome as genes for tolerance readily evolve within natural weed populations, hence new chemistry herbicides, in close association with agrochemical companies, should currently be being screened in this PL. The recommendation is to perform more focused studies on fewer crops and chemicals that are better replicated, controlled and analysed. The data presented on *Orobanche crenata* virulence has had an impact in identification of the most virulent isolates in Egypt, and several lentil and faba bean lines displaying resistance have been identified, but it is not always clear what the result of a considerable amount of work is. *O. crenata* and *O. foetida.* It would be useful to have an evaluation of how translatable this work is across continents.

In searching for plant type for machine harvest and genotypes with desired traits identified a number of chickpea lines with an erect growth habit that are suitable for mechanical harvesting have been identified. Similar searches were conducted with faba bean and lentil and combined in some cases with a screen for herbicide tolerance. Lines were selected as being suitable for mechanical harvest in all species. In pyramiding genes (but not using molecular techniques) at least 10 breeding lines combining herbicide tolerance and traits suitable for machine harvest have been developed each in chickpea, faba bean and lentil. Considerable amounts of data are presented but no conclusions are reached. The programme seemed somewhat fragmented and there was no identification of a clear path of progression from this point forwards which should presumably refine and improve the lines further across different locations so that they are suitable for adoption by farming communities.

In efforts to search for markers for herbicide resistance in chickpea, there was a re-sequencing effort of 40 herbicide responsive accessions but it was not made clear how sequence variation was linked to herbicide resistance. The RIL mapping populations will be a useful resource for understanding herbicide tolerance, particularly as they are linked by a common parent ICC 14077. However, no detail of the eventual number of lines in each population is given nor if they will be descended from single seed descent. The project talks of the development of molecular markers but this is only possible with genome/transcriptome sequence. Since populations are also being developed in these crops in other PLs it is recommended that efforts be coordinate to streamline the number and type of populations developed so that there are fewer populations to maintain, but each is better described at a molecular and physiological level.

Transgenic events generated and evaluated for herbicide tolerance in chickpea. This is an ambitious project and showed promising results from the leaf swabbing assays, but unfortunately spraying assays were not successful and there was no provision of data from molecular testing to establish why the plants were not resistant; it would be helpful to show some PCR assays to demonstrate that the insert was still in the plant and correctly orientated in the constructs.

Some good quality agronomy is being conducted in the search for appropriate harvesting machines, herbicides and cultural practices and positive recommendations are made about which varieties to grow and how they should be managed in the field. Work should be continued to establish whether these factors hold true in different environments. Secondly, such rigorous trial practices should be used to inform how breeding lines are evaluated and to provide phenotype data to associate with markers. It would be useful to know how coordinated the yield was across plants grown under different row spacing was, plant size is achieved by increased branching in plants sown less densely and this means that more secondary and tertiary branches are bearing pods, often in a delayed timeframe to the main pods, thus making it difficult to coordinate harvest maturity of the grain to a single time point suitable for mechanical harvest.

In making cultivars suitable for mechanical harvesting available to farmers a relatively modest programme of seed distribution has taken place. It is not clear if the scale of the farm trials was limited by seed availability or not. No increase in yield was observed with the new variety of chickpea NBeG 47 and no data are presented beyond yield to record how farmers reacted to the new variety or any other sociological data to support how the new variety was received. A better collaboration with social scientists is required at the design stage of experiments in order to improve the utility of the work carried out.

A.1.7.5. Impact

This product line aims to addresses the emerging requirement of mechanisation of agriculture in developing countries for increasing profitability and reducing drudgery of women. The herbicide tolerant and machine harvestable grain legume cultivars will reduce the labour requirements and ideally production cost if successful. Evidence that people have changed practice in terms of the manner of harvest mechanism and the variety of seed used is still lacking. This stated impact needs to be backed up by evidence that the seed has been adopted and used, and that women have been/will be able to find suitable alternative employment and whether that is inside the agriculture sector or outside of it. Although complete delivery of these impacts is some way downstream, the PL should already be evaluating awareness and acceptance of the principle of new seed varieties in the production system. This will enable researchers to react to the views of the farming community as they design their research programmes. The impact of the resources on the research community itself is easier to evidence; having the material in the public domain does not itself confer impact. Uptake and use of the information is the impact.

A.1.7.6. Sustainability

Of all of the PLs, this is the one with the greatest proportion of W1/W2 support, with 50% of funding in 2013 and 37% in 2014.

The PL sets out to address some important goals but at present falls short of working efficiently with other PLs and in coordinating projects within its own PL. Some economies of scale and cross fertilisation of ideas would benefit the PL and better evaluation of projects is required at all stages in order to direct thinking and give more reactivity within the programme. There are too many cases of experiments which are under-analysed or poorly controlled which represents wasted effort and means that further decisions are taken on the basis of poor data.

A.1.7.7. Gender

Staffing has a 4.6:1.0 male: female ratio, and for postgraduate training it is 3.75:1.0.

The gender balance is improving at all the levels because of the concerted efforts by participating CGIAR centers. However, it will require several years to reach the desired level. There is a high probability that the changes that have been introduced to promote gender balance and diversity would be embedded in Grain Legumes and the local culture in many countries. Cultural differences may slow progress in some countries.

A.1.7.8. Capacity building

With 15 Masters and 17 PhD students this PL has a healthy post-graduate cohort. Gender balance is not so healthy, with 1.5:1 male female ratio for Masters' students and 7.5:1 for PhDs. At least two short-term training organised for NARS researchers on legume improvement for herbicide tolerance and mechanical harvesting. The training courses are to be commended, but **more follow-up is needed to establish how well the learning of individuals is disseminated to the wider communities**

A.1.7.9. Partnerships

CGIAR centers (ICARDA and ICRISAT), ARIs and NARS are involved in development of technologies, while NARES, government and non-government extension agencies, NGOs, CBOs, Farmers' groups and farmers in target countries will be involved in evaluation and dissemination of technologies. The work was done in conjunction with producers and suppliers of herbicides and other agro inputs.

A.1.7.10. Overall score

Table A1.7.10 summary of PL7 scores.

Category	Maximum score	PL7
Outputs	30	22
Impact	35	20
Environment, coordination, and capacity building	20	17
Gender balance and sensitivity	15	8
Total	**100**	**67**

A.1.7.11. Conclusions and recommendations

The product line needs more rigorous adherence to communication structures within the PL and between other PLs. A wide spread of work is undertaken at present and the CCEE suggest performing more focused studies on fewer crops and chemicals that are better replicated, controlled and analysed. There is good agronomy taking place in the PL and work should be continued and broadened to encompass a greater range of environments so that new varieties and practices are tested more rigorously. These trial practices should be used to inform how breeding lines are evaluated and to provide phenotype data to associate with markers in a more coordinated approach to trait improvement. A better collaboration with social scientists is required at the design stage of experiments in order to improve the utility of the work carried out and to understand its reach. More follow-up is needed from training activity to establish how well the learning of individuals is disseminated to the wider communities.

A.1.8. Product Line 8: Pigeonpea hybrid and management practices

A.1.8.1. Relevance

Yields of pigeonpea are globally low (c. 700 kg/ha), in part due to cultivation in harsh environments and competition for water light and nutrients as planted in sole or intercrop systems, and in part due to use of low yield potential varieties and losses due to pests and diseases. Yields are also constrained by drought due to the rainfed nature of the crop, yet flooding also reduces yield potential. Hybrids in India have shown greater yield stability due to focus on choice of parents with inherited resistances to these abiotic stresses and to biotic stresses, but they still succumb to pod and flower borers, and pod fly.

The focus on hybrid pigeonpea is very much an Indian focus within the PL. Mention is made of Tanzania, Myanmar, Kenya, Malawi and Uganda, but in reality these countries neither have the expertise to currently support hybrid seed production nor do they require the same given that, especially in Kenya, much genetic variability exists (c 1100 germplasm lines are available in ESA) for yield potential and hybrids have not yet been in demand although work has recently been initiated. Indian varieties in general are smaller seeded and are not acceptable to the ESA markets. Nevertheless, this PL acts as an umbrella for breeding research on pigeonpea in both ESA and India. Over 1 million ha are planted to pigeonpea in ESA, and great opportunity exist to increase production and to export to India.

At the time of commencing Grain Legumes a hybrid pigeonpea variety was already released in India, and major efforts within Grain Legumes were planned to extend the reach of that and other newer hybrids in India.

Stated focus was on developing new sources of CMS systems and fertility restorers, and introduction of required resistances into parents by way of marker assisted selections and genetic engineering. These are sensible objectives required to sustain a hybrid seed production system.

Other breeding objectives in the PL are to develop short season super-early pigeonpea varieties, to fit into various undefined niches.

Focus on seed production technology to ensure rapid bulking of seed and dissemination of improved hybrids must be by way of private and public sector seed companies. A sustainable production and marketing system for hybrids requires that private and public sector seed company resources be harnessed, and training oriented to their practical needs. Improved integrated crop management practices must also be in place to ensure yield potential of hybrids (and other improved cultivars) is achieved, and establishment of a set of principles that can be applied across agroecologies is a relevant target.

A.1.8.2. Efficiency

The role of PL coordinator within a single centre PL was not compromised by inter-centre politics nor competition, and provided contributors to PL8 an opportunity to look into many scientific aspects of conventional and genomics related activities underpinning pigeonpea crop improvement. Challenges existed to diffuse the hybrid technology, since it is relatively new innovation for the pigeonpea crop, to the NARS scientists and public and private agencies (particularly in the field of seed production) involved in crop improvement. No difficulties were encountered in the process.

A.1.8.3. Quality of science

The development of hybrid pigeonpea as a commercial reality has been sustained by a large amount of good science (Table A1.8), leading to a reasonable level of outputs per FTE (11.9/FTE

over the five year period from 2010 to 2014) including the first draft genome sequence of pigeonpea. Most publications (68) focused on breeding and genetics, with 12 on agronomic studies around optimal spacing for hybrids and screening for flood tolerance, and 7 on seed and seedlings and 4 on systems research. More publications were in association with developing country universities (27) than with NARS (10) or advance research institutes (9). Two were with private company contributions and 7 were with CIMMYT staff in the Generation Challenge Programme. Publications on occasions had authors from more than two institutions.

Table A1.8. Quality assessment of nominated papers from PL8.

Output	Synopsis of output	Quality rating out of 15
1	Investigation of the stability of male sterility and fertility restoration in CGMS lines of pigeon pea across a range of environmental conditions.	9
2	Identification of male-sterility maintainers and fertility restorers in pigeon pea and the demonstration that hybrids exhibit a high stability of fertility restoration across a range of environmental conditions.	9
3	Sequence analysis of mitochondrial genomes in genotypes of pigeon pea to identify ORFs that may play a key role in CMS-related mitochondrial rearrangements.	10
4	Review of the success of the pigeon pea hybrid ICPH2671 in terms of grain yield and resistance to Fusarium wilt and sterility mosaic diseases. This hybrid has proved of great commercial success.	11
5	Publication not available to download	-
6	The first report of the mapping of determinacy traits and association mapping in pigeon pea using SNP markers and DArt arrays.	12
7	High profile report of the reference genome sequence of chickpea and an assessment of its value in the identification of the genetic basis for a range of agronomically important traits.	15
8	Study of three male-sterile lines of pigeon pea and their resilience to temperature stresses.	9
9	Study on the genetics of fertility restoration in pigeon pea genotypes using four CMS lines and three known fertility restorers.	9
10	Four intra-specific genetic maps using SSR loci were used to construct, with other published map data, a first consensus map in pigeon pea. Analyses of QTL data on fertility restoration were also carried out in this study.	12
		Overall quality rating ~ 10

A.1.8.4. Effectiveness

7 FTE; 10 female 26 male; 17 NARS 19 ICRISAT

It is good practice to develop various sources of CMS and maintainers, and this has been possible through donors from *Cajanus reticulatus* and *C. lineatus*. The sequencing of mitochondrial genomes early in Grain Legumes allows for the exact mitochondrial genomic segments responsible for male sterility in pigeonpea to be defined. New hybrids have been produced efficiently using morphological (distinctive leaf type) markers for female lines.

Novel photothermal control of MS (<20 C as male [fertile pollen] and >25 C as female [male sterile]), and choosing suitable environments for seed production removes the dependency on restorer line technology.

One of the issues with seed systems is the measurement of purity, and seed standards for hybrid seed in Andhra Pradesh have been set; hybrid purity assessment kits have been developed by ICRISAT and are available, using BAC-end sequences (BESs) and SSR markers, for the two leading hybrids and four promising hybrids, but their level of commercialisation is unknown.

Independent of the development of F1 hybrid pigeonpea, continuing development of super early types, for India and elsewhere continues. Very early lines that are apparently photo/thermo insensitive from pre-CRP research serve as excellent donors for earliness. Variation in earliness [short, medium and long duration] is being exploited in association with TL II, EC-IFAD, SIMLEASA and AGRA funds. Canopy architecture allowing for competition-free introduction of new varieties into the common intercrop system with maize, is an important focus, and modelling could be a useful adjunct to field experimentation.

Management of pigeonpea as a horticultural crop (transplanting to efficiently use field space and time, determination of optimal plating rectangularity) to ensure maximal growth before flowering, is being trialled in Tandur near Hyderabad in India with spectacular results.

One issue, in this and other PLs where FPVS is undertaken, especially in ESA countries, is to document and adopt farmers' selection criteria. Incorporating these into early stages of selection programmes should improve upon selection efficiency.

A.1.8.5. Impact

Commercial seed multiplication of hybrids in various states of India has been supported through training and storage facilities, starting in 2012 with c. 6 t nucleus/breeder seed, and subsidised seed sales to farmers in Andhra Pradesh, Telangana, Odisha, Maharashtra, Karnataka, Gujarat and Madhya Pradesh have underpinned the planting of >100,000 ha of hybrid seed, in line with projected outcomes.

Yields are reported as 2.5 t/ha vs. 1.5 t/ha for improved varieties [and 1 t/ha local varieties]. Effective training of public and private sector stakeholder players in the hybrid seed system has underpinned this achievement, and further efforts are needed to document increasing impact – a relatively easy task of monitoring hybrid seed sales.

Local use of Purdue Improved Cowpea Storage bags for hybrid seed is giving good storage, with only 0.3 vs 15% bruchid losses, and >90% germination.

A.1.8.6. Sustainability

As with other PLs, W1/W2 funding has declined from 30% in 2013 to 22.5% in 2014. However, the goal of developing and extending the adoption of hybrid pigeonpea is well supported by the Indian

government, and funding from the same and from private sources (for the hybrid seed industry is more lucrative than is the OP industry) is likely to increase over time, as the success of hybrids is proven.

However, for ESA the exclusion of pigeonpea from TL III presents a major concern with sustainability for the pigeonpea breeding activities, and this funding gap must be filled very soon.

A.1.8.7. Gender

From the research side, a 3:1 ratio exists between males and females, and for students it is close to 1:1 favouring females. Within training, emphasis was given to impart training to women farmers in improved crop management practices of hybrid pigeonpea, to distribute small seed packs of hybrid seed, to involve women entrepreneurs in hybrid seed production and to expose them to further technology opportunities through visits to experimental research stations of NARS and ICRISAT. Overall, one quarter of persons trained across Africa and Asia (16,600) were female, interesting with the proportion declining from 2012 to 2014. These efforts led to substantial increase in net income from their unit land.

Further emphasis on women's benefits was undertaken to build entrepreneurship by providing mini-dal-mills for value adding to the crop, which led to women self-sustaining their families and livelihoods. Further, women cooperatives were also encouraged in the target villages which benefitted their overall communities.

A.1.8.8. Capacity building

15 female students and 13 males

As in the section on Gender, numerous (in the thousands) trials were conducted in five states in India to demonstrate the hybrid technology and to create awareness among small and marginal rainfed farmers (but are those the ones that will benefit most from hybrids?!).

A.1.8.9. Partnerships

This product line involves only ICRISAT from the international centres, and all the research activities are carried out within ICRISAT with collaboration from NARS partners in Asia and ESA regions. The pigeonpea hybrid parent seed consortium and the associated All India Coordinated Pigeonpea Research Improvement Project on Pigeonpea through ICAR support the provision of inputs for farmers in India. In ESA many organisations are partners with ICRISAT, working with pigeonpea. Examples include seed companies, export traders, the Agricultural Seed Agency, and she soil health programme of AGRA. Given the different germplasm bases for the breeding work in India, and ESA, and the difficulty for transfer of some genetic materials from ICRISAT to ESA, the PL is divided geographically, and there appears to be little interaction between continents.

A.1.8.10. Overall score

Table A1.8.10 summary of PL8 scores.

Category	Maximum score	PL8
Outputs	30	20
Impact	35	25
Environment, coordination, and capacity building	20	15
Gender balance and sensitivity	15	8
Total	**100**	**68**

A.1.8.11. Conclusions and recommendations

The geographical focus on hybrid pigeonpea is in India, whereas much of the R&D in this PL also takes place in Africa, where the focus is there on open-pollinated and larger seed sized pigeonpea. Therefore there is limited exchange of pigeonpea, confounded by the difficulties of free release of some germplasm from India, although super-early materials are being developed that fit into many cropping system niches. On both continents there is good impact from the breeding programmes, with anticipated goals being successfully achieved in a timely manner, largely due to good extension services, both public and private. Good science has underpinned these notable advances. However, exclusion of pigeonpea from TL III is of a major concern, and the breeding activities in Africa must be supported to ensure continuity and avoid major loss of earlier investments. Agronomy work, treating field-management of pigeonpea as if it were a horticultural crop, is illustrating the high yield potential of the crop, and this needs to be extended both geographically and with other grain legume species.

A.2. Final scoring of Product Line Self Assessment

The team assessed the research environment in terms of its 'vitality and sustainability', including its contribution to the vitality and sustainability of the wider discipline or research base, interaction with other CRP programmes, with other international, national and regional institutions, and other projects within the Grain Legumes CRP.

The overall scoring of the environment, coordination and capacity building was derived from the information provided in the self assessment by each Product Line (Table A2.1). The score took into account the metrics of student numbers, as an indication of whether or not the PL was engaged in generating a vibrant research community that will provide a legacy and continuity of research in the programme, the degree of engagement with other programmes and CRPs, and evidence of international reputation.

The final scores for each Product Line are summarised in Table A2.2 PL1 is the strongest, followed by PL6; both were helped by strong impact cases that were well evidenced although PL6 did not have many students. PL4 is rather weak; this was because very few outputs were put forward (<1 peer reviewed paper per FTE) and few students were engaged with the product line. PL2, PL3 and PL5 were all comparable in terms of overall performance although they had different areas of strengths and weaknesses, for example PL2 failed to provide any gender information in the required section, PL3 had <2 outputs per FTE and PL5 has the highest score for publications but fell down on impact. PL7 and PL8 scored well and did not have significant weaknesses in any section.

Table A2.1. Environment, coordination and capacity building per Product Line [Raw data from self assessments].

PL	Number of research students	Capacity building score (Max 10*)	Comments on environment and coordination narrative Good = 3; Some = 2; Limited = 1; No = 0 International = 4; National = 2; Regional = 1; No evidence = 0;	Research Environment (10 Max)	Overall Environment & Capacity building % (Max 20)
1	35	8	Good engagement with other CRP programmes, good engagement with other institutions, evidence of international standing	10	18
2	9	2	Good engagement with other CRP programmes, good engagement with other institutions, evidence of international standing	10	12
3	25	6	Some engagement with other CRP programmes, some engagement with other institutions, evidence of international standing	8	14
4	10	4	Some engagement with other CRP programmes, some engagement with other institutions, evidence of national standing	6	10
5	36	8	Good engagement with other CRP programmes, good engagement with other institutions, evidence of international standing	10	18
6	9	2	Good engagement with other CRP programmes, good engagement with other institutions, evidence of international standing	10	12
7	32	8	Good engagement with other CRP programmes, some engagement with other institutions, evidence of international standing	9	17
8	27	6	Good engagement with other CRP programmes, some engagement with other institutions, evidence of international standing	9	15

* >40 students = 10; <40 students = 8; <30 students = 6; <20 students = 4; <10 students = 2; 0 students = 0;

Table A2.2. Summary of scores derived from the self assessment for each Product Line [Information from self assessments].

		Product Line							
Category	**Maximum score**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Outputs	30	15	21	12	10	25	21	22	20
Impact	35	30	15	15	10	20	30	20	25
Environment, coordination, and capacity building	20	18	12	14	10	18	12	17	15
Gender balance and sensitivity	15	13	4	9	8	10	8	8	8
Total	**100**	**76**	**52**	**50**	**38**	**73**	**71**	**67**	**68**

A.3. Team member profiles and specific evaluation responsibilities

Our team comprises four persons, three co-Leaders and one Post-doctoral Fellow, with a total of 170 person days allocated for the Evaluation. The background and specific consolidating responsibilities of each team member are indicated below followed by some additional personal biographical information.

Person	Expertise	Responsibility
Professor Jim Dunwell	Geneticist and expert in applications of molecular biology in sustainable intensification of agriculture with industry and university appointments.	PL 4,5 and quality control, 'Sustainability' and 'Partnerships'
Professor David Midmore	Experience in CGIAR research and management and an expert on production systems, agronomy and resource use efficiencies.	PL1,2,8 and overall writing, 'Relevance', 'Efficiency', 'Effectiveness', 'Capacity Building', 'Governance and Management'
Associate Professor Carol Wagstaff	Phytochemist and expert in improving the nutritional quality of crop plants by way of molecular and management interventions.	PL 3,6,7 and publication analysis, 'Quality of Science', 'Impact', 'Capacity Building'
Dr Shirley Smith	Seven years' experience in international policy and development studies with research focus on governance, stakeholder engagement in cross-sector consultation processes, and community representations.	All PLs and on-line survey and writing for 'Gender'

Professor Jim Dunwell:
Nationally he was a member of the Cabinet Office Strategy Unit panel on economic aspects of GM crops (2003), and a member of the Advisory Committee on Novel Foods and Processes, part of the Food Standards Agency (2001-2006). From 2001-2006, he was the ex officio ACNFP representative on the Advisory Committee on releases to the Environment (Defra), and he was then appointed to this committee in his own right in October 2006. He was a member of the Royal Society working group on biological approaches to crop plant production 2008-2009 (including workshop in Delhi), and was asked by the UK Chief Scientist Sir John Beddington to prepare a review on Crop Biotechnology for the Government Foresight exercise (2010). He was also part of the group that prepared an update on GM for the present Chief Scientist Sir Mark Walport and the Council of Science and Technology in 2014. Amongst many review activities in Chair and member positions, for the BBSRC in the UK) he served on the panel for the joint BBSRC India Biotechnology Department (DBT) programme, Delhi 2014.

Internationally he was a member of the panel reviewing projects for the Flemish government (2004) and the review team for the joint Swiss Government/India Biotechnology Department programme in biotechnology. He chaired of the review of GM technology programme for the Malaysia Palm Oil Board (2006) and has reviewed project grants for government organisations in many countries including the USA, Singapore, South Africa, Denmark, and Holland. He spoke at workshops in Ghana, Nigeria, Uganda, and Tanzania, organised by Biosciences for Agriculture in Africa (B4FA) in 2013/14.

Professor David Midmore:
His initial research undertaken with CIMMYT in Mexico in the mid-70's led to the development of wheat as a true tropical crop (in the sense that it can now be cultivated in the lowlands of the tropics), an achievement that he replicated with the tropical potato while at CIP in the 1980's.

He worked with the private sugar industry in the Caribbean, in Taiwan at the Asian Vegetable Research and Development Centre in the early 1990's and since 1995 he holds an appointment as Foundation Professor of Plant Science at CQ University. His extensive experience in tropical horticulture led to the invitation to write for CABI on the subjects of 'The principles of tropical horticulture' and 'Asian vegetables'. He has an holistic grasp of the issues facing the future of global agriculture and horticulture, and his opinions and input are sought widely, including by the DFID, USAID, ACIAR, USDA and the CGIAR where he has undertaken Programme and Consortium reviews. He reviews regularly proposed and ongoing projects for a number of national institutions/agencies [e.g. Finland, Singapore, Qatar]. His research has led to impact in the potato, bamboo and vegetable industries in Asia and in Australia.

Since early 2010 he has been based at the School of Agriculture, Policy and Development at the University of Reading (UK) as a Visiting Professor, commuting two to four times annually to Australia.

Associate Professor Carol Wagstaff:
As a member of staff with the University of Reading for the past 8 years, and prior to that with both industry and university positions, she has a good grasp of how to ensure that research leads into impact. Her main aims are to improve the quality of food, including the nutritional value, appearance, flavour and shelf life, as well as helping consumers make healthy dietary choices. Working at the interface between plants and humans she investigates which phytochemicals and crop matrix benefit the consumer, in particular focusing on gut health. She also has a practical background in resource allocation in crops and yield improvement.

She has been an advisor to the FoodPlus Programme at Crops for the Future Research Centre, Malaysia, a Strategic Advisor to the Produce Quality Group, East Malling Research, UK, the Conference Chair for Eucarpia Leafy Vegetables 2015, Spain, and an Advisory Board Member for Journal of Experimental Botany. Recently she has developed formal connection and funding through the UK Knowledge Transfer Programme, which links industry with universities to fast-track uptake of research outcomes. She is also the Director of The Food Advanced Training Partnership.

Dr Shirley Smith:
Her doctoral studies, completed 2012, explored the relationships and linkages between government, mining company and civil society stakeholders using the framework of corporate social responsibility within the context of the Extractive Industries Transparency Initiative. She focused on the impact of governance systems on grass roots representation and how representatives gain authority for their actions in multi-stakeholder groups.

Advisor to NGO in Madagascar, *ad hoc* 2006-2013: Research and project design to support funding applications. Health and Safety Consultant: Developed risk based approach to projects for international volunteers working with rural communities as well as practical assistance with project delivery.

Health and Safety Manager, British Broadcasting Corporation (BBC), London, UK, 1990-2006: *Occupational Health and Safety (H&S) System Development and Advisory Team Leadership.* She managed multiple projects delivering strategic management tools to aid and monitor H&S implementation. Accountable for the delivery of cost effective and consistent support to programme makers and news-gatherers enabling them to be innovative and creative whilst operating within a healthy, safe and secure environment.

A.4. Self-nominated outputs by PL

Additional outputs were also considered that were in the form other than publication in order to reflect the extent of activity in each PL. Many of these would be considered key contributions towards impactful outcomes of product lines.

Additional outputs for PL1 were:

- Bean based food dietary combinations and or bean based industrial products have been developed in 10 countries. These are: Zambia, Malawi, Mozambique, Zimbabwe, Tanzania, Burundi, Uganda, Madagascar, Kenya and Cameroon
- Bean nurseries for niche markets (snap beans in Kenya, Uganda, Rwanda, South Africa, Tanzania, Ghana and canning beans in Ethiopia, Zambia, Kenya, Rwanda, South Africa, Zimbabwe) tested on farm
- 134 abiotic and biotic stress tolerant bush bean varieties were released across 16 countries in East-southern Africa
- ISFM work (for example green manures and composting) in Burundi, Rwanda, Tanzania, Zambia, Zimbabwe, Kenya, DRCongo, Ethiopia, Madagascar
- IDPM work has largely been on soil pathogens in Uganda, Malawi, Zambia, Zimbabwe, Uganda, Rwanda, Burundi, and Sudan
- Cowpea varieties were released in Mali (2), Niger (1), Mozambique (3), Malawi (1), Nigeria (4), Tanzania (2), Burkina Faso (2), Benin (1).
- Soybean varieties were released in Ethiopia (3), Ghana (3), Kenya (1), Malawi (1), Mozambique (5), and Nigeria (5).

Additional outputs for PL3 were:

- Key methodologies were established for evaluating heat tolerance in chickpeas, faba bean, lentil and common beans. Ninety-two genotypes of chickpea, 90 of faba bean and 10 of Lentil were identified as heat tolerant.
- Two faba bean varieties with tolerance to heat released in Sudan: shendi (BB7 x El-Selaim-L/1) and (Marawi El-Selaim-L/1 x Basabeer).
- For chickpea, two varieties Salawa and Burguieg produced more than two times than local farmer's population in Sudan.
- Focused Identification of Germplasm Strategy (FIGS) sets (200 accessions each) for lentil (heat and cold) were developed using the method described in Khazaei et al. (2013).
- Seven lentil lines were identified as heat tolerant (ILL2181, ILL82, ILL5151, ILL5416, ILL4857, ILL956 and ILL598) in addition to three heat tolerant lines (FLIP2009-55L, ILL2507 and ILL4248) identified in Indian program.
- A "QTL-hotspot" containing QTLs for several root and drought tolerance traits was transferred from the drought tolerant line ICC 4958 to a leading desi chickpea cultivar JG 11 through marker assisted backcrossing (MABC).
- Heat tolerant chickpea variety JG 14 (ICCV 92944) released in India was also released as Yezin 6 covering over 40,000 ha in Myanmar during 2012-13 crop season. This variety was released as Chania desi 2 in Kenya during 2013.
- Surveys of germplasm accessions of Phaseolus at CIAT, Cali identified sources of heat tolerant lines that can resist at least 3°C higher average temperatures; many of these correspond to lines generated from interspecific crosses between tepary bean (*Phaseolus acutifolius*) and common bean (*P. vulgaris*).

- One black bean variety released in Nicaragua was subsequently recognised to have a degree of heat tolerance.
- Pollen viability was confirmed to be a primary mechanism of heat tolerance in common bean, although it explains only part of the observed tolerance. Grain filling is similarly important, and probably other mechanisms.
- An estimate of bean area in high temperature production areas was calculated to facilitate targeting of improved germplasm of common bean.
- Heat tolerant chickpea lines (ICCV 93054, ICCV 91007, FLIP97-263C, S090694, S090812, S091352, S090315, FLIP93-146C, FLIP07-329C, S090243, S090341, FLIP07-310C) identified.
- 40 improved lines of lentil and 24 faba bean lines with climate smart traits in yield trials

Additional outputs for PL4 were:

ICRISAT

- In the on-farm demonstrations, at 35 DAS, it was clearly demonstrated the advantage of inoculating rhizobia over un-inoculated control.
- A total of 11 salinity tolerant rhizobia were demonstrated for its plant growth-promotion in chickpea however, no nodules were found in any of the four cultivars grown in both of the saline soils. The experiment needs to be repeated for its consistency.
- The genes predicted in the pan-genome would be helpful in characterisation of the nitrogen-fixation genes in other rhizobia.
- The 11 rhizobial isolates (ICKM-1, ICKM-4, ICKM-7, ICKM-9, ICKM-12, ICKM-14, ICKM-15, ICKM-17, ICS-30, ICS-31 and ICS-32) produced many PGP and biocontrol traits. Of the 11 rhizobial isolates studied for antagonistic activity against various pathogens of chickpea, five of them showed broad spectrum antagonistic activity while none of the isolates were found inhibited *S. rolfsii*. When the rhizobial isolates were evaluated for their PGP traits under field conditions, at 35 days after sowing (DAS), all the isolates enhanced nodule number (8–41%), nodule weight (16–50%), root weight (3–22%) and shoot weight (11–32%) over the un-inoculated control.
- A total of 52 rhizobia specific to chickpea are isolated and characterised for African locations.
- Of the five carrier materials (peat, talc, talc + starch, charcoal and charcoal + sugarcane pulp) used in the above study, peat seems to be working better. However, this needs to be confirmed.
- Hands on training on Rhizobium inoculum production were provided for 10 technicians. Such training needs to be given to progressive farmers and more technicians.
- A total of 211 mini-core lines, 68 land races, 10 wild accessions and 7 checks, were screened for symbiotic nitrogen fixing potential under greenhouse conditions. At 45 days after sowing, nodule number per plant, nodule weight, acetylene reduction activity (ARA) of selected lines/accessions based on visual observation, dry weight (shoot + root) were done. The experiment was completed and the results are being analysed. The results of this experiment showed the following nodulation variants among 296 chickpea accessions:
    - Non-nodulating, 0 nodules: 44 accessions; Poorly nodulating, 0.1 to 1 nodule/plant: 44 accessions
    - Low nodulating, 1.1 to 5 nodules/plant: 137 accessions; Medium nodulating, 5.1 to 10 nodules/plant: 49 accessions
    - Good nodulating, 10.1 to 20 nodules/plant: 19 accessions; Excellent nodulating, > 20.1 nodules/plant: 3 lines

- A field experiment at ICRISAT was conducted with four treatments including T1 = Positive control (100 % Recommended dose of fertilizer - DAP); T2 = M. ciceri (mixed inoculums of M. ciceri (IC-59 + IC-76) were used); T3 = M. ciceri (mixed inoculum of IC-59 and IC-76) + DAP; T4 = Absolute Control (without inoculation, without DAP).Three genotypes such as JAKI 9218, Shubhra and JG 11 were used. At 35 DAS, nodule number, nodule mass and shoot weight were found significantly higher in T2 and T3 when compared to control as well as the treatment where only DAP was applied (T1). Among the T2 and T3 treatments, T3 was found superior over T2.

ICARDA

Identification of Rhizobium strains

- Combined two strains inoculated faba bean (FB-418 and FB-419) chickpea and faba bean yielded more than the single strain inoculated treatments and produced the highest nodule number and dry weight
- Two chickpea rhizobium strains, CP-70 and CP-125 demonstrated consistently better performance in terms of nodulation, biomass and seed yield. It appears, the seed treatment with efficient rhizobium strain is required to boost up the yields of chickpea and soil fertility in the rain-fed Mediterranean environments
- Application of phosphorus and Rhizoboium inoculation improved the nodulation and biomass production in chickpea and faba bean crop as compared to control plot
- Multi strain inoculated faba bean yielded more than the single strain inoculated treatments and produced the highest nodule number and dry weight
- Rhizobium nodulation and nitrogen fixation were highly correlated and shown binomials trends
- Rhizobia treated with pink-pigmented facultative methylotrophic bacteria (PPFMs) in faba bean showed better performance than the rhizobia alone. Also improved rhizobia has better performance than native performance
- A total of 78 isolates (50 from faba bean and 28 from chickpea nodules) have been collected during the growing season (2015) at the flowering stage from the following locations: Faba bean (DaKahleya, BaniSwaif, Sharkeia, Menia, Asout, and Kena) and Chickpea (Giza and BaniSwiaf).

Screening for Rhizobium nodulation and nitrogen fixation

- 50 chickpea genotypes evaluated for rhizobium nodules. Four genotypes (FLIP07-268C, FLIP07-217C, FLIP07-254C, and FLIP07-44C) identified as superior genotypes.
- 400 mutant lines of faba bean and 42 breeding lines evaluated for rhizobium nodulation. Three genotypes (WS11-142, WS11-18 and WS11-91) showed high nitrogen fixation in two locations Terbol and Kafardan.
- The faba bean genotype 13 “45/018F87307/06A“ and 25 “Sakha 1” showed the best plant N contents (mg)/plant comparing to other genotypes.
- Wide range of rhizobium nodulation among 233 faba bean genotypes (landraces and breeding lines)varied 15 to 200 nodules has been observed
- Nubaria2 (Rad2095/86 x ILB1550) and LS108 (ILB 1814 L. 1/96 x Sel. 99 Lat. 10460) were the highest fixed nitrogen in both situation comparing to all tested genotypes with values superior to 35%
- The following chickpea lines FLIP07-14C, FLIP07-268C, FLIP07-308C, FLIP07-322C, FLIP08-23C and ILC482 showed the best performance across the different environments.

- Faba bean NA112 mutagenised population is under development.
- Chickpea FLIP93-93C mutagenised population is under development

CIAT

- ISFM work (for example green manures and composting) in Burundi, Rwanda, Tanzania, Zambia, Zimbabwe, Kenya, DRCongo, Ethiopia, Madagascar
- IDPM work has largely been on soil pathogens in Uganda, Malawi, Zambia, Zimbabwe, Uganda, Rwanda, Burundi, and Sudan

Additional outputs for PL5 are:

- Novel baculovirus specific to the legume pod borer Maruca vitrata, MaviMNPV
- Novel exotic biological control agents from Asia, the hymenopteran parasitoids Therophilus javanus and Phanerotoma syleptae
- Chickpea germplasm carrying resistance to Leaf miner developed and shared with NARS.
- Management options for chickpea leaf minor developed and these include planting date and botanical pesticides (neem oil).
- ENT 11, ICPL 332WR – pod borer (*Helicoverpa*) tolerant lines released in Telengana, India.
- Protocols for assessment of biosafety of transgenic chickpeas to natural enemies.
- A total of 15 entomopathogenic actinomycetes having the potential of killing *Helicoverpa armigera*, *Spodoptera litura* and *Chilo partellus* were identified. The secondary metabolite from SAI-25 (*Streptomyces* spp.) responsible for killing *H. armigera* was identified as cyclo (Trp-Phe) belonging to diketopiperazine group.
- Protocol for sporangia and zoospore production of *Phytophthora cajani*, *Phytophthora blight pathogen* of pigeonpea
- Standardised screening protocol for identification of resistant sources to *Phytophthora* blight
- Protocol based on Loop mediated isolthermal amplification (LAMP) for rapid detection of *Fusarium oxysporum* f. sp. *ciceris* and *Rhizoctonia bataticola* pathogens of chickpea
- First report of emerging diseases under climate change scenario in pigeonpea such as sudden death disease (*Fusarium acuminatum),* Alternaria blight (*Alternaria alternata* and *Alternaria tenuissima*)

Additional outputs for PL6 were:

2014

- Two new varieties of desi chickpea for ESA and two kabuli chickpea GLK28127 in India and FLIP03-27C in Afghanistan and three varieties of lentil for SEA (FLIP2011-33L and FLIP2010-27L in Afghanistan, IPL526 in India) have been released.
- Crop ontology of chickpea and lentil in IBP containing breeders preferred traits http://www.cropontology.org/ontology/CO_339/Lentil
- Varietal release, human resource and research budget databases for food legumes established for Ethiopia, Eritrea and the Sudan
- Complete database of international nurseries of chickpea, faba bean and lentil over the years https://drive.google.com/open?id=0B_4bwJOt2etZUDlSSm5iZk1Gd1U&authuser=0
- The impact report on improved cultivars of chickpea in Andhra Pradesh and Karnataka states of India was peer reviewed and finalised.

- Chickpea reference set (300 accessions) was re-sequenced at 5X to 13X coverage using whole genome re-sequencing (WGRS); a comprehensive genetic map comprising of 1,013 marker loci and spanning a distance of 723.64 cM was developed from ICC 4958 × ICC 1882 RILs and the "QTL-hotspot" earlier identified for drought tolerance traits was saturated with 49 SNP markers (Mol Genet Genomics, DOI 10.1007/s00438-014-0932-3), Four SSR markers (TA37, TA34, H4F03 and NCPRG48) associated with leaf miner resistance in chickpea.
- Lentil specific 57 EST-SSR markers have been developed (P-6 report). Lentil genome sequence is expected soon with Canada and US as partners (http://knowpulse2.usask.ca/portal/project/Lentil-genome-sequencing-%28LenGen%29%3A-establishing-a-comprehensive-platform-for-molecular-breeding).
- First draft of suitability map of grain legumes in South Asia developed.
- Model assessment of phenology and yield of lentil completed through simple simulation model for lentil development, growth and yield in East Africa.
- Thirty-six promising breeding lines were supplied to 17 NARS partners in India through international nurseries (ICSN-Desi and ICSN-kabuli).
- A set of 96 chickpea genotypes from composite collection were sequenced using whole genome sequencing approach.
- A set of 337 chickpea advanced lines were screened for resistance to local strains of Ascochyta blight (AB) in Morocco.
- FIGS set of lentil germplasm (136 accessions) for Fusarium wilt has been developed for screening in wilt sick plot.
- Thirty-six advanced breeding lines of desi (18 lines) and kabuli (18 lines) were supplied through two International Chickpea Screening Nurseries (ICSN Desi and ICSN-Kabuli) to 17 locations in India.
- Twenty two BC3F5 introgression ICCV 10 lines with QTL hotspot for drought related traits were evaluated at 4 locations in India under irrigated and rainfed conditions. Promising lines were identified at each location. At ICRISAT-Patancheru these introgression lines gave 16-29% higher seed yield than ICCV 10 under rainfed conditions and 16-44% higher yield under irrigated conditions.
- A total of 168 desi and 84 kabuli breeding lines were evaluated in PYTs) and 62 desi and 40 kabuli entries were selected for evaluation under AYTs. A total of 64 desi and 72 kabuli breeding lines were evaluated under AYTs and 18 desi and 18 kabuli breeding lines were selected for development of international chickpea screening nurseries (ICSNs).
- Multiple disease resistance was found for wilt, AB and BGM in eight breeding lines in chickpea.
- A set of 300 advanced lines of kabuli chickpea were developed and evaluated in addition to three AYTs each with 64 entries to assess yield potential of early maturing lines. Seven international kabuli chickpea nurseries (CIENS-15, CIEN‑SL1-15, CIEN‑SL2-15, CIABN-15, CIFWN-15, CILMN-15, CIDTN-15) with specific traits were prepared and shared with NARS partners of South Asia, Sub-Saharan Africa and CWANA region.
- Total 755 lentil breeding lines were multiplied for international nurseries besides PYTs and AYTs. Eight International lentil nurseries with 36 elite lines in each nursery (LIEN‑Y-15,

LIEN- R-15, LIEN- E-15, LIMN-15, LIDTN-15, LIFWN-15, LIRN-15, LIABN-15) were prepared and shared with partners in South Asia and Africa.

- WGRS data were generated for 129 lines and RAD sequence data (0.80X) on 11 lines in chickpea. Alignment of sequence data to the draft genome sequence of chickpea has provided >1.3 Million SNPs in genome, >108 K in mRNA and >42 K in CDS regions.
- MABC was undertaken to pyramid Fusarium wilt (FW) and Ascochyta blight (AB) resistance in chickpea genotype C214 through foreground selection with associated markers (5 for FW and 4 for AB).
- Twenty-four desi chickpea gene sequences with known or predictable phenotypes were identified bioinformatically to assess the mutation frequency of chickpea TiLLING platform. Note that so far in the mutant populations described as 'TiLLING' within the Grain Legumes program there has been no identification of a mutant individual that has been analysed with respect to the predicted phenotype. There has been some DNA analysis, but the loop has never been closed.
- A set of 181 lines derived from ILC588 X ILC3279, were evaluated in 10 environments and three major QTLs on LG1, LG3, and LG4 for early flowering identified.
- In order to develop TiLLING populations in lentil, genotypes, ILL4605 and ILL5883 were treated with EMS 0.4%.
- Linkage analysis showed SSR marker GLLC106 located 10 cM from the gene imparting resistance against rust in lentil.
- 44.4 tons of breeder seed (BS), 12.6 tons of foundation seed (FS), 246.0 tons of certified seed (CS), and 411.1 tons of truthfully labelled seed (TL) was produced during the post-rainy season 2013-14. Public sector produced 634.3 tons of FS and 10,126.0 tons of CS and farmers produced 30.2 tons of TL seed during post-rainy season 2013-14. A total of 520 seed samples of varying sizes were distributed to farmers.
- Village based seed enterprise (VBSE) established to tackle the seed constrains in the region of Telangana. The project farmers were trained in principles and objectives of VBSE, seed production methods, and seed storage and marketing especially seed business.
- 18.9 t Foundation & TL seeds of Simal, MP Bharati, Khajurah-1, ILL 7723, Shital produced in Nepal, and 16.7 t of certified and TL seeds of BariMasur 4, BariMasur 5, BariMasur 6 and BariMasur 7 in Bangladesh and 970 t seed of HUL 57, PL6, KLS 218, NDL1, IPL 406, and Pusa Vaibhav in India produced for distribution to farmers in India.
- A total of 3240 farmers, 229 villages and 689 ha of land were covered with improved production technologies of chickpea, lentil and grasspea under OCP-ICARDA project.
- Total 987 on-farm demonstrations (PVS, ICPT, VLSS) were conducted in RRFL of 48 villages in 2 target districts -Ranchi and Palamau in Jharkhand. In VLSS, ~30 tons of seeds of improved chickpea and other crop varieties were produced.
- A total of 1535 farmers including 494 women farmers in Nepal, and 2255 farmers in Bangladesh and 3930 farmers in India were trained through organisation of field days and training programs on lentil improved technologies.
- Five lentil varieties were demonstrated in eight districts of Nepal and three varieties in 10 districts in Bangladesh and 10 varieties in 175 villages in India. On an average, improved

varieties and technologies gave yield advantage of 37% in Nepal, 53% in Bangladesh, and 42% in India. A total of 527 male and 299 women farmers were involved in Nepal and 911 farmers took part in demonstrations in Bangladesh. A total of 1065 ha area have been covered with the active involvement of 3743 farmers in 175 villages in India.

- In Ethiopia, four varieties of chickpea (Areri, Habru, Shasho, Minjar, Natoli) and two of lentil Alemaya, Derso) were multiplied on 278 ha involving 1112 farmers (13.5% female) producing 715 tons of seed.
- Over 161,882 metric tons (MT) of quality seed (breeder, foundation, certified and truthfully labelled seeds) of improved chickpea cultivars was produced in South Asia (125,499 MT in India; 113 MT in Bangladesh) and ESA (34,335 MT in Ethiopia; 1935 MT in Tanzania and Kenya).
- For lentil, 26 VBSEs established producing 18.9 MT foundation and TL seeds of improved varieties in Nepal, 16.7 MT of certified and TL seeds in Bangladesh and 970 MT in India.
- Adoption study of improved chickpea cultivars in Dharwad and Gulbarga districts of Karnataka, India revealed 65% and 1% of the total cropped area under JG 11 and BGD 103, respectively. In Andhra Pradesh state, adoption of improved varieties (JG 11, JAKI 9218 and JG 130) has reached ~98%. Adoption study in Sub-Saharan Africa indicated 57269, 18887 and 20683 ha area under improved varieties of chickpea, lentil and faba bean in Ethiopia and 50050 and 16800 ha under faba bean and chickpea in Sudan.
- FPVS were conducted on improved chickpea varieties in India, Bangladesh, Tanzania, Ethiopia and Kenya in addition to 1992 on-farm demonstrations on chickpea and 5169 on lentil. 26 village based lentil seed hubs established in India, Bangladesh and Nepal.

2013

- Three short duration desi chickpea varieties, one (Chania desi3 - ICCV 97126) in Kenya and two (Dalota and Teketay) in Ethiopia and three short duration lentil varieties, one each in Bangladesh (BINA M7), Ethiopia (Dembi), and India (IPL316) were released for cultivation. Six extra-early breeding lines with ~100 days to maturity from two crosses developed and are under evaluation for yield performance and agronomic traits.
- 23 extra-early chickpea lines are under screening for biotic stresses resistance
- 20 chickpea lines in ICSN-desi, 20 lines in ICSN-kabuli, 13 lines in ICSN-kabuli large seeded, 24 lines in a MABC trial, 42 lines in AB resistance. 3 entries each in ICSN-Desi and ICSN-Kabuli and 8 entries in ICSN-Kabuli Large Seed were found superior.
- 32 elite lines of chickpea evaluated in various yield trials in India and 17 elite lines in Ethiopia and two elite lines each in Tanzania and Kenya.
- 200 elite kabuli lines with early maturity identified for yield evaluation and disease reaction.
- 250 elite lines under seven international kabuli chickpea nurseries in MET trials across the target countries.
- 220 elite lines under 8 International lentil nurseries under testing in 32 countries.
- In lentil, an extra early wild accession, ILWL118 identified for transferring genes of earliness. Six extra early lines developed.

- 83 FPVS were conducted on improved chickpea varieties in India, Bangladesh, Tanzania, Ethiopia and Kenya in addition to 1992 on-farm demonstrations on chickpea and 5169 on lentil. 16 village based seed hubs were established in India for lentil seed production. The varieties preferred by farmers were JG 14 (ICCV 92944) and Barichola 9 in Bangladesh, JG 14 and JAKI 9218 in Odisha and JG 14 and BG 372 in Bihar.

2012

- Over 8,000 MT chickpea seed of improved cultivars was produced in sub-Saharan Africa (Ethiopia, Tanzania and Kenya). A total of 36,447 MT of quality seed of chickpea varieties was produced in South Asia (36,360 MT in India and 87 MT in Bangladesh). A total of 18 Village Seed HUBs were established and 495 MT of Foundation, Certified and Truthful Level Seeds of lentil varieties produced.

Additional outputs from PL7 were:

Suitability to machine harvesting

- Six kabuli chickpea varieties, namely Seckin, Arda, and Hasanbey in Turkey; GHAB5 in Lebanon; Nour in Tunisia; and Aragui in Georgia were released for cultivation in WANA region during 2013. These varieties are resistant to Ascochyta blight and amenable to machine harvest.
- Four machine harvestable kabuli chickpea varieties, Garaja in Azerbaijan, Saral in Iran, Vostok in Kazakhstan and Baraev in Russia were released for cultivation in 2014.
- Several chickpea breeding lines (e.g. ICCV 03205, ICCV 03112, ICCV 04111 and ICCV 08102), suitable to mechanical harvesting and yield levels similar to or higher than the check cultivars were identified through multi-location evaluation in India.
- The chickpea breeding line ICCV 96836 showed high level of resistance to Ascochyta blight (score 2.0 on 1 to 9 scale) and was amenable to mechanical harvesting.
- Two machine harvestable chickpea varieties (NbeG 47 and GBM 2) were proposed for release in India.
- A field survey among chickpea growing farmers in two districts (Gulbarga and Dharwad) of Karnataka state of India revealed that the labor cost was on a rising trend over the years due to increasing labor scarcity and it currently accounts for about 32% of the total variable cost incurred in chickpea cultivation.
- An agronomic study on two row spacing and three seed rates was conducted on two tall and erect genotypes of chickpea. The highest yield was obtained in the genotypes HC 5 sown in 22.5 cm wide rows using 50 kg/ha seed rate.
- Four varieties of lentil, namely Bozok, Gumrah, Karagul, and Tigris registered for cultivation in Turkey during 2013. These varieties are amenable to machine harvest and resistant to Ascochyta blight.
- Twenty advanced breeding lines of lentil with several beneficial characters including extra earliness, suitability for mechanical harvest and enhanced micronutrient content on the grain (Fe and Zn) were identified.
- Four machine harvestable faba bean varieties, Hama2 and Hama3 in Syria, Didea in Ethiopia and Santa Elena in Mexico were released.

- Twenty-five new faba bean breeding lines suitable for machine harvesting were identified.

Herbicide tolerance

- Herbicide tolerance screening methods were standardised in chickpea, lentil and faba bean
- Sources of herbicide tolerance were identified in chickpea, pigeonpea and faba bean.
- Screening of 40 kabuli chickpea genotypes against Klenic (Glyphosate 480 g/L) at two concentrations (500 ml/Ha and 1000 ml/Ha) resulted in identification of three genotypes, FLIP08-115C, FLIP07-247C and FLIP08-75C with least phytotoxicity.
- Six kabuli chickpea genotypes with resistance to Stomp (Pendamethalin 30% S/L) and Challenge (Aclonfen 60%) were identified.
- Several chickpea breeding lines (e.g. ICCV 03104, ICCV 03402, ICCV 95138, ICCV 97115, and ICCV 10) tolerant to herbicide imezathapyr identified in India by screening at four locations.
- A study was conducted on 12 weed control treatments on five chickpea genotypes. Herbicides quizalofop ethyl (Targa Super 5 EC) and clodinafop (Topik 15 WP) were safe to chickpea genotypes, but Carfentrazone ethyl (Affinity 40 DF) and metribuzin (Sencor 70 WP) were found more effective in weed management.
- Screening of 150 lentil genotypes against Metribuzin (Sencore) and Imazethapyr (Pursuit) at PAU (India) showed wide genetic variation for phyto-toxicity among lentil genotypes.
- Two EMS-induced mutant lines (Mu-38 and Mu-418) of faba bean variety BPL 710 were found tolerant to herbicide glyphosate.
- Faba bean line Elizar showed high level of resistance to herbicide Glyphosate (@600 g/ha of glyphosate at flowering).
- Twenty-two machine harvestable faba bean lines were found tolerant to 259 g ai/ha of metribuzin.

Tolerance to parasitic weeds

- Sources of resistance to parasitic weed *Orobanche* spp. were identified in lentil and faba bean.
- Twenty-four lentil lines with moderate to high level of resistance broomrape were identified.
- The faba bean variety Misr 3 released in Egypt showed resistance to broomrape under all the four infested soils.
- Two faba bean varieties, Misr 3 and Giza 943, with resistance to orobanche were evaluated by 37 famers in Egypt. All the trials were spread by 125 g of ai/ha and showed reduction in *Orobanche* with 25% increase in yield compared to the national average.
- The most virulent *Orobanche* isolates prevalent in Egypt in faba bean fields were identified. This information will be useful to enhance resistance of faba bean genotypes to *Orobanche*.
- Survey studies indicated that faba bean area under orobanche infestation increased by 25% in last two years as compared to 2012 season.
- Broomrape biotypes existed in Malawi and Shandaweel soils were found more virulent than those collected from Giza and Sakha.
- Spatial distribution and genetic diversity of *Orobanche* species affecting faba bean in Ethiopia and Egypt were studied.

Seed production

- Three countries, Morocco, Tunisia, and Sudan, identified for establishing small-scale seed enterprise. In Morocco, Al Hilal and El Wided cooperatives near Merchouch village with combined area of 550 ha and 47 member farmers identified as the potential group for small-scale seed enterprise.
- During 2013, Algeria, Egypt, Lebanon, Morocco, Sudan, Tunisia and Turkey were engaged in breeder and foundation seed production of the improved varieties of faba bean (16), chickpea (26) and lentil (19). The total amount of foundation seed produced was 88.3 MT.

Additional outputs from PL8 are:

- 4 varieties and 3 hybrids were released in India.
- Draft genome sequence of pigeonpea was completed ushering the crop in to genomic era and created opportunity for development of large genomic resources for crop improvement.
- Seed production technology was standardised for different ecoregions to produce large-scale hybrid seed.
- Agronomic interventions for hybrid cultivation such as drip irrigation and transplanting techniques were standardised for exploiting potential yields from hybrid cultivation.
- Marker based hybrid purity assessment kits were developed to test the purity of hybrid seeds {a perfect substitute for traditional GOT(Grow out tests)}.
- Reliable and repeatable screening techniques were developed for screening of Phytopthora (An emerging disease in pigeonpea).
- Candidate gene(s) for A4 derived cytoplasmic male sterility were identified.
- Large-scale hybrid seed (657 tons in 2013 and 503 tons in 2014) was produced by all stake holders and cultivation of hybrid pigeonpea was extended to 120000 ha in 2014 and 2015.
- 14 varieties released in Kenya(3), Malawi(2), Mozambique(4), Tanzania94), and Zambia(1).
- 55 varieties entered in to National performance trials of Kenya, Tanzania, Malawi, Mozambique, Zambia and Uganda.
- 937 PVS(95-Kenya, 360-Tanzania, 82-Malawi, 126-Mozambique, 274-Uganda) and 1258 demos(225-Kenya, 503-Tanzania, 80-Malawi, 450-Uganda) were conducted to identify best bet farmer preferred varieties and promote best fit technologies.
- 3817 t of quality seed produced(2172 t-Malawi, 1278-Tanzania, 316-Kenya and 51-Mozambique) and disseminated.
- Best outstanding partnership award received along with Tanzanian NARS for 'Developing and adoption and expansion of area of high yielding, wilt resistant, bold and cream coloured pigeonpea varieties in Tanzania' during 2012.
- Best outstanding partnership award received along with Malawian NARS for 'Enhanced productivity through promotion of high yielding, wilt resistant, farmer and market-preferred pigeonpea varieties in Malawi' during 2013.

A.5. Online survey data, respondents host organisations, and e-survey

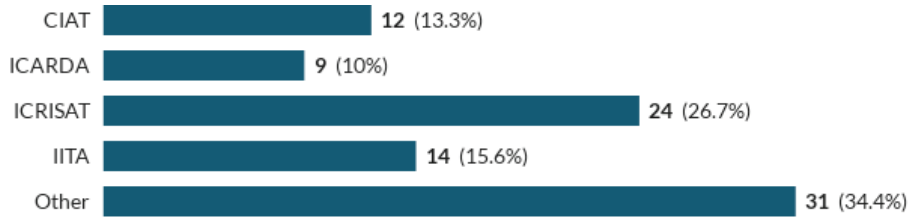
Summary of Survey Results under Report Headings

An online survey was open from 2nd to 14th and from 20th to 22nd July 2015 [13] using an independent platform, Bristol Online Surveys (BOS). The survey was targeted at ICRISAT, ICARDA, CIAT and IITA researchers who contribute their time to Grain Legumes. A number of non-CGIAR partners and Management representatives were also included. The survey registered 126 completed responses from 377 invitees: a response rate of 33.4%. [14] Response numbers were adequate for Research Managers (51), Active Researchers (33) and non CRP participants (36). Few Extensionist/Development Agents or Students responded (2 and 4 respectively); thus, their responses are not included in the body of the report and their views are not adequately represented in issues covered by the survey.

The survey was designed with two distinct routes: i) those engaged in (79 respondents), and ii) those outside Grain Legumes (35 respondents). Within the former, four paths were constructed: i) Research Manager, i.e. Manager within a Partner Institution, member of the Steering Committee/Independent Advisory Committee/Research Management Committee; ii) Active Researcher (hereafter referred to as Scientist); iii) Extensionist/Development Agent; and iv) Student. The questions addressed relevance, efficiency, quality of science, programme effectiveness, impact, sustainability, and the cross-cutting issues of gender, partnerships, capacity building and governance. Open-ended questions were included. The survey results are used as complementary evidence in the final report. The survey questions can be found at the end of this summary of findings. In a few instances, respondents were routed past certain questions in the survey; thus percentages originating from survey responses are always based on the actual number of responses to each question, not the total number of respondents within a particular path.

Figure A5.1 indicates the employer organisations of the 79 respondents within Grain Legumes. The disciplines with the most respondents are Scientists and Research Managers (Figure A5.2). Ninety percent of respondents in the Scientist group are either PL or FP coordinators; and every PL is represented (Questions 34&35). The numbers of Students and Agents are statistically insignificant, 4 and 2 (5.1% and 2.5%) respectively.

Figure A5.1. Employer organisation of respondents working within Grain Legumes.



Source: Grain Legumes Survey

Note: Table A1: List of other organisations is included at the end of this summary.

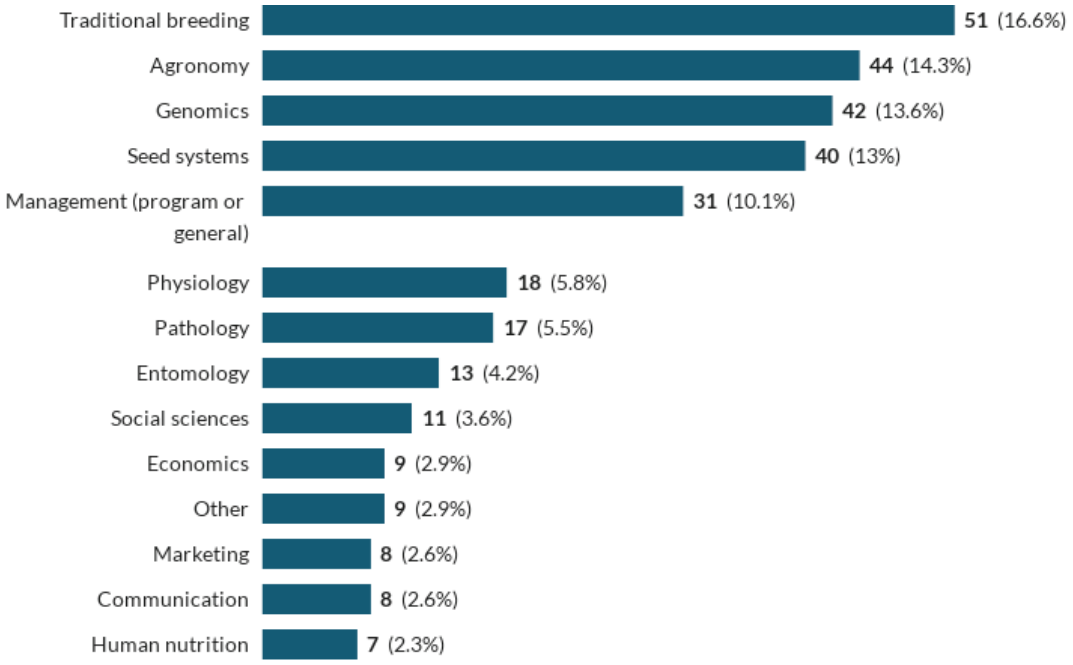
Respondents represent a broad cross section of scientific disciplines (Figure A5.2): breeders (traditional and genomics), agronomy; and seed systems are strongly represented; with approximately 10% Research Managers (Question 2).

While the support can come from the CRP the action must be taken by the lead and participating centers.

[13] The survey was reopened for IITA invitees due to their omission in the initial round of invitations.

[14] Personal invitations to complete the survey were sent to 436 individuals. To account for invalid email addresses, duplicate invites and long-term absence, such as maternity leave, 377 is a more accurate reflection of invitees.

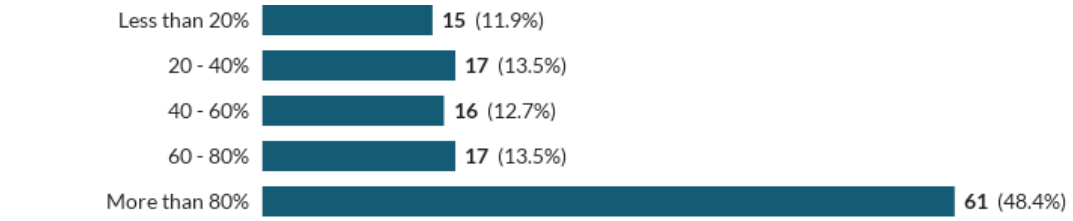
Figure A5.2. Scientific Discipline of Respondents



Source: Grain Legumes Survey

Almost half of all respondents reported that over 80% of their work involved legumes (Figure A5.3).

Figure A5.3. Proportion of time spent working on legumes.



Source: Grain Legumes Survey

The findings of the survey are presented under the headings established in the Inception Report as areas that will specifically be addressed.

- *Relevance:* Global development, urbanisation and technological innovation are progressing rapidly. Therefore a key question for the reviewers is to establish whether the aims and focus of the Grain Legumes are still fit for purpose and relevant to the global community.

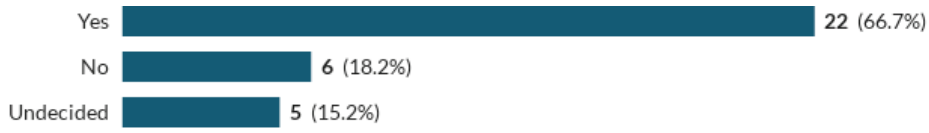
One of the most positive responses in the survey is that 82% of Research Managers considered Grain Legumes as a global leader (Question 33, Figure A5.4); nevertheless, 18% disagreed. It was suggested that this status may have evolved from pre-CRP successes within centres and by individuals, rather than work within Grain Legumes: "*Several Individual scientists are global leaders in research and development, but that was the case before the development of the CRP. The CRP has not been in operation long enough to have developed a reputation one way or the other*". Leadership status may also be threatened by confusion regarding funding and governance routinely commented on in both the survey and interviews: *"[if] the current confusion regarding funding and management/ governance continues, it will alter the situation".* One comment indicates that networks outside Grain Legumes are valued: e.g. *"CIAT has a wider partnership with NARS under the PABRA platform".*

Figure A5.4. Is the CRP considered a global leader in grain legume research and development? (Research Manager)

Source: Grain Legumes Survey

Questions regarding the structure of the Grain Legumes program indicate a strong preference for grain legumes to remain combined (Figure A5.5). One Research Manager commented that: *"If grain legumes are split up they will become less visible to the development community and donors"*. A large majority of both Research Managers and Scientists perceived a comparative advantage in combining all grain legume research under one CRP (Questions 26, 66, 67), based on group learning and knowledge sharing, common constraints and targeting efforts to reduce duplication. A manager commented: "*From a science perspective, constraints within the seed system are similar, BNF research on rhizobium-plant interactions, genomics-synteny, nutritional analysis, gender considerations."* A Scientist added: [Considering] *"Grain Legumes as a group, there is definitely an advantage in dealing with them collectively for dealing with specific problems of a legume crop by... [learning from] the other, or addressing common issues, maybe also at the market integration... [level]"*. To support the comparative advantage argument a Research Manager cited the Tropical Legumes model as productive; as was the shift to a non-geographical mandate: *"I see this working well if the CRP is then not locked into a geographical mandate; because legumes traverse from Arid to temperate areas..."*

Figure A5.5.There is a comparative advantage in combining all grain legume research under one CRP (Research Manager).



Source: Grain Legumes Survey

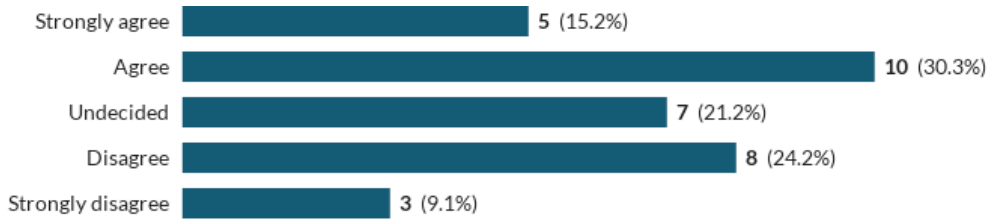
Approximately 20% of Scientists see little comparative advantage, due to the diversity of legumes and different climatic environments: *"Due to the diverse requirements of the grains there is no advantage in combining the activities"*. The concept of regional focus is also valued, e.g. *"...the CRP should prioritize based on regions e.g. Africa and Asia".* A minority Research Managers concur*:* "*Tropical and temperate grain legumes have different requirements";* and *"Dryland Grain Legumes would be better to combine with Dryland Cereals and Dryland Systems CRPs while Humid Tropics GL would be better to combine with Humid Tropica [Tropics] CRP or Humid Tropics major commodities like Root and Tibers [Tubers], Maize and Rice"* (Questions 26, 66, 67).

Further support for maintaining legumes under one CRP is provided by comments to the question "Is a mega-program CRP better than the sum of its parts or could the same research have been done just as well or better if the four centres had worked independently (Question 23)?". More than two thirds of Research Managers support the concept of Grain Legumes in terms of the power of synergy and collaboration. For example: *"The program has provided unique opportunity to share scientific knowledge including methodologies and ideas in more purposeful manner, which is of paramount importance to change world legumes research scenario".* Several cited TL programs are positive examples of comparative advantage: *"...three of the centres did work together through the TL projects (and in TL I that included many outside partners). The CRP is just another mechanism to achieve this".* However, a minority of Research Managers offered different opinions, noting that the Grain Legumes structure increases transaction costs and time spent planning. *"Transaction costs, politics of budget allocations, large number of reviews and planning meetings have reduced the time and resources*

available for research. We need to look at efficiencies to reduce these transaction costs as well as revise planning processes that are responsive to the needs of farmers and national government priorities."

Almost half (45%) of Research Managers considered an eco/production approach superior to a PL approach in delivering impact (Question 25, Figure A5.6). For what is an important topical issue, however, 33% disagreed and 21% undecided; some suggested that the PL approach has been focused on delivering outputs, whereas a systems approach would increase complexity. For example*: "A systems approach has always had difficulty in finding practical interventions. Even systems approaches end up looking for improved components. Systems work sets the context for intervention with components".* Those holding the middle ground emphasise the value of priorities, objectives, collaboration and funding regardless of approach, e.g. "It does not matter what approach you follow as long as your goals are clear, and funding is available to deliver the results". One respondent perceives PLs as contributing to a systems approach with some limitations: *"Like drops of water to a [sic] ocean, PLs contribute to systems approach. Nonetheless, PL has its deficiency as it talks about a single product and not does not explain all the activities we do to achieve outputs in a crop".*

Figure A5.6. An eco/production/systems approach would be superior to the product line approach in delivering impact

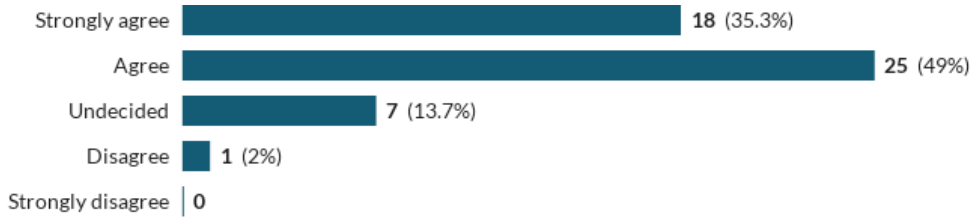


Source: Grain Legumes Survey

A large majority of Scientists agreed that initial selection of eight legumes was generally considered appropriate, particularly for the semi-arid tropics (Question 67). A few suggested that others are key and worthy of inclusion, e.g. mung bean, sesame, grasspea and dry pea. One comment cautioned that combining legume research with other crops would weaken the focus: *"It will kill grain legumes as combining will make it less visible".*

Two thirds of comments from Research Managers indicate that constraint analyses and lessons from *ex post* studies have informed program design for enhancing the likelihood of impact, although several suggest that further analyses are needed or learning is yet to be incorporated (Question 21, Figure A5.7). For example: *"I believe that CRPs have been over evaluated but learning has not been efficiently translated into redesign give the rigidity of CRP design and activities."* Conversely, *"There has been little formal quantitative constraint analysis. Most is based on expert opinion".* A large majority of Scientists (84%) agree that lessons learnt from research conducted prior to CRP have influenced their choice of current research (Question 55). Comments indicate that the research agenda and the Grain Legumes objectives are heavily influenced by previous research projects. For example: *"Prior to CRP, the research was material oriented. However, it gave insights into the specific problems addressed. With CRP, the programmes got focused into 'Product oriented' which is very important for tangible results".*

Figure A5.7. Lessons learned from research conducted prior to the CRP have influenced my choice of current research (Scientists)



Source: Grain Legumes Survey

Opportunity exists for Scientists to follow-up on good ideas with research (90% agree), although funding and inconsistent collaboration between Scientists can be limiting factors (Question 59, Figure A5.8). Window 3 and bilateral funding seem to increase the opportunity. Some CGIAR Centres have formal mechanisms to collect and review novel research ideas, e.g. *"The evaluation meeting in IITA is good opportunity for me. And conversations with my supervisors also are good opportunity for me"*.

Figure A5.8. Opportunity exists for me to follow-up on good ideas with research (Scientist)

Source: Grain Legumes Survey

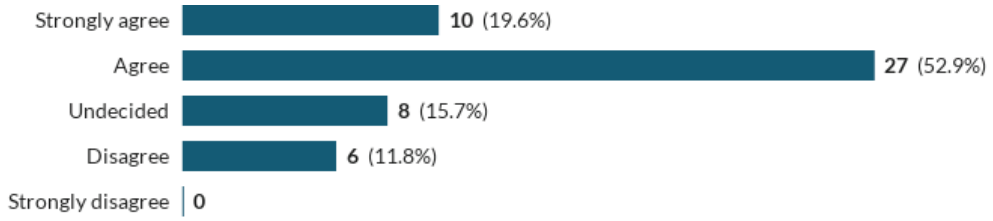
- *Efficiency:* The review team will use documented evidence plus interviews to examine the structure and effectiveness of leadership across the Grain Legumes. This will include governance structures, financial management and engagement with the Independent Advisory Committee as described in Figure 6. The team will be informed by the sections above on partnering to evaluate the effectiveness of partnership management, of project management across PLs and how IP (Intellectual Property) is managed across multiple partners inside and outside the grain legumes program.

The majority of Scientists agreed that they feel an integrated part of Grain Legumes, although 18% disagreed (Question 37, Figure A5.9). Moreover, 12% do not understand the organisational structure in which they work and 16% are undecided (Question 38, Figure A5.10). Understanding, however, does not necessarily mean acceptance: *"I understand it but that doees [sic] not mean this is the structure I prefer".* Clarity may be better where collaboration is highly valued, *"it provides the forum for me to work closely with international instituite [sic] like ICRISAT".* Others are unsure of key personnel and relationships: *"Not sure of the collaboration between centres due to differences in standards of operation in seed systems"* and *"I don't know some key people in the CRP line".*

Figure A5.9. Do you feel an integral part of the CRP? (Scientist)

Source: Grain Legumes Survey

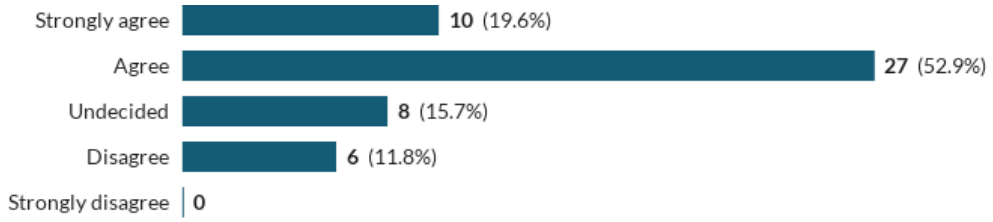
Figure A5.10. I fully understand the CRP organisational structure in which I work (Scientist)



Source: Grain Legumes Survey

According to 88% of Research Managers, Grain Legumes activities have enhanced synergy in research and development (Question 10, Figure A5.11). Comments, however, showed a more balanced split of opinion. Supporting comments cited the collaboration between centres, and NARS; and some specific outcomes, such as seed systems. *"The CRP has brought together institutions that were not used to work together. This is noticeable at the country level." "There have been some good outcomes (e.g. physiology across legumes, seed systems, applications of genomics)."* A similar number indicated limited and strained collaboration or the high financial implications within Grain Legumes: *"CRP activities have fostered greater collaboration and synergies. However, these have come at large transaction costs that need to be addressed in the design of a second phase of CRPs."* In addition, *"It seems that on-going work of the Centers has been forced into a so-called "collaborative" research structure. Maybe some synergies that have developed but they are not readily apparent."* Similarly, *"Very little true interaction within the Product lines."*

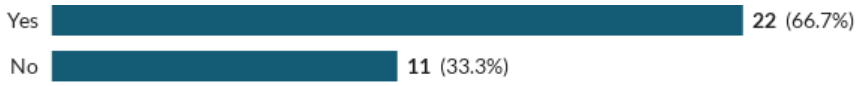
Figure A5.11. CRP activities have enhanced synergy in research and development (Research Manager)



Source: Grain Legumes Survey

Two thirds of Research Managers agreed that value has been added by the programme's design and implementation, management and commissioning; one third, however, disagreed (Question 30, Figure A5.12). However, it is not clear whether the reformed CGIAR organisational structure has increased efficiency and successful program implementation (Questions 28&29, Figure A5.13). Some commented on increased efficiencies; for example *"...in utilising the shared facilities; individuals covering more than just one centres [sic] work and having common agendas. However, this may not be uniform across all CRPs projects and activities".* In addition, [Grain Legumes is] *"...more transparent than in the past. Resource allocation to NARs has improved".* Nevertheless, the current structure is widely considered to have too many layers, resulting in complex, difficult and time-consuming management processes. For example: *"...reform has NOT increased efficiency. Lessons? There are too many. Build on your strengths, don't alienate strong actors as if they are competitors. Be humble, leadership is not the same as bullying. Consult honestly with integrity. More structure does not equal better".* Similarly, *"The roles of center management and CRP management need clarification."*

Figure A5.12. Has value been added by the programme's design and implementation, management and commissioning processes? (Research Manager)



Source: Grain Legumes Survey

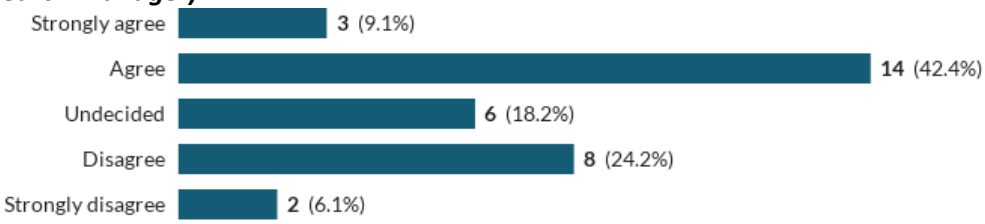
Further vehicles for improved efficiency include bilateral projects which are seen as more cost effective than W1/W2 where transaction costs are disproportionately higher. Change management is also cited as inefficient; it *"should be introduced systematically and rolled out in phases to enable the program/project staff to smoothly transition into the new structures".* One comment suggests that States should plan for radical change in funding patterns: *"Not only for this CRP, but for the whole CGIAR system, countries must take much more responsibility and contribute financially for the strengthening of infrastructure and staff. The model of depending on a few charity donors and international agencies will not last long. Many countries that were miserable in the recent past now would be able to contribute with funds and qualified people, and consequently, in the governance of the whole system"* (Questions 28&29).

Figure A5.13. Have the reformed CGIAR organisational structures and processes increased (or decreased) efficiency and successful program implementation? (Research Manager)

Source: Grain Legumes Survey

Approximately half of Research Managers agreed that opportunity exists for radical modification of research direction followings findings from M&E; yet, comments qualify that agreement (Question 9, Figure A5.14). Notably, with the absence of routine M&E activities, many comments referred to the CCEE review: *"The current research direction is good and needs to be continued. What will a bunch of people with limited exposure to Grain Legumes be able to suggest compared to scientists who have 10 to 30 years of experience in legumes?"* Others are more accepting of change: *"Both research management and direction can be modified following the review." "More integration is expected in the GL CRP across all commodities after the findings of M&E."* Others commented on the function*: "M&E can not [sic] modify research direction. It helps in how improving the way work is conducted"* and *"If we need to reduce trasaction [sic] costs and need to be effective, it is imperative to improve the structure."* The theme of sustainable funding runs throughout the survey: *"Level of funding and control of budgets/research agendas made it difficult to make radical changes. Control still mostly by Centers, and donors who support specific agendas."*

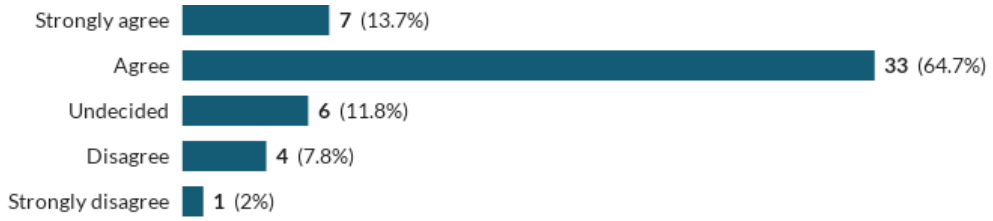
Figure A5.14. Opportunity exists for radical modification of research direction following findings from M&E (Research Manager)



Source: Grain Legumes Survey

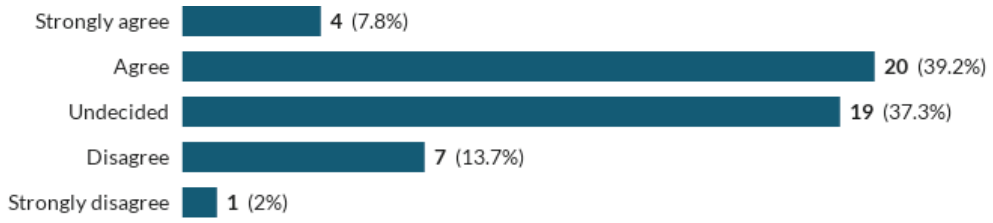
A large majority of Scientists (78%) agreed that information is shared freely and routinely with the PL in which they work; 10% disagreed and 12% undecided (Question 39, Figure A5.15). Responses were less positive about inter-PL information sharing; 48% agreed, 14% disagreed and 37% undecided (Figure A5.16). It is unclear whether information is freely and routinely shared between CRPs; 28% disagreed, 26% agreed and 47% undecided (Figure A5.17). Comments indicated few interactions between CRPs or across PLs: *"Need a better coordination to accomplish cross sharing between PLs and CRPs"*; *"i guess the problem is that we never have any scientific exchange in these PLss [sic], either within or across".* Information sharing within a PL or regarding a specific crop was more positively regarded: *"with my PL I shared my problems regarding the project and always get quick response. with other PLs I share freely but between my CRP other CRPs it is not shared routinely".*

Figure A5.15. Within my PL, information is shared freely and routinely (Scientist)



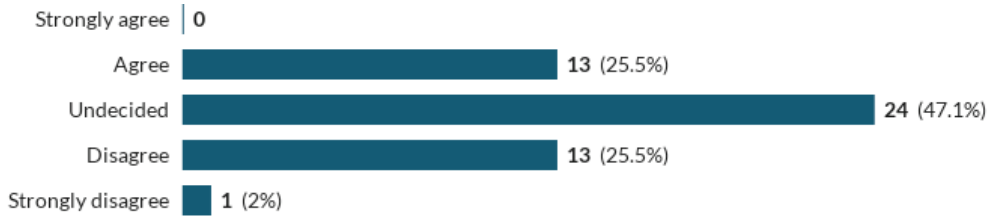
Source: Grain Legumes Survey

Figure A5.16. Between my PL and other PLs, information is shared freely and routinely (Scientist)



Source: Grain Legumes Survey

Figure A5.17. Between my CRP and other CRPs, information is shared freely and routinely (Scientist)



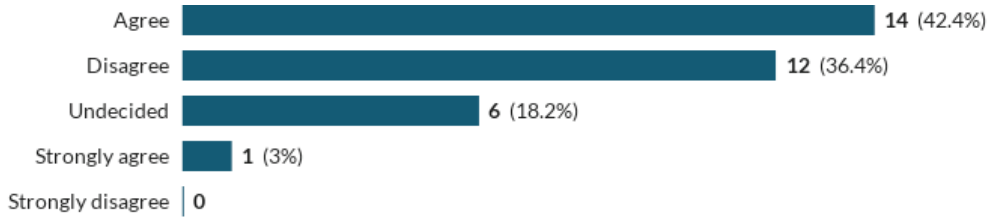
Source: Grain Legumes Survey

Overall, the majority of Research Managers largely disagreed or were undecided about there being sufficient clarity for outsiders on the needs, priorities and activities in Grain Legumes (Question 20, Figures A5.18, A5.19). The following comment summarises opinion: *"There is a need for more efforts on the GL CRP to bring more visibility to the needs, priorities and activities of the Program",* although one suggests that *"The answer will be 'yes' it [sic] we are asked about the Center instead of CRP".*

Figure A5.18. There is sufficient clarity for outsiders on needs in the CRP (Research Manager)

Source: Grain Legumes Survey

Figure A5.19. There is sufficient clarity for outsiders on priorities in the CRP (Research Manager)

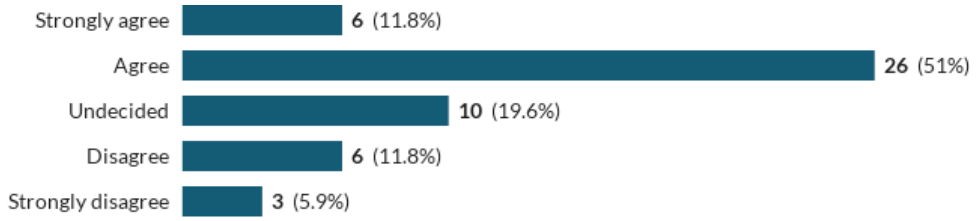


Source: Grain Legumes Survey

Consultation and communication with staff is predominantly *ad hoc*, although annual meetings are a more formal mechanism (Question 40). Meetings, emails, phone calls and web conferencing provide direct methods of communication; websites, blogs and newsletters are more general. The majority of comments indicated top-down methods, only a few Scientists mentioned formal means of consulting or communicating upwards: *"Interaction with PL Coordinator, PL team members and CRP leader"; "In IITA, there is the meeting to evaluate each researcher's work in every year. At this time, senior researchers and head of West Africa hub in IITA give the opportunities to discuss the works"* and *"Through CRP coordinator within IITA".*

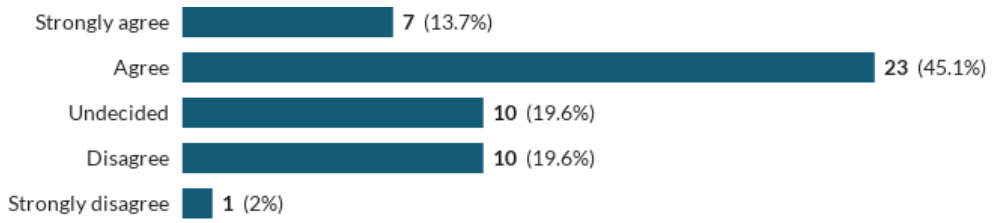
A small majority of Scientists agreed that they have access to the equipment and training needed for their research (52% and 59% respectively) (Question 47, Figures A5.20, A5.21). Whereas 18% did not have access to the necessary equipment and 22% did not have the training they require; 20% undecided. Comments indicated an equal split between those with the necessary equipment and training and those without, although one is due to relocation from Syria. The major issues restricting achievements, however, are funding (34%) and time constraints (16%) (Question 47b), for example: *"With CRP, number of meetings have increased and as a result, time has restricted to attend more of the experimentation. Budget cut has been rule than exception and this has adversely affected to carry our [sic] some of the experiments".* Specific comments relate to the need for capacity building or access to seed technologies and nurseries.

Figure A5.20. I have access to all the equipment required for my research (Scientist)



Source: Grain Legumes Survey

Figure A5.21. I have access to all the training I need for my research (Scientist)



Source: Grain Legumes Survey

- *Quality of science:* The Grain Legumes has access to a wide range of technologies and this section will ask if they are being utilised in a way that will increase our fundamental understanding of the biology that underpins several PLs. We will assess whether data are collected in response to hypothesis driven research and whether they are used in the most effective way to inform and deliver, both independently at the contributing organisation or CRP level.

This topic was more comprehensively explored in the PL self assessment, thus data are not included.

- *Measured program effectiveness:* The evaluation team will assess a sample of individual projects [or Activity Clusters], as guided by the PL leaders, that contribute strategically to the overarching aims and vision for the Grain Legumes. This will be done by comparing each PL to the five strategic components and the frameworks (Figure 4).

Overall, Grain Legumes is well recognised and valued among respondents not engaged in the program (Question 107, Figure A5.22). Eighty percent of non-Grain Legumes respondents were aware of the program; however, this includes 21% with current or former collaborative links to the program. For the majority (89%), non-participation in Grain Legumes was due to not being invited, only 7% declined the invitation and one person was formerly engaged in Grain Legumes (Figure A5.23).

Figure A5.22. Have you heard of the CRP in Grain legumes? (non CRP Respondent)

Source: Grain Legumes Survey

Figure A5.23. What is the primary reason you are not involved? (non CRP Respondent)

Source: Grain Legumes Survey

A sizeable majority of non-CRP respondents, 61%, agreed that GL is relevant to their work and 68% agreed that outcomes from GL would add value to their work (14% felt that Grain Legumes was superfluous to their work, 18%) were undecided and 7% considered it not applicable.). However, three respondents (10%) negatively commented on the low return of CRP: *"...report-heavy and impactless", "...doing the best it could under the poorly designed CRP structure", "...limited value to those not working on specific crops", "...no commitment to understanding the farmer community and structural barriers to sustainable technology adoption".* Conversely, two respondents offered positive comments: *"Receiving information from breeders in order to orient research in crop genetic resources is always useful", and "The focus of the CRP is global; thus it includes solutions or ideas applicable in*

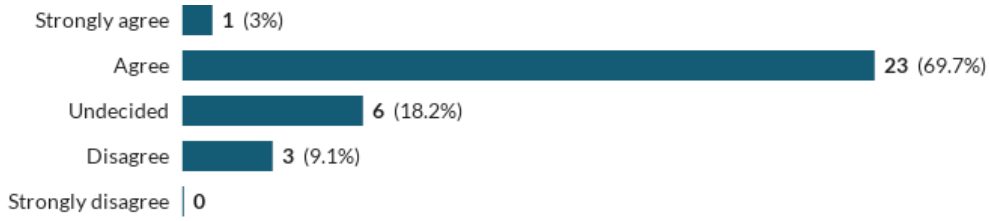
my own breeding projects". Three respondents felt unable to comment on its value and relevance, due to unfamiliarity with GL. The Tropical Legumes programmes are less well known (57%). Two non CRP respondents (13%) had been directly involved in a TL, having benefitted from funding for breeding and seed systems for beans; and comparative genomics (Question 108, Figure A5.24).

Figure A5.24. Have you heard of the Tropical Legumes Programmes? (non CRP Respondent)

Source: Grain Legumes Survey

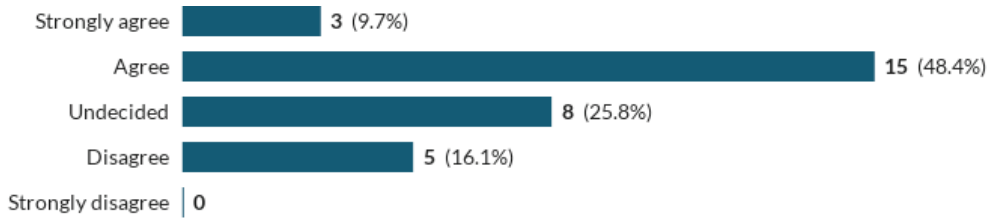
The majority of Research Managers agreed that Grain Legumes has achieved its Intermediate and CGIAR System Level Outcomes (73% and 51% respectively) (Question 7, Figures A5.25, A5.26). The associated comments, however, indicated a less positive response: *"These are still a long way off. The important question is whether the CRP is headed in that direction. I think it is, but slowly and with some obstacles." "Yes if considering that it builds on the previous work." Sustained efforts are required to achieve and better coordination and transparency among partners on technical aspects." "While GL scientists have done their best to deliver, the funding support from Donors and Consortium itself has been dismal. In addition, scientists have to spend more time in preparing reports, extension proposal, new proposal, etc rather than doing actual research."*

Figure A5.25. GL CRP has achieved its Intermediate Development Outcomes (Research Manager)



Source: Grain Legumes Survey

Figure A5.26. GL CRP has achieved its CGIAR System-Level Outcomes (Research Manager)

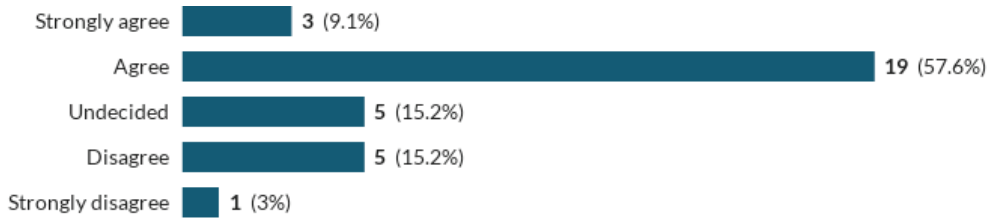


Source: Grain Legumes Survey

Two thirds of Research Managers agreed that Product Lines are "Game Changers"; 18%, however, disagreed (Question 16, Figure A5.27). Approximately half of the comments suggested that the concept of "Game Changers" is somewhat redundant as PLs are a retrofit of pre-existing objectives: *"Product lines are simply restatements of previous objectives of the programs of the Centers. They may be more uniform and somewhat easier to comprehend, but the objectives are basically the same except for the "repackaging."* In addition, *"This is an old concept for most of us so I wouldn't give credit to this being a "game changer". Focused product development based on market requirements should be a fundamental component to crop improvement if high rates of adoption are to be realized".* Others suggested that PL outputs are delivering potential "Game Changers": *"Product lines identified 'clear products' to deliver and have worked to deliver the products for development; where they work, the results are game changers". "The delivery of the CRP and impact to be made depends on the Product*

Lines, how well they reflect the needs and priorities for the CRP and how the program is designed depends on the PLs."

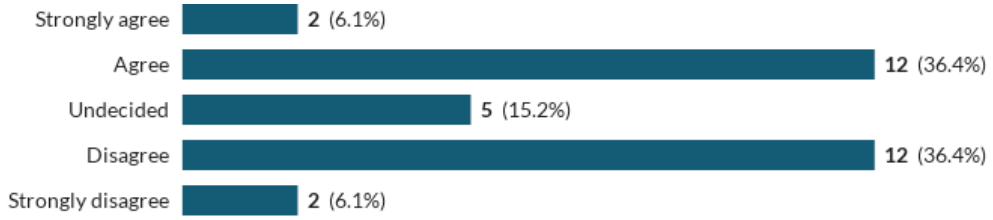
Figure A5.27. Product lines are real 'game changers' (Research Manager)



Source: Grain Legumes Survey

Opinion was equally divided over whether PLs are donor driven (Question 17, Figure A5.28). The majority of comments however, suggested that the notion is not new: *"Activities may be donor driven, but then under the CGIAR system and Centers objectives were mostly donor driven."* Similarly, *"In as much as funding determines priorities/options for research. Large W3 funding is totally donor driven and thus, what remains is minimal in driving the agenda"*. In addition, the difference between funding sources was noted: "*Yes, because >70% funding still comes from Donor funded (W 3) projects. Until the W1/W2 funding reaches >80%, this will continue to be Donor driven".* A middle-ground suggests that *"It is driven by both donors, ISPC and scientists. Unfortunately, the product lines are too narrow and not agile enough to respond to diverse national requirements. To be relevant one needs to be agile and respond to demands on the ground".* Others concur: *"...more flexibility is needed in the product lines."* A small number of comments suggest that researchers drive the agenda: *"they are researcher driven informed by their previous lessons"* or *"the product lines identified critical areas that were constraints in the focus geographies; the communities identified these as important and the donors [sic] interest matches the needs of the communities in those geographies".*

Figure A5.28. Activities within product lines are 'donor driven' (Research Manager)



Source: Grain Legumes Survey

- *Impact:* The review panel will examine the impact pathways that underlie each product line to assess if the route to impact is well defined, measureable and achievable. The impact will be compared to the stated aims of CGIAR and the Grain Legumes.

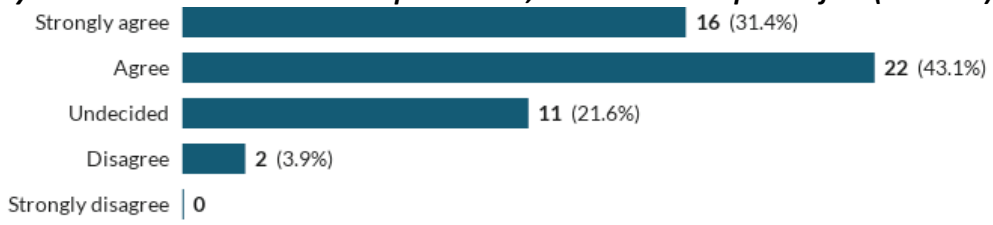
According to Research Managers, the major success of Grain Legumes was its capacity to provide a platform for collaboration within CGIAR Centres and with partners, thus enabling a more cohesive legume community at this early stage of the program (Question 22). *"...its success has been [the] ability to expand on the research human resources, bring together professionals from different organisations into fora to discuss strategies and research questions.* Others comment on specific strengths, such as breeding and crop improvement and its capacity to deliver technologies: *"...new areas of crop development were opened (heat tolerance, herbicide resistance, etc). Some modest communication among colleagues on common themes"*. The final sentence, however, qualified the issue of collaboration somewhat. Similarly, *"There has been some integration. The varieties are in*

place in the rice fallows. The big failure has been to adopt a coordinated and integrated approach to comparative genetics. This means that the genomics efforts cannot deliver".

Research Managers perceived the major weaknesses to be implementation, funding and governance (Question 22), as summarised by this comment: *"...the program is weak on actual implementation due to the persistent threat of budget cuts. Also, the management structure is awkward with there being CGIAR centers and their management structure and imposed on that structure is the structure of the CRPs. While the CRPs are expected to form complementary relationships and better utilize resources, they effectively siphon funds for management activities while reducing available resources for actual research."* Specific weaknesses include lack of support for the Grain Legumes Director; M&E; value chain and diversification; gender diversity; and the time spent managing change. As indicated by the following: *"Poor support from the lead center to the director"*; *"Its failures has been on monitoring CRP as a program"; "More work is needed on value chain and diversification of production systems"* and, regarding efficient use of time: *"...we spend more time on log frames, reporting etc. rather than actual work. Change is always needs but, we spend lot of time on organizing ourselves for CRP."* Two comments specifically refer to gender diversity: *"The major weakness are [sic] more to do with governance issues and particularly gender disparities in the management structures";* and *"I think the challenge was that the gender component was added later, and the specialist who was on board left and so the program experienced a lag in the implementation of gender research."*

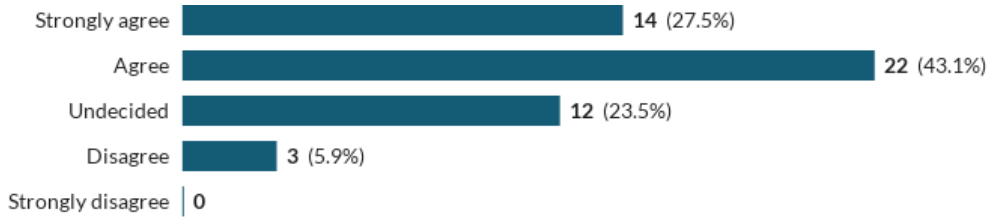
Figures A5.29 to Figure A5.31 indicate how Scientists perceived the impact of their research within the period of Grain Legumes (Question 48). The majority noted an increase in production, sales and consumption of grain legumes (43% agreed, 31% strongly agreed), similarly 43% agreed and 28% strongly agreed that their research has led to reduced poverty, hunger or malnutrition. A sizeable number are undecided in both cases: 22% and 24% respectively. The impact on farming systems is stronger with 31% strongly agreeing, 31% agreeing; yet, 31% are undecided. Comments (Question 48a) provide specific examples of progress across the range of PLs. Three quarters of Scientists stated that their work will contribute to the objectives of Grain Legumes in future; however, 24% commented that their work will not (Question 49). Timeframe for research outcomes varied between later in 2015 to 2025, although the mode was between 2 to 5 years.

Figure A5.29. My research has led to increased production, sales or consumption of GL (Scientist)



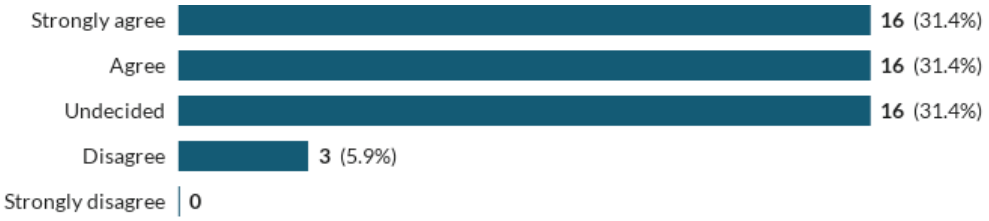
Source: Grain Legumes Survey

Figure A5.30. My research has led to reduced poverty, hunger, or malnutrition of small-holder farmers (Scientist)



Source: Grain Legumes Survey

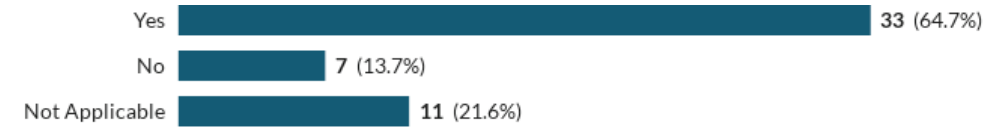
Figure A5.31. My research has led to improved sustainability of farming systems (Scientist)



Source: Grain Legumes Survey

A significant majority of Scientists agreed that there is evidence of improved crops or enhanced finances of smallholder farmers and the agricultural system arising from the ability of grain legumes to fix nitrogen in soils (Question 50, Figure A5.32). Several respondents offered evidence to support their assertion, for example: *"Through my tests, I observed that some cowpea lines showed the capacity to develop nodulation under the application of indigenous rock P. And they showed the similar good growth with under the application of P fertilizer. Rock P is cheaper than chemical fertilizer. If we can suggest low cost cultivation system using rock P, it will be helpful for small-holder farmers to enhance their finances".* In addition, *"Promiscuous soybean varieties able to cope with naturally occurring rhizobia for enhanced BNF (thus, not requiring inoculants) have been released and disseminated across SSA"* .One respondents suggested that: "*PL4 has simply taken the wrong route of trying to identify the perfect bacteria and has totally overlooked the macro-symbiont (the plant)".*

Figure A5.32. From your knowledge of the CRP, is there evidence of improved crops, or enhanced finances of smallholder farmers and the agricultural system from the ability of grain legumes to fix nitrogen in soils? (Scientist)



Source: Grain Legumes Survey

Almost one third of Scientists are unable to directly link research outputs to a CRP activity (Question 57, Figure A5.33). Fewer than half can link outputs to a CRP activity; examples given included varietal improvements; others specifically mentioned PL outputs, such as *"PL 6 and PL 7: Early chickpea varieties and Mechancially [sic] harvestable chickpea"*. Also, *"PL4/High N2-fixing ability of legumes - Standard operating procedures for the production, quality control and application of rhizobium inoculants..."*.

Figure A5.33. Are you able to directly link an output to a CRP funded activity? (Scientist)

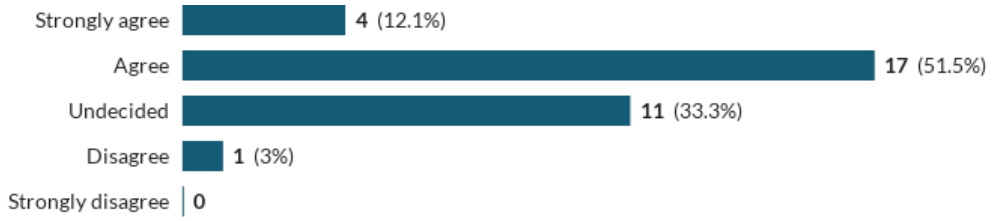
Source: Grain Legumes Survey

Several Scientists expressed an interest in working with new communities (Question 64), e.g. *"Small holder farmers where high yielding; adapted and disease resistant leguems [sic] are not scaled out".* The impact of the research in the wider community has a broad range of response; which indicates broad engagement (Question 64): *"I have been working with small holder farmers, local seed grower, farmer cooprative [sic] unions and other stackholders [sic] to bring miningful [sic] impact on bean technology generation and promotion, to contribute for the change in the livlihood [sic] of them and*

to improve production and productivity in the country". Similarly, *"Management of pests and pathogens contribute to yield stability in smallholder communities".* Engaging with Grain Legumes, however, was less amenable: *"I work at a US university. It seems to me that there is a current paucity of opportunities for closer interactions with CRP in general. The 2014 CRP-GL forum held in conjunction with international congress(es) in genomics and food research I though [sic] as a good way of linking them. I hope there are others in the future".*

Two thirds of Research Managers agreed that sufficient efforts have been made to document outcomes and impact from pre-CRP research, with reasonable coverage over research areas; yet, notably, a sizeable one third is undecided (Question 12, Figure A5.34). Several acknowledged the value of publications and their dissemination, for example: *"This area seems to be an important outcome of the development of CRPs in general";* and *"In last 4 years there has been significant effort to assess impact and disseminate results. Some publications exist and others are in the pipeline".* Others suggested a more systematic approach and wider dissemination: *"While some outcomes have been properly documented this is not the case across all 8 crops. Lessons learned could have also been better documented, including goverance [sic] and management of CRPs"; "More efforts should be made for wide circulation of documents or research outcomes among partners and media."* One respondent suggested the emphasis on publications is too strong: *"We are spending more time and resources to study and document the impacts, this should be rationalized. Documenting outcomes help us to build upon but we can draw analogies and need not make an attempt to document every research."*

Figure A5.34. Sufficient efforts have been made to document outcomes and impact from pre-CRP research, with reasonable coverage over research areas. (Research Manager)



Source: Grain Legumes Survey

Scientists were fully aware that publications are important pathways for impact (Questions 62&63, Figure A5.35) and 80% have published within the last three years. Those that have not were either relatively new to Grain Legumes, midway through research activities or have publications in draft, e.g. *"Still new (less than 2 years). Still understanding the subject, but two articles have been lined up for publication".* One comments that report writing encroaches on time for publications: *"Joined recently and no time for publications. Writing reports kill all the time"*. Impact factors range from 0.5 to 9; this is reviewed more thoroughly within each PL.

Figure A5.35. Are you aware that publications are important pathways for impact? (Scientist)

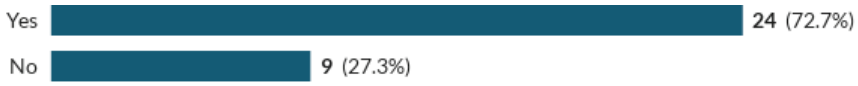
Source: Grain Legumes Survey

- *Likely sustainability*: Sustainability of each product line is closely linked to impact and the review team will assess whether the programme of work completed and proposed will generate a lasting benefit for CGIAR and the communities it serves. It will also look to the sustainability of Grain Legumes activities from the point of view of funding and importance.

A large proportion (73%) expected the benefits of CRP's activities to be sustained when the CRP ends (Question 31, Figure A5.36). In particular, collaboration with NARS and private partnerships: *"As long*

as efforts for Capacity Development of the NARS as well as key R&D institutions at the national level are well supported, the benefits from the activities will be sustained. Involvement of the private sector is key for this to happen". Responsibility was also placed on countries to focus on sustainability: *"Sustainability has been a major problem. Individual countries should [fund] these projects so that when the donors leave there will be continuity".* Strategic changes were anticipated in terms of M&E and planning: *"...Process of planning research will likely change as will M&E systems to become more agile, informative and pragmatic to support technology targeting, implementation and learning".* From a pragmatic perspective: *"Most of the activities were based on strong research programs which do not depend on the CRP per se for continuity, if funding permits them to continue to function"*.

Figure A5.36. Do you expect the benefits of the CRP's activities to be sustained when the CRP ends? (Research Manager)



Source: Grain Legumes Survey

Approximately 57% of Research Managers were concerned that steps have not been put in place to ensure sustainable funding; only 42% showed optimism (Question 32, Figure A5.37). Some expressed concerns over the proposed merger with Dryland Cereals and Systems in terms of loss of focus: *"The proposals are being submitted for next phase. I strongly feel that merger of CRP-GL with CRP-Dry land will have negative impact on legumes research for development".* Others perceive a failure within the CRP system: *"This is very specific to each center, but there are no central efforts on behalf of the CRP". "Over the past 3 years, the CO assumed the responsibility (sometimes usurping the same from Centers). The CO does not have a proper plan."* Greater stability is seen in bilateral funding: *"Centers have been bilateral funding as being more efficient and stable than W1/2 funding. This was especially evident in 2015".* Some linked sustainability with strong capacity building and effective relationships with NARS: *"Sustainability comes from enhancing capacity development in national program partners which is the case now".* Similarly, *"Lots of capacity building. Working with local partners encorages [sic] institutionalisation of approaches".* One comment refers to the proposed merger: *"in principle yes [steps are in place for sustainable funding], but what we see in the current configuration of GLADAS is not very reassuring for e.g. humid tropic legues [legumes]".*

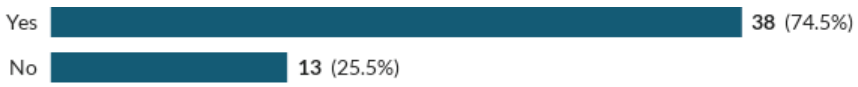
Figure A5.37. Have steps been put in place to ensure sustainable funding? (Research Manager)

Source: Grain Legumes Survey

- *Gender*: Gender is a crosscutting area of assessment in the proposed review and is a key area for the Grain Legumes, particularly because legumes are often considered as secondary crops (compared to maize and wheat) which are therefore cultivated primarily by women. Gender barriers, such as access to resources and technologies, were recognised in the CRP program description, and the review will assess to what extent such barriers are overcome by implementation of the research strategy. The review team will expect data or text to be provided that will describe how each product line is able to contribute to the increased income, food security, nutrition, environmental and resource conservation for resource-poor women and men existing in rural livelihoods. The team will investigate to what extent gender balance is achieved in delivering each program, through providing demonstration or test farms, participating in varietal selection and managing production, as set out in the CRP proposal (Table 1).

Twenty six percent of Scientists are unaware of the Grain Legumes gender strategy (Figure A5.38). Few mentioned the gender specialists within the CRP, but there is acknowledgement of interactions with PLCs. Donor requirements influence several Scientists to mainstream gender issues: *"I have not read the strategy but I have always mainstream gender in my research becasue [sic] of donor requirements and awareness created by them"*. Although 82% believed that gender is adequately considered, many responses lack substance in terms of proactively seeking opportunities for gender mainstreaming; however, there is some sensitivity on which to build.

Figure A5.38. Does the CRP have a gender strategy? (Scientist)



Source: Grain Legumes Survey

- *Capacity building:* The evaluation will analyse the way in which the Grain Legumes has identified and met internal and external capacity gaps. The CGIAR Capacity Development Community of Practice has developed a number of tools and frameworks to inform Centers and these will be used, along with other appropriate frameworks, to guide the evaluation. The review will assess the effectiveness of capacity development, considering stakeholders to include internal and Grain Legumes staff, external partners, governments, policy makers and the private sector. The team will assess the extent to which there are methods for implementing capacity building within each product line, and how well staff at all levels feel they can contribute ideas towards capacity building.

There was a strong perception that relationships between the various stakeholders are dynamic and effective in terms of achieving programme outcomes/objectives (Question 27). Limitations, however, were seen in terms of poor synergy, low team spirit, complexity and fluidity of relationships; caused, in part, by concerns about funding sustainability. *"Managers and scientists are still focused on the sustainability of the research centers, rather than CRPs. "Nobody loves the CRPs", but they do love their centers." "Relationships have been based on personal contacts rather then [sic] on a facilitated approach." "Relationships are most effective within a country, especially with CGIAR staff based in that country. I believe countries should have a stronger voice in setting CRP priorities."* Furthermore relationships were considered: *"...quite dynamic and complex as there are so many stakeholders involved. This requires good communication and timely feedback on the CRP and depends on the leadership qualites [qualities] of the CRP Director. With carity [clarity] of roles and responsibilities of the stakeholders, this can be effcetively [effectively] managed."*

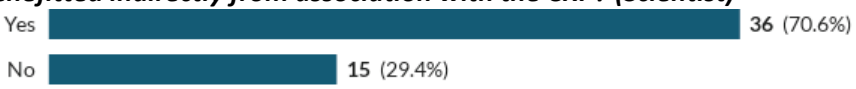
A large majority of Scientists have benefitted directly from their association with Grain Legumes (80%); however, 20% felt that they have not (Questions 41-43, Figure A5.39). The three perceived key benefits are being part of a larger research network; receiving funding and the sharing of breeding materials. Those who have not benefitted directly from Grain Legumes would have liked the opportunity to attend meetings to share research with peers, utilising a broader platform to facilitate knowledge exchange. *"Facilitating the knowledge exchange and learning of interest groups --all interest groups in order to influence science quality, innovation, in all biophysical, social science and management -where this happened the focus was limiting."* A minority would like training or additional funding support. Ninety percent of respondents currently not benefitting indicated that there would be added-value to their research if they benefitted directly from Grain Legumes (Question 44).

Figure A5.39. Have you benefitted directly from association with the CRP? (Scientist)

Source: Grain Legumes Survey

Indirect benefits showed a similar trend: 71% of Scientists have benefitted, 29% have not (Questions 45&46, Figure A5.40). Networking, collaboration and information sharing are the key indirect benefits: *"Tools developed by CRP used in other bean project work, resource mobilisation aligned with CRP"; "Priorities identified in CRP helped to justify research problems and strategy"*. The opportunity to share breeding materials is also valued: *"During chickpea annual field day ICRISAT give [sic] full freedom for selection of breeding lines to us .Those lines we can use in our breeding program"*.

Figure A5.40. Have you benefitted indirectly from association with the CRP? (Scientist)



Source: Grain Legumes Survey

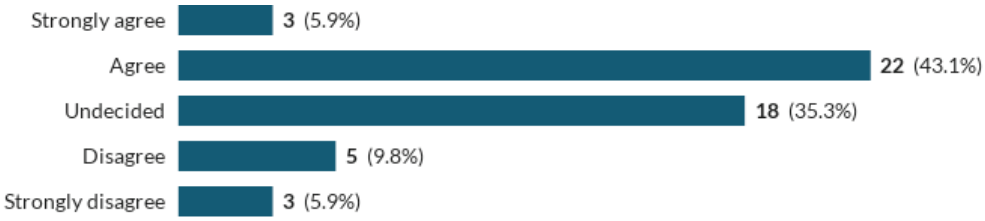
Only 41% of Scientists have personally benefitted from capacity building within the timescale of CRP (Question 51, Figure A5.41). Most was supported by CGIAR or CGIAR Centres. Capacity building for partners, however, is more forthcoming (Question 52). Several report under- and postgraduate degrees; training for NARS partners and topics such as gender, genomics, seed systems, data collection and analysis.

Figure A5.41. Have you directly benefitted from capacity building in the past three years? (Scientist)

Source: Grain Legumes Survey

Mentoring of the Grain Legumes research community is inconsistent (Question 58, Figure A5.42): several Scientists suggested that no mechanism exists for mentoring and little effort is exerted in engaging Scientists in providing mentoring. One respondent stated that CRP 4 was better, as it *"...has a pool of more experienced Nutritionist[s]"*.

Figure A5.42. I am mentored effectively (Scientist)



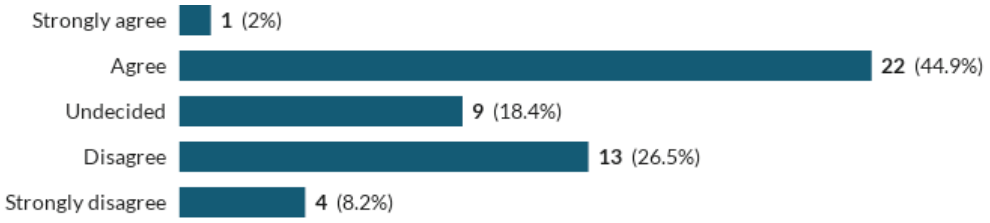
Source: Grain Legumes Survey

In general, most Scientists are satisfied with the time or support offered by CRP for i) training and mentoring; ii) coordination, iii) meetings and iv) research activities (Figure A5.43). Surprisingly, considering the underlying theme of too many meetings and reports, 59% express satisfaction with the time CRP allows for research activities. Fewer than 40% express satisfaction over the subjects of v) incentives for working with partners, and vi) reporting structure and processes. Scientists answered a subsequent question about partnerships more positively, however: 65% agreed that "Partnerships with other organisations are well supported by Grain Legumes" (Question 53). Funding is the most

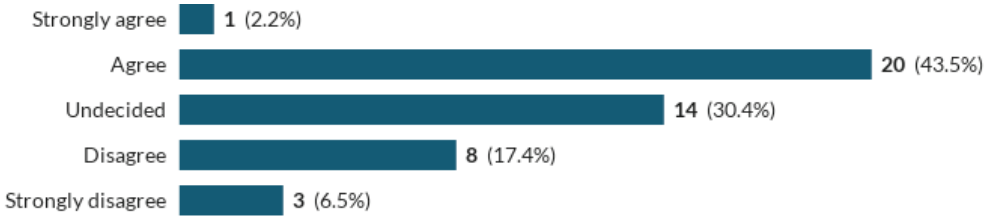
hotly disputed topic with 52% stating that Grain Legumes does not provide adequate support to ensure funding reliability.

Figure A5.43. Please indicate how satisfied you are with support from CRP in the following areas: (Scientist)

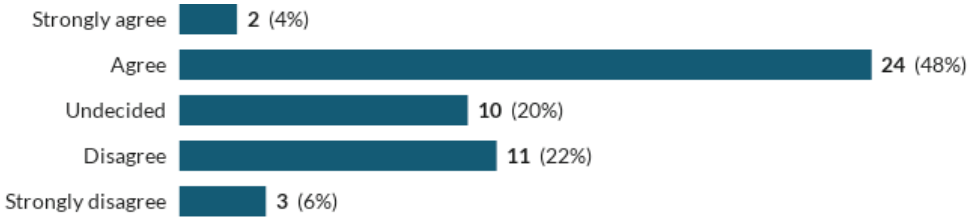
Time for training and mentoring:



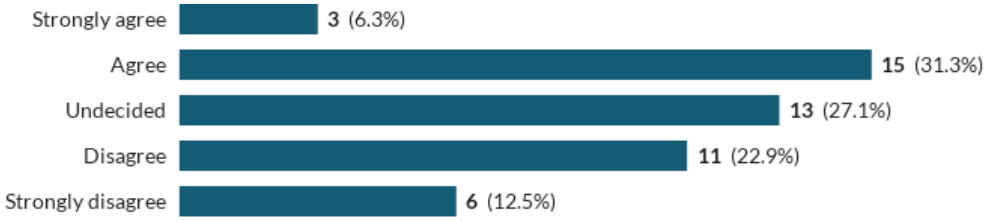
Time for coordination:



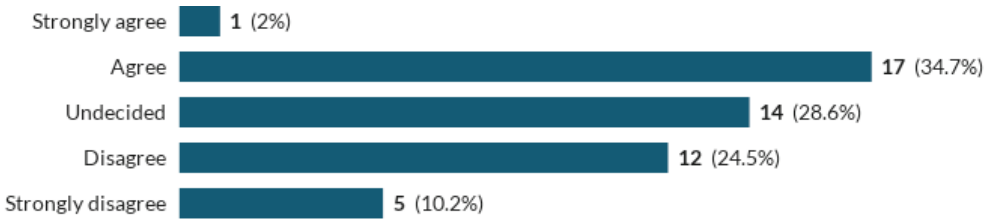
Time for meetings:



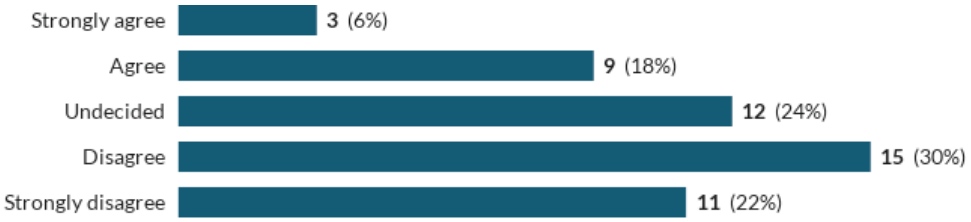
Incentives for working with partners:



Reporting structure and processes:



Funding reliability:



Source: Grain Legumes Survey

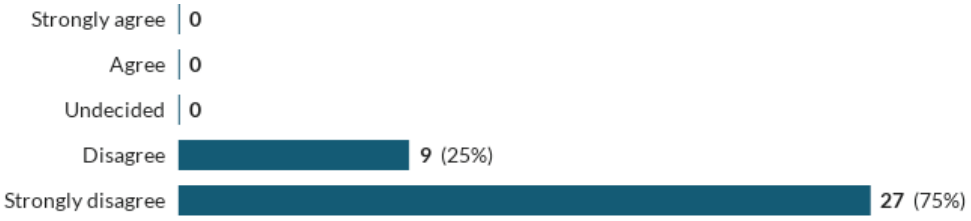
- *Partnerships, inclusivity or exclusivity, synergy in relationships:* The review team is aware of how significant and important external partnering with organisations, projects and individuals can be to the success of a research programme. The team will examine to what extent there is effective involvement of partners in research and activity programming, what the criteria are for developing partnerships, how they are contracted and how communication between partners and within the CRP are managed.

Partnerships with other organisations are well supported by Grain Legumes (65% of Scientists agreed), although, as previously mentioned, only 38% of Scientists agreed that there are incentives for working with partners. The majority of partnerships are with NARS, other CGIAR Centres or Universities (Question 53, Figure A5.44). Partnerships with the private sector were uncommon. The benefit in legume researchers formally engaging with one another was unanimously agreed by non Grain Legumes respondents (Question 110, Figure A5.45).

Figure A5.44. Has the CRP supported your partnership with other organisations?

Source: Grain Legumes Survey

Figure A5.45. There is no benefit in researchers on legumes to get together formally (non Grain Legumes Respondent)

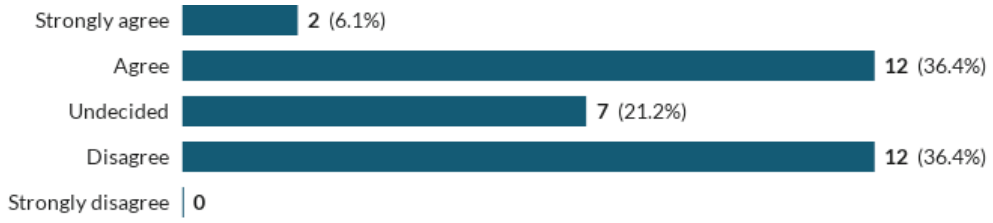


Source: Grain Legumes Survey

Partnership is another topic that splits Research Manager opinion; similar numbers agreed and disagreed that NARS and other partners are sufficiently well represented in the structures of Grain Legumes, although 21% were undecided (Question 18, Figure A5.46). There was a broad range of opinion regarding NARS in particular: *"NARS are represented in the RMC, the highest management structure of the CRP; however, its [SIC] not possible to have all the NARS from all countries represented in this structure; at the product line level, most implementing teams come from the NARS".* An alternative view is that *"[NARS] are poorly represented and engaged, but to be more so they need a greater stake in the activity - that is difficule [sic] with a diminishing W1 budget".* Further constructive

comments included: *"We can expect better and quality engagement of NARS through competitive grants (this is active participation!) rather than involving them in planning and other meetings (this is passive participation)". "While I agree, more could be done to incentivize NARS to contribute and engage more. At ICRISAT we are now working on country strategies that are driven by the needs of farmers and markets that has [sic] been well received by all and fosters stronger NARS engagement."*

Figure A5.46. NARS and other partners are sufficiently well represented in the structures of the CRP (Research Manager)



Source: Grain Legumes Survey

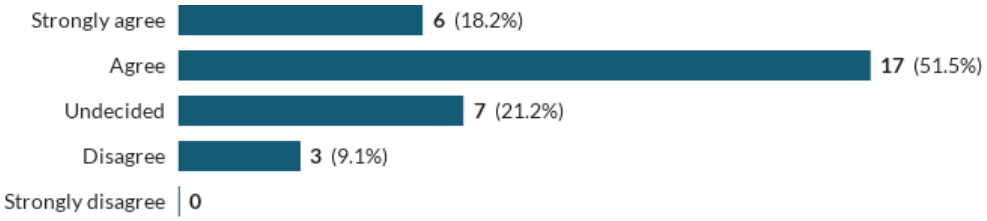
Non CRP respondents commented on the facilitating role of Grain Legumes and Tropical Legumes (TL) programs in developing synergies, whilst acknowledging that other mechanisms exist (Question 111). Sixty-one percent are members of networks, other than Grain Legumes and TL, which support research synergy (Figure A5.47). Opinions about networks varied from *"CGIAR-led global programmes have the capacity to be truly global in reach"* to *"...forced synergies often fail, especially from a research perspective"*. The majority of those who commented acknowledged the value of face to face contact, although many highlighted the challenge of sustaining a common focus: *"It requires projects for us to work together across institutions, not just nice thoughts"; "...usually there is not time or facilitation to get real synergistic thinking done"*; and *"...research gains in one legume species may have little application to another legume species". "There should be ways that scientists can interact but save travel times." "Researchers should at least meet once to set up the calendar of the work... in order to avoid redundance and share the objectives. "It is very important that researchers meet to share the different research experiences in their respective countries..."*.

Figure A5.47. I belong to another network that supports research synergy (non Grain Legumes Respondent)

Source: Grain Legumes Survey

A large majority of Research Managers (80%) agreed that CRP partners are effectively leveraging their knowledge and research capacities, enabling them to coordinate strategies with diverse public and private organisations (Question 11, Figure A5.48). Some commented that further collaboration is required: *"Yes and No. Partners are leveraging their knowledge but the GL CRP has underperformed in the case of private sector engagement. More can be done with GL processors and promoting legumes as companion crops for seed companies that market maize." "I don't see much evidence of that, but maybe it is still early for the CRP." "Some knowledge is shared and there are some indications that experiences are shared across organisations for mutual benefit. Getting people together for discussions of common problems may be the net benefit of the CRP."* The ever-present theme of funding is also mentioned: *"The CRP Partners are doing their best. However, the uncertain and paltry funding has negatively affected the partnerships with NARS that was built over past 3-4 decades."*

Figure A5.48. CRP partners are effectively leveraging their knowledge and research capacities, enabling them to coordinate strategies with diverse public and private organisations (Research Manager)



Source: Grain Legumes Survey

The degree of interaction between Scientists and beneficiaries was generally high and perceived as productive (Question 65). Comments suggested that frequent, targeted interactions are effective, particularly accompanied by a review of impact: *"Strong interaction by way of farmer's participatory approaches and interaction by person and through telephone and field visits"*. Sixteen of the 51 Scientists commented that interactions should improve.

There was almost a complete consensus that end users' viewpoints and needs are incorporated into the research agenda (Question 54, Figure A5.49). Comments offered techniques such as on-farm participatory varietal selection trials, feedback from on-farm demonstrations, experiments and trials, multi-stakeholder meetings and close collaboration with NARS.

Figure A5.49. Are end users viewpoints and needs incorporated into your research agenda? (Scientist)

Source: Grain Legumes Survey

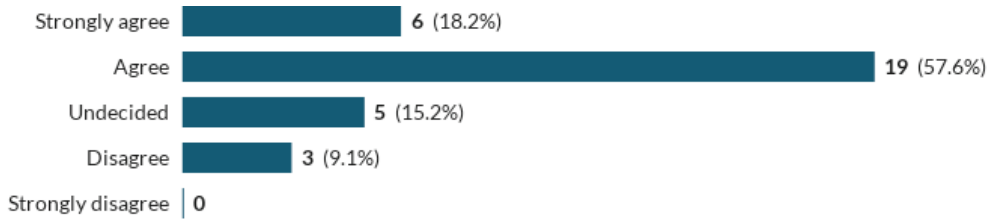
Research Managers considered mechanisms for setting, allocating and managing partnership budgets unclear (Question 19). Although they perceived the allocation to be based broadly on their work plans and contribution: *"Budget is usually allocated to partners (an amount is given) then they should plan activities within that amount. It would be good if they present activities with budget and then a panel (steering committee) decide on the proposed budget and activities".* Others suggested influence by donors through competitive grants: "*Partnership budgets are mostly W3 funds and thus are set in negotiations with donors on specific budgets".*

Moreover, allocation through CGIAR centres seems to cause delays: *"to say the least, it is utter confusion. Each CRP follows its own rules, and is creating lot of heartburn among partners, esp. NARS".* It is unclear whether the following action is widespread or if it has improved budget disbursement: "*Initially partner budgets were managed through the different CGIAR centers but this caused severe delays in disbursing funds to partners. Also different CGIAR centers adopted different allocation percentage. Based on this experience, ICRISAT as the Lead center, made direct payments to all partners (NARS, Universities, etc.) based on signed agreements. Budgets were allocated to the CGIAR centers based on "base budget" in the initial years, to provide stability of funding. In 2014/ 2015, budgets were allocated not only on the basis of base budget, but also competitive grants mechanism. The respective recipients manage their own budgets."* There was also acknowledgement of the role of RMC, SC and IAC: *"Budget allocations are made by the Director of the CRP with consultations with the RMC, SC and IAC"*.

- *Governance and management including financial leadership*: The review team will use documented evidence plus interviews to examine the structure and effectiveness of leadership across the Grain Legumes. This will include governance structures, financial management and engagement with the Independent Advisory Committee as described in Figure 6. The team will be informed by the sections above on partnering to evaluate the effectiveness of partnership management, of project management across PLs and how IP is managed across multiple partners inside and outside the grain legumes program. We will also evaluate, through other cross-cutting areas, one relating to communication and the other impact of earlier (pre-CRP) research and development. Lines of communication that work effectively are essential at many different levels. The review will examine the formal reporting framework and whether it is successful in a practical sense between scientists, managers and advisory partners within a product line, between product lines and between the Grain Legumes and other CGIAR programs. The team will also examine how effective the grain legume program is at communicating its findings with the outside world through peer-reviewed publications, trade and grey literature and other forms of media that engage the stakeholder community.

Research Managers agreed that Grain Legumes has an integrated approach to governance and management (18% strongly agree, 58% agree); yet, respondents' comments offered notable qualifications (Question 8, Figure A5.50). These include: implementation is fragmented; bureaucratic and cumbersome governance; multilayers creates confusion; originally dominated by ICRISAT; poorly designed at the beginning; need more diversity of stakeholders; and poor representation of partners, particularly NARS.

Figure A5.50. There is an integrated approach to the governance and management of the CRP (Research Manager)



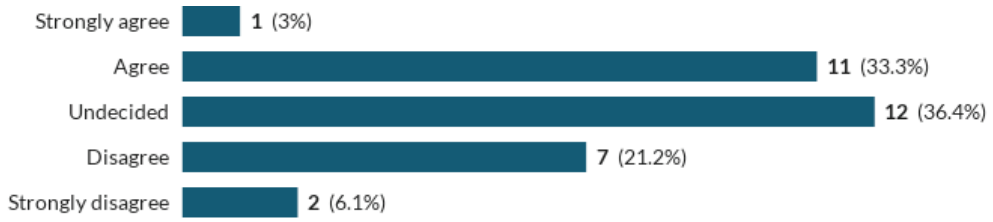
Source: Grain Legumes Survey

Regarding budgets and finance allocations within Grain Legumes, a small majority (58%) agreed that they are clear; 27% undecided and 15% disagreed (Question 13). Comments variously acknowledged themes of transparency and inclusivity; lack of clarity in allocation or prioritisation; and outright confusion. Transparency: *"The CRP budget proposals and allocations are open information from the CRP Director and all the product line leaders are involved in the process".* Lack of clarity: *"The allocations are pretty clear, even an attempt to break it down at the FP level, etc. Less clear how the decisions were made re priorities/needs/opportunities"* and *"The BUDGETS are clear, how they are spent at centres is less so".* Confusion: *"There is utter confusion created mostly by the Consortium Office who do not seem to know what they are doing"*. One constructive comment suggests that: *"This is a complex and somewhat political process. It could be made more transparent based on area cultivated, the number of poor the crop serves, performance based on standard KPIs."*

Research Mangers' opinion is split regarding whether structures are in place to minimise CRP transaction costs: 36% agree that they exist; 36% are undecided and 27% disagree or strongly disagree (Question 14, Figure A5.51). The following comments summarise the consensus of those in disagreement: *"The formation of the CRPs for the various activities of the CGIAR Centers effectively imposed an additional management structure within existing management. It is not entirely clear how*

this helps overall research progress. Clear supervisory controls are difficult to ascertain" and *"Centre and CRP management are in opposition".*

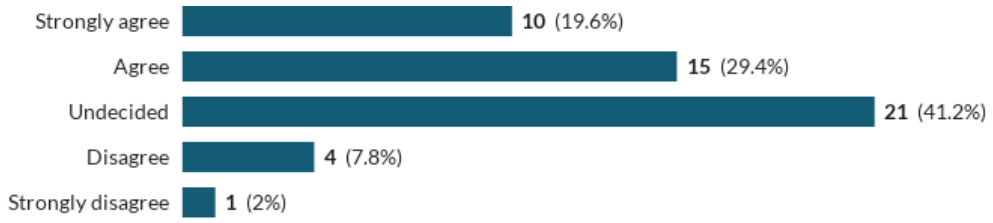
Figure A5.51. Structures are in place to minimise general management costs/processes (Research Manager)



Source: Grain Legumes Survey

Although a significant number of Scientists are undecided about transaction costs being too high (Question 56, Figure A5.52), 20% strongly agree and 29% strongly agree that they are; only 10% disagree. Costs which may have increased are cited as governance, meetings, travel, overheads and increased numbers of staff due to the structural hierarchy. For example: *"I think the PL and Flagship coordinators might be adding extra cost, besides integration of CRP management and the Center's management".* In addition, *"Scientists and managers spent too much energy into governance and management of the CRP".* The cost of research methods may also be increasing, such as modern breeding methods. Other costs may have decreased, however, such as infrastructure and equipment.

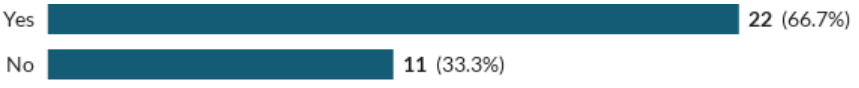
Figure A5.52. Within the CRP, I perceive transaction costs to be high (Scientist)



Source: Grain Legumes Survey

Nevertheless, two thirds of Research Managers (67%) agreed that the Grain Legumes Director should have control over the budget to assist with strategic, prioritised and transparent budget setting, within clear boundaries of control (Question 15, Figure A5.53). The following comments highlighted the broader issue of conflict surrounding accountability and control within Grain Legumes: *"Assigning budgetary control over W1 and W2 effectively neutralizes the management of the CGIAR Centers, making them secondary to the managers of the CRPs. It needs to be one way or the other."* Moreover, *"This [budget control] should be the prerogative of the Centers who have to deliver. Both CRP Director and Center Program Managers need to agree". "Actually, if research program directors are CRP directors, we wouldn't have been discussion [sic] this issue."* Others added: *"this has been a problem as the budgetary control is through the participating centers"* and *"CRP GL director should have control over management of budget at centre level and not at scientists level. CRP director should provide oversight and guidance and not execution and (micro)management".*

Figure A5.53. Should the Grain Legumes Director have budgetary control over all W1/W2 expenditure? (Research Manager)



Source: Grain Legumes Survey

Table A5.1. Respondents' host organisations other than the four main CGIAR Centres

AREEO-Agricultural Research Education and Extension Organization of Iran
CENTA/El Salvador, C.A.
Central Research Institute for Field crops Ankara, Turkey
CORAF/WECARD
Department of Agricultural Research Services(DARS)
Embrapa
Expert strategic advisor
FAO of the UN
ICAR-Indian Agricultural Research Institute, New Delhi
INRA Morocco
Iowa State University, under Legume Innovation Lab
Member of the Independent Advisory Committee. Currently I am a retired pulse crop breeder
NARS
National Agricultural Research System
National Programs that is the Uganda National Agricultural Organization. We routinely have collaborative works with ICRISAT especially germplasm evaluations
Panjab University, Chandigarh, India
Punjab Agricultural University, Ludhiana, India
Rajmata Vijyaraje Scindia Krishi Vishwavidyalaya Gwalior(SAU)
Regional Agricultural Research Station, Palem, India
The University of Western Australia
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD
University of California
University of Georgia
USDA-ARS

CRP GRAIN LEGUMES - E-SURVEY QUESTIONS

1. Which of the following disciplines are you involved in? (You may select several.)

    Genomics
    Traditional breeding
    Entomology
    Physiology
    Agronomy
    Pathology
    Economics
    Marketing
    Seed systems
    Social sciences
    Human nutrition
    Communication
    Other
    Management (program or general)

2. What proportion of your time is spent working with legumes?

3. (Hidden question used by the system to confirm anonymous authorised access to the survey)

4. Are you involved in the Grain Legumes Research Programme [CRP] of the CGIAR? NOTE: The CGIAR Research Program (CRP) on Grain Legumes (GL) is led by the International Centre for Agricultural Research in the Semi-Arid Tropics (ICRISAT), which combines and coordinates the Research-for-Development (R4D) activities of eleven principal partners: four CGIAR centres (ICRISAT-lead centre, CIAT, ICARDA and IITA), a CGIAR Challenge Program (Generation), four major national agricultural research systems (EIAR, Ethiopia; EMBRAPA-Brazil, GDAR-Turkey and ICAR-India) and two USAID-supported legume Cooperative Research Support Programs, all of whom are leaders in grain legume research and development. Established in mid-2012, the program aimed to achieve five Intermediate Development Objectives (IDOs - Food Security, Income, Nutrition & Health, Productivity and Environment).

5. Which best describes your current role within the CRP?

Research Manager: i.e. Manager within a Partner Institution, member of the Steering Committee/Independent Advisory Committee/Research Management Committee

Active Researcher, and not one of the above

Extensionist/Development Agent

Student

6. Within which organisation are you employed?

CIAT

ICARDA

ICRISAT

IITA

Other

RESEARCH MANAGER

7. Please indicate how strongly you agree or disagree with the following statements:

7.1. GL CRP has achieved its Intermediate Development Outcomes

7.2. GL CRP has achieved the CG System-Level Outcomes

8. Please indicate how strongly you agree or disagree with the following statement(s)

8.1. There is an integrated approach to the governance and management of the CRP

9. Please indicate how strongly you agree or disagree with the following statement about Monitoring and Evaluation (M&E):

9.1. Opportunity exists for radical modification of research direction following findings from M&E

10. Please indicate how strongly you agree or disagree with the following statement:

10.1. CRP activities have enhanced synergy in research and development

11. Please indicate how strongly you agree or disagree with the following statement.

11.1. CRP partners are effectively leveraging their knowledge and research capacities, enabling them to coordinate strategies with diverse public and private organisations

12. Please indicate how strongly you agree or disagree with the following statement.

13. Please indicate how strongly you agree or disagree with the following statement.

    13.1. Budgets and finance allocations within the CRP are clear

14. Please indicate how strongly you agree or disagree with the following statement.

    14.1. Structures are in place to minimise general management costs/processes

15. Should the CRP GL Director have budgetary control over all W1/W2 expenditure?

16. Please indicate how strongly you agree or disagree with the following statement.

17. Please indicate how strongly you agree or disagree with the following statement.

    17.1. Activities within product lines are 'donor driven'

18. Please indicate whether you agree or disagree with the following statement.

    18.1. NARS and other partners are sufficiently well represented in the structures of the CRP

19. How are partnership budgets set, allocated and managed?

20. Please indicate whether you agree or disagree with the following statement(s):

    20.1. There is sufficient clarity for outsiders on needs in the CRP

    20.2. There is sufficient clarity for outsiders on priorities in the CRP

    20.3. There is sufficient clarity for outsiders on activities in the CRP

21. Have adequate constraint analyses and lessons from ex post studies informed program design for enhancing the likelihood of impact?

22. What, overall, have been the successes and weaknesses of the programme, both relevant to the original goals and any unanticipated benefits?

23. Is such a mega-program CRP better than the sum of its parts - that is, could the same research have been done just as well or better if the four centres had worked independently?

24. Comments:

25. Please indicate whether you agree or disagree with the following statement:

    25.1. An eco/production/systems approach would be superior to the product line approach in delivering impact

26. There is a comparative advantage in combining all grain legume research under one CRP.

27. How dynamic and effective are relationships between the various stakeholders in terms of achieving programme outcomes/objectives?

28. Have the reformed CGIAR organisational structures and processes increased (or decreased) efficiency and successful program implementation?

29. What lessons can be learned?

30. Has value been added by the programme's design and implementation, management and commissioning processes?

31. Do you expect the benefits of the CRP's activities to be sustained when the CRP ends?

32. Have steps been put in place to ensure sustainable finding *(Note: typo funding)*?

33. Is the CRP considered a global leader in grain legume research and development?

ACTIVE RESEARCHER/SCIENTIST

34. Are you a PL coordinator or a Flagship Project coordinator?

35. To which Product Lines do you contribute? Select as many as appropriate.

36. What proportion of your time is spent on CRP Grain Legumes?

37. Do you feel an integral part of the CRP?

38. Please indicate whether you agree or disagree with the following statement.

    38.1. I fully understand the CRP organisational structure in which I work

39. Please rate the following statements regarding information sharing:

    39.1. Within my PL, information is shared freely and routinely

    39.2. Between my PL and other PLs, information is shared freely and routinely

    39.3. Between my CRP and other CRPs, information is shared freely and routinely

40. What mechanisms exist for formal consultation and communication with staff at all levels?

41. Have you benefitted directly from association with the CRP?

42. How have you benefitted directly from your association with the CRP?

43. How would you have liked to benefit directly from the CRP?

    43.a. Would there be any added-value for your research if you benefitted directly from the CRP?

44. Have you benefitted indirectly from association with the CRP?

45. How have you benefitted indirectly from association with the CRP?

46. How would you have liked to benefit indirectly from the CRP?

47. Please indicate whether you agree or disagree with the following statement(s):

    47.1. I have access to all the equipment required for my research

    47.2. I have access to all the training I need for my research

        47.b. Are any of the following restricting what you can achieve within the CRP?

48. Please indicate whether you agree or disagree with the following statements regarding the impact of your research within the CRP, over the past three years:

    48.1. My research has led to increased production, sales or consumption of GL

    48.2. My research has led to reduced poverty, hunger, or malnutrition of small-holder farmers

    48.3. My research has led to improved sustainability of farming systems

49. If your research has not yet contributed to increased production, reduced poverty or sustainable production, is it likely to?

50. From your knowledge of the CRP, is there evidence of improved crops, or enhanced finances of smallholder farmers and the agricultural system from the ability of grain legumes to fix nitrogen in soils?

51. Have you directly benefitted from capacity building in the past three years?

52. Please outline any demonstrable outputs and outcomes of capacity building/synergy among the various partners in the past three years:

53. Has the CRP supported your partnership with other organisations?

54. Are end users viewpoints and needs incorporated into your research agenda?

55. Please indicate whether you agree or disagree with the following statement(s):

55.1. Lessons learned from research conducted prior to the CRP have influenced my choice of current research

56. Please indicate whether you agree or disagree with the following statement:

56.1. Within the CRP, I perceive transaction costs to be high

57. Are you able to directly link an output to a CRP funded activity?

58. Please indicate whether you agree or disagree with the following statement:

58.1. I am mentored effectively

59. Opportunity exists for me to follow-up on good ideas with research

60. Please indicate how satisfied you are with support from CRP in the following areas:

60.1. Time for training and mentoring

60.2. Time for coordination

60.3. Time for meetings

60.4. Time for research proper

60.5. Incentives for working with partners

60.6. Reporting structure and processes

60.7. Funding reliability

60.8. Not applicable

60.9. Other

61. Does the CRP have a gender strategy?

61.b. Has gender been adequately considered in your activities in terms of relevance to, and effect on, women?

62. Are you aware that publications are important pathways for impact?

63. Have you published in the last three years?

63.b. Do you know the impact factor of the journal for your best publication?

If yes, what is the impact factor?

If no, what is the name of the journal?

64. How does your work achieve impact in the wider community? Are there communities with whom you would like to work?

65. What has been the degree of interaction between scientists involved in the programme and potential users of the scientific research emerging from the program?

66. To what degree is there a comparative advantage of combining all grain legume research under one CRP?

67. Is the current selection of eight grain legumes within the CRP logical and justified?

68. W1/W2 funds received by the CRP are to be used in a discretional manner. How would you use them? (You may select several options.)

EXTENSIONIST/DEVELOPMENT AGENT

69. With which organisation do you interact in the CRP?

70. To which Product Lines do you contribute? Select as many as appropriate.

71. What proportion of your time is spent on CRP Grain Legumes?

72. Do you feel an integral part of the CRP?

73. Please indicate whether you agree or disagree with the following statement.

    73.1. I fully understand the CRP organisational structure in which I work

74. Please rate the following statements regarding information sharing:

    74.1. Information is shared freely and routinely within the CRP

    74.2. Between my discipline and others in the CRP, information is shared freely and routinely

75. Have you benefitted directly from association with the CRP?

76. How have you benefitted directly from association with the CRP?

77. Is there any added-value for your research from your benefitting directly from the CRP?

78. How would you have liked to benefit directly from the CRP?

79. Have you benefitted indirectly from association with the CRP?

80. How have you benefitted indirectly from association with the CRP?

81. 78. How would you have liked to benefit indirectly from the CRP?

82. How strongly do you agree or disagree with the following statements regarding the impact of your work within the CRP over the past three years:

    82.1. My work has led to increased production, sales or consumption of grain legumes

    82.2. My work has led to reduced poverty, hunger, or malnutrition of small-holder farmers

    82.3. My work has led to improved sustainability of farming systems

83. If your work has not yet contributed to increased production, reduced poverty or sustainable production, is it likely to?

84. From your knowledge of the outcomes of the CRP, is there evidence of improved crops, enhanced finances and longer term sustainability of smallholder farms from the ability of grain legumes to fix nitrogen in soils?

85. Have you directly benefitted from capacity building in the past three years?

86. Please outline any demonstrable outputs and outcomes of capacity building/synergy among the various partners in the past three years:

87. Has the CRP supported your partnership with other organisations?

88. Are end users' viewpoints and needs incorporated into your work plans?

89. Please indicate whether you agree or disagree with the following statement(s):

    89.1. Lessons learned from pre-CRP work have influenced my choice workplans

90. Please indicate whether you agree or disagree with the following statement:

    90.1. Within the CRP, I perceive transaction costs to be high

91. Does the CRP have a gender strategy?

92. Has gender been adequately considered in your activities in terms of relevance to, and effect on, women?

93. Please indicate whether you agree or disagree with the following statement:

    93.1. I am mentored effectively

94. Please indicate how satisfied you are with support from CRP in the following areas:

94.1. Time for training and mentoring

94.2. Time for coordination

94.3. Time for meetings

94.4. Time for extension/development proper

94.5. Incentives for working with partners

94.6. Reporting structure and processes

94.7. Funding reliability

95. How does your work achieve impact in the wider community? Are there communities with whom you would like to work?

96. What has been the degree of interaction between scientists involved in the CRP and potential users, such as yourself, of the scientific research emerging from the CRP?

97. Please indicate whether you agree or disagree with the following statement:

97.1. There is a comparative advantage of combining all grain legume development and extension under one CRP?

98. Please indicate the percentage emphasis you believe the CRP should place on basic, applied or developmental research. (Your answers should total 100%):

98.1. Basic

98.2. Applied

98.3. Developmental

STUDENT

99. I am undertaking a PhD or Masters degree or other award

100. I understand how my research sits within the framework of the CRP

101. My research is clearly contributing to the goals of the CRP

102. Please indicate whether you agree or disagree with the following statements:

102.1. My CRP supervisor(s) have the skills and subject knowledge to support my research

102.2. My CRP supervisor(s) provide feedback that helps me direct my research

103. Please indicate how strongly you agree or disagree with the following statement about access to resources:

103.1. There is adequate provision of library facilities (including physical and online resources)

103.2. I am able to organise good access to necessary equipment

104. How strongly do you agree or disagree with the following statement(s) about networking:

104.1. Interaction with other postgraduate students is actively encouraged in the CRP

104.2. My involvement with the CRP has assisted me in developing contacts or professional networks

105. Please indicate whether you agree or disagree with the following statements:

105.1. My understanding of 'research integrity' (such as rigour, ethics, transparency, attribution of the contribution of others) has developed during my study

105.2. My ability to communicate information effectively to diverse audiences has developed during my programme

105.3. I am encouraged by CRP staff to prepare scientific papers during my post-graduate studies

106. How strongly do you agree or disagree with the following statement(s) about involvement beyond your research discipline:

106.1. There are opportunities to become involved in the wider research community in my CRP institution, beyond my own discipline

106.2. My host institution invites and responds to feedback from me as a student

NON CRP RESPONDENT

107. Have you heard of the CRP in Grain legumes?

107.a. If yes, what is the primary reason you are not involved?

107.b. If yes, how strongly do you agree or disagree with the following statement(s):

107.b.1. The CRP is superfluous to my own research

107.b.2. Outcomes from the CRP are essential for me to add value to my own research

108. Have you heard of the Tropical Legumes Programmes?

109. Have the Tropical Legumes programmes supported you in your research?

110. How strongly do you agree or disagree with the following statement(s):

110.1. There is no benefit in researchers on legumes to get together formally

110.2. Other mechanisms exist to gain synergies between legume researchers

111. I belong to another network that supports research synergy

A.6. Persons consulted

The following list includes some members of the Research Management Committee, the DGs of the centres and sampled members of the other governance committees, individual researchers consulted during site visits as well as their partners in NARs and intended beneficiaries. Names with an '*' indicate communication via email.

Name	Organisation	Designation	In person	As group	Skype/ phone/ email
Director General					
David Bergvinson	ICRISAT	DG		X	
Ruben Echeverria	CIAT	DG		X	
Mahmoud Solh	ICARDA	DG		X	
Management Entity and Research Management Committee Members					
Noel Ellis	ICRISAT	Grain Legumes Director	X	X	X
G.G. Koppa	ICRISAT	GL Senior Program Manager	X		X
Product Line Coordinators and Research Management Committee Members					
Steve Beebe	CIAT	PL1 - Drought & low-P beans, cowpeas & soybeans			X

Michel Ghanem	ICARDA	PL2 - Heat tolerant chickpea, bean, faba bean & soybean	X		X
Patrick Okori*	ICRISAT	PL3 - Drought tolerant, aflatoxin-free groundnut	X		
S.K. Chaturvedi*	IIPR	PL4 - BNF chickpea, bean, faba bean & soybean	X		
Manuele Tamò	IITA	PL5 - Insect-smart chickpea, cowpea & pigeonpea	X		X
Shiv Agrawal	ICARDA	PL6 - Extra-early chickpea & lentiL	X		
Pooran Gaur	ICRISAT	PL7 - Herbicide-tolerant chickpea, faba bean & lentil	X		X
Rajeev Varshney*	ICRISAT	PL8 - Hybrid pigeonpea	X		
Flagship Project Coordinators and Research Management Committee Members					
Vincent Vadez*	ICRISAT	FP1 Managing productivity			X
P. Janila*	ICRISAT	FP3 Trait deployment	X		
Mercy Lunghoa*	CIAT	FP4 Facilitating legume seed and technology delivery systems	X		
Zewdie Bishaw	ICARDA	FP4 Enhancing post-harvest processing and market opportunities	X		
Enid Katungi	CIAT	FP6 Knowledge, impacts, priorities, and gender organisation			X
Esther Njuguna-Mungai	ICRISAT	FP8 Management	X		
Steering Committee					
Flavio Breseghello*	EMBRAPA	Director General of Embrapa Rice and Beans			X
Jeff Ehlers*	BMGF	Steering Committee Member			X
Other Research Management Committee Members					
David Hoisington*	Feed the Future Innovation Lab	Mycotoxin Innovation Lab			eX
Peter Carberry*	ICRISAT	DDG	X		
Irvin Widders*	Feed the Future Innovation Lab	Collaborative Research on Grain Legumes			eX
Others					
Ken Giller*	N2Africa Wageningen			X	
Prof. Dr. Ir. Jean T. Claude Codjia	University of Ketou, Benin	Vice Chancellor		X	

Lionel Guezodje	FUPRO-Benin	President		X	
Rufin Godjo	FUPRO-Benin	Executive Director		X	
Joe Tohme	CIAT	Geneticist		X	
Richard Thomas	ICARDA, Amman	Head of Dryland Systems	X		
Shoba Sivasankar	ICRISAT	Director, CGIAR Research Program on Dryland Cereals	X		
MOROCCO FIELD VISIT					
Oumekaltoum	ICARDA		X		
Meriem	ICARDA		X		
Shiv Agrawal	ICARDA				
Sripada M Udapa	ICARDA	Geneticist	X		
Somanagouda B Patil	ICARDA	Agronomist	X		
Aqeel Hasan Rizvi	ICARDA	Project Manager & Legume Breeder	X		
Mustapha El Bouhssini	ICARDA	Principal Entomologist	X		
Ahmed Amri	ICARDA	Head of Genetic Resources	X		
Fouad Maalouf	ICARDA	Faba bean breeder			
Aakash Goyal	ICARDA	Chickpea breeder	*X*		
Seid A Kemal	ICARDA	Pathologist	*X*		
Karthica Rajendran	ICARDA	Lentil Breeder	X		
BENIN FIELD VISIT					
Manuele Tamò	IITA - Benin	Insect ecologist		X	
Eustache Biaou	INRAB - Benin	Research assistant		X	
Haruna Braimah	CSIR - Crops Research Institute - Kumasi GHANA	Biocontrol Entomologist		X	
Elie Dannon	IITA - Benin	Insect ecologist		X	
Benjamin Datinon	IITA - Benin	Entomologist		X	
Brice Gbaguidi	IITA - Benin	Technology transfer - sociologist		X	
Fousséini Traore	INERA - Ouagadougou, BURKINA-FASO	Entomologist		X	
Abouabakar Djibirl Souna	IITA - Benin	PhD student - entomology		X	
Adetonah Sounkoura	IITA - Benin	Agricultural economist/gender expert		X	

Coulibaly Ousmane	IITA - Benin	Agricultural economist		X	
Ajuonu Obinna	IITA - Benin	Research associate - biocontrol		X	
N'cho Simon	IITA - Benin	Agribusiness economist		X	
L'Université d'Agriculture de Kétou					
Prf Jean T Claude Codjia	UAK Ketou	Rectuer	X	X	
Victorin Gbogbo	UAK Ketou			X	
Xavier Akonde	UAK Ketou			X	
Noel Kpoahoun	UAK Ketou			X	
August Kindaduzandji	UAK Ketou			X	
Haruna Braimah	CSIR CRI Ghana		X	X	
FUPRO (Farmers' Association in Benin)					
Rufin Godjo	FUPRO	President	X	X	
Lionel Guezodje	FUPRO		X	X	
Delois Cynthia	FUPRO			X	
Nicoise	FUPRO			X	
Charls Gnangassi	FUPRO			X	
Eustache Biaois	INRAB			X	
Farmers Group				*X*	
Women's Farmers Group				*X*	
INDIA FIELD VISIT					
Peter Carberry	ICRISAT	DDG	X		
Noel Ellis	ICRISAT	Grain Legumes Director	X		
GG Koppa	ICRISAT	Grain Legumes Project Manager	X		
Rajeev Varshney	ICRISAT	Grain Legumes Research Program Director, ICRISAT		X	
Supriya Bansal	ICRISAT	Head Financial Services	X		
Warwick Easdown	AVDRC	Director	X		
Ram Nair	AVDRC	Vegetable Breeder - Legumes	X		
Vincent Vadez	ICRISAT	Principal Scientist			X
Vanika Garg	ICRISAT	Post Grad student		X	
pushpavalli Raju	ICRISAT	Post Grad student		X	
Swathi Parupalli	ICRISAT	Post Grad student		X	
Sivasakthi	ICRISAT	Post Grad student		X	

Vijay Raj	ICRISAT	Post Grad student		X	
Hindu Vemuri	ICRISAT	Post Grad student		X	
N Rajesh	ICRISAT	Post Grad student		X	
Purushothaman	ICRISAT	Post Grad student		X	
Feda Alo	ICRISAT	Post Grad student		X	
P asuninig	ICRISAT	Post Grad student		X	
Simi Jacob	ICRISAT	Post Grad student		X	
Pronob J Paul	ICRISAT	Post Grad student		X	
sunil choudhari	ICRISAT	Post Grad student		X	
K Sadajah	ICRISAT	Post Grad student		X	
Mallikarjuna BP	ICRISAT	Post Grad student		X	
Ramanagouda S G	ICRISAT	Post Grad student		X	
G Alekhya	ICRISAT	Post Grad student		X	
M Sruidya ?	ICRISAT	Post Grad student		X	
S Priyanka	ICRISAT	Post Grad student		X	
G Sivakumar	ICRISAT	Post Grad student		X	
T Satyanarayana	ICRISAT	Post Grad student		X	
Y Shasidhar	ICRISAT	Post Grad student		X	
Jimmy Dbala	ICRISAT	Post Grad student		X	
Seleman Kaineka	ICRISAT	Post Grad student		X	
Ealian	ICRISAT	Post Grad student		X	
S Srinivasan	ICRISAT	Scientist		X	
Sobhan.Sajja	ICRISAT	Scientist		X	
Shilp Purwhit	ICRISAT	Scientist		X	
Sandip Kali	ICRISAT	Scientist		X	
Viras Kumar Singh	ICRISAT	Scientist		X	
Pallar Sinhar	ICRISAT	Scientist		X	
H C Sharma	ICRISAT	Scientist	X	X	
Mamta Sharma	ICRISAT	Scientist		X	
Pooja Bhatnagar Mathur	ICRISAT	Scientist		X	
P Janila	ICRISAT	Scientist		X	
G V Rangarao	ICRISAT	Scientist		X	
Hari Kishan Sudini	ICRISAT	Scientist		X	
K Vijay Krishna Kumar	ICRISAT	Scientist		X	
Shivali Sharma	ICRISAT	Scientist		X	

Pooran Gaur	ICRISAT	Scientist		X	
Kiran Sharma	ICRISAT	Scientist	X	X	
Parankusam S	ICRISAT	Scientist		X	
Abirami Ramalingam	ICRISAT	Scientist		X	
P T Lekha	ICRISAT	Scientist		X	
N Lalitha	ICRISAT	Scientist		X	
Mahendar Thudi	ICRISAT	Scientist		X	
T V Murali	ICRISAT	Scientist		X	
CV Sameer Kumar	ICRISAT	Scientist		X	
Manish Pandey	ICRISAT	Scientist		X	
Rachit Saxena	ICRISAT	Scientist		X	
S Gopalakrishnan	ICRISAT	Scientist		X	
L Krishnamurthy	ICRISAT	Scientist		X	
Manish Roorkiwal	ICRISAT	Scientist		X	
Vinay Kumar	ICRISAT	Scientist		X	
Padmaja Ravula	ICRISAT	Scientist		X	
M Srinivas Rao	ICRISAT	Scientist		X	
Uttam Kumar Deb	ICRISAT	Scientist		X	
D Kumara Charyulu	ICRISAT	Scientist		X	
NEW DELHI					
Jeet Singh Sandhu	Indian Council of Agricultural Research (ICAR)	Deputy Director General (Crop Science)	X		
Sushil K. Chaturvedi	ICAR-Indian Institute of Pulses Research (IIPR)	Head, Crop Improvement Division	X		
Shailesh Tripathi	ICAR-Indian Agricultural Research Institute (IARI)	Senior Scientist (Chickpea Breeding)	X		
C Bharadwaj	ICAR-Indian Agricultural Research Institute (IARI)	Principal Scientist (Chickpea Breeding)	X		
Sarvjeet Singh	Punjab Agricultural University (PAU)	Senior Scientist (Pulse Breeding)	X		
Poonam Sharma	Punjab Agricultural University (PAU)	Principal Scientist (Pulse Microbiology)	X		
Harsh Nayyar	Panjab University (PU)	Professor (Botany)	X		

Veera Jayalakshmi	Acharya NG Ranga Agricultural University (ANGRAU)	Principal Scientist (Chickpea Breeding)	X		
A G Vijaykumar	University of Agricultural Sciences (UAS) - Dharwad,	Senior Scientist (Plant Breeding)	X		
DM Mannur	University of Agricultural Sciences (UAS) - Raichur	Principal Scientist (Chickpea Breeding)	X		
Mohammad Yasin	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RVSKVV)	Principal Scientist (Chickpea Breeding)	X		
Dr MV Nagesh Kumar	RARS, Palem-509215, Mahaboobnagar(district), Telangana (state), India	Principal Scientist (plant Breeding) professor Jayashankar Telangana State Agricultural University	X		
Dr C Sudhakar	Agricultural Research Station (ARS), tandur, Rangareddy (distrct),Telangana (State), India	Principal Scientist	X		
Dr AL Rathnakumar	Directorate of Groundnut, Junagadh, Gujarat	Principal Scientist	X		
Dr T Radhakrishnan	ICAR-DGR	Director of Directorate of Groundnut Research	X		
Dr. Ashutosh Sarker	Pulses Research Laboratory Division of Genetics, IARI	Coordinator, South Asia and China Regional Program	X		
BB Singh					X
Harsh Kumar Dikshit, PhD		Principal Scientist & Principal Investigator Lentil and Mungbean	X		
DR K Swarnalakshmi		Senior Scientist Microbiology	X		
A K Singh	ICAR New Delhi	Head & Project Leader (Rice)	X		
A Ashok Kumar	ICRISAT	Senior Scientist	X		
Hari D Upadhyaya	ICRISAT	Director Genebank	X		
ETHIOPIA FIELD VISIT					
K.P.C. Rao	ICRISAT		X	X	
Said Silim	ICARDA		X	X	

Chris Ojiewo	ICRISAT		X	X	
JC Rubyogo	CIAT		X	X	
Asnake Fikre				X	
Kidane				X	
Berhanu Fenta				X	
Million				X	
Zewdie Bishaw				X	
Daniel Dauro	Agricultural Transformation Agency (ATA)		X		
Dr (Mrs) Aster Yohannes	Holleta			X	
Gemechu Keneni	Holleta			X	
Angaw Tsigie	Holleta			X	
Dereje Fikadu	Holleta			X	
Fikadu Amsalu	Holleta			X	
Melkassa Field Station				*X*	
Lume Adama Farmers' Cooperative Union				*X*	
ACOS				*X*	
Debre Zeit Field Station				*X*	
Amwari				*X*	
Woreda Bureau of Agriculture Extension Staff				*X*	
KENYA FIELD VISIT					
Emmanuel Monyo	ICRISAT		X	X	
David Karanja	KALRO			X	
JC Rubyogo	CIAT		X	X	
Joyce Malinga	KALRO			X	
Robin Buruchara	CIAT			X	
Philip Leley	KALRO			X	
David Macharia	KALRO			X	
Moses Siambi				X	
Esther Njuguna	ICRISAT	Gender Scientist		X	

N Ganga Rao	ICRISAT		X	X	
Bernard Towett	Egerton University			X	
Rose Ubwe	Selian Agricultural research Institute, Arusha, Tanzania			X	
Robert Kileo	Lake Zone Agricultural Research and Development Institute, Mwanza			X	
David Kalule	National Semi Arid Resources Research Institute, Soroti			X	
Katumani				*X*	
Dry Land Seed Company				*X*	
Rose Mutuku	*Smart Logistics*			*X*	
MALAWI FIELD VISIT					
Donald Siyeni	Department of Agricultural Research Servises (DARS)	Legumes Agronomist		X	
Justus Chintu	Department of Agricultural Research Servises (DARS)	Legumes Team Teader		X	
Barthlomew Chataika	International Center for Tropical Agriculture (CIAT)	Program Technical Officer-Bean Breeding		X	
Esnart Yohane	Department of Agricultural Research Servises (DARS)	Research Scientist		X	
Annie Matumba	Department of Agricultural Research Servises (DARS)	Research Scientist		X	
Virginia Chisale	Department of Agricultural Research Servises (DARS)	Research Scientist		X	
Canon Engoke	International Institute of Tropical Agriculture (IITA)			X	

Rodah M. Zulu	International Center for Tropical Agriculture (CIAT)	Nutritional Facilitator		X	
Enock Maereka	International Center for Tropical Agriculture (CIAT)	Seed Business Development Specialist		X	
Sika Gbeabekegbe	International Institute of Tropical Agriculture (IITA)	Scientist		X	
Arega Alene	International Institute of Tropical Agriculture (IITA)	Economist		X	
Olivia Kadeyo	International Institute of Tropical Agriculture (IITA)	Research Assistant		X	
Rowland Chirwa	International Center for Tropical Agriculture (CIAT)	Bean Breeder		X	
Lloyd Phiphira	International Institute of Tropical Agriculture (IITA)	N2Africa Coord		X	
D Mulekano	International Institute of Tropical Agriculture (IITA)			X	
Patrick Okori	ICRISAT	Country Rep/PL Coord		X	
Taku Tsusaka	ICRISAT	Socio-Economist		X	
Harry Msere	ICRISAT			X	
Osuru Madzonga	ICRISAT			X	
Felix Sichali	ICRISAT			X	
Anitha Seetha	ICRISAT	Post-Doc Fellow		X	
Jim Goodman	Exagris Africa Limited			X	
M Bekunde	Africa Rising			X	
I Zeledon				X	
Demonstration/ Exhibition				*X*	
RWANDA FIELD VISIT					

Augustin Musoni	Rwanda Agricultural Board,	Head of Legume Programme		X	
Eliud Abucheli Birachi	CIAT			X	
Mercy Lungho	CIAT			X	
Eugenie	Innovation Platform, Kamatete	vice-president		X	
Alfred Rumongi Tabaru	Rwanda Agricultural Board, Musanze	Researcher		X	
Stephen Etienne		N2Africa		X	
Telephore Ndabamenye	Rwanda Agricultural Board	Head of Crop Production and Food Security		X	
Farmers group, value chain actors and partners	*Gakenke*			*X*	
Value Chain Actors	*Musanze*			*X*	
Traders	*Kigali Market, Kimironko*			*X*	

NOTE: Key personnel, such as PL and FP coordinators, may be listed twice to record their attendance in group sessions; however, they are only counted once in the numbers of persons consulted. Names in Italics refer to groups where names were not recorded.