Assessing the adoption and economic & environmental impacts of Brachiaria grass forage cultivars in Latin America focusing in the experience of Colombia

Proposed study implementation strategy

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Presentation overview

- Background on Brachiaria grasses
- CIAT contribution to Brachiaria research
- Studying the adoption of Brachiaria and its economic & environmental impacts
    - Study design & sampling strategy
    - How to measure and study adoption
    - Methodological approach for identifying impacts
    - Key productivity, livelihood & environmental indicators
    - Remaining challenges

Background information on Brachiaria grasses

- Brachiaria sp. native to Africa, introduced to LAC in 50's (Brazil)
- Initial research selected Brachiaria *decumbes* cv. Basilisk as best adapted grass to replace degraded native savanna or cerrado pastures
- Later research continued evaluating Brachiaria germplasm accessions from various Brachiaria species. In late 80's Brachiaria breeding efforts were initiated.
- Currently estimated area is around 90 million ha in LAC (out of 250 million ha in native and introduced pastures), but evidence on adoption of Brachiaria sp. varies from country to country & more anecdotal evidence

Background information on Brachiaria grasses

- Brachiaria grasses are adapted well to acid and low fertility soils of the tropical Americas
- Compared to native pastures increases green matter to feed animals (50t/yr/ha vs. 10t/yr/ha) implying more meat & milk
- Improved Brachiaria cultivars offer higher levels of crude protein and energy that results in higher milk quality (premium price)
- It could also generate environmental benefits: improved soil quality, belowground carbon sequestration and stocking rate (pasture intensification) , releasing land for other uses

CIAT contribution to Brachiaria research

- In 1970's CIAT joined efforts to do agronomic research of Brachiaria sp. introduced from Africa: evaluating & selecting accessions suitable for LAC & developing best management practices

- In 80's from CORPOICA station (Carimagua) CIAT research resulted in release of several cultivars: La Libertad, Toledo & Insurgente (B. *brizantha*); Llanero (*B. dictyoneura)* & Humidicola (*B. humidicola)*

- In 1989 CIAT started the cross of B. *ruziziensis* x B. brizantha x B. *decumbens* to create hybrid cultivars Mulato & Mulato II

CIAT contribution to Brachiaria research

- Both Mulato and Mulato II hybrids were evaluated under field and through a partnership with Papalotla released in 2000 & 2005. More recently two more hybrids (Cayman and Cobra) have been released.

- It is currently unknown the distribution of acreage across different Brachiaria cultivars, and this is a gap to be filled by this study.

- Furthermore CIAT & partners aim to provide evidence of the various impacts associated with its adoption.

Theory of change behind adoption of Brachiaria

- The adoption of Brachiaria grasses is expected to increase farm productivity (green matter, meat & milk production & quality)
- More livestock products and specially better quality would imply premium prices, increasing farm and livestock income
- Poverty reduction & increased food security could be achieved by higher farm income and more livestock food available

Environmental effects associated with Brachiaria adoption

- More productive land due to adoption of Brachiaria grasses may induce pasture intensification, increasing the stocking rate. It is expected some reduction on the rate of deforestation & adoption of complementary sustainable land uses.
- But more productive pasture may have the opposite effect, attracting pasture expansion and inducing even more land clearance.
- Livestock is a good contributor to GHG emissions (specially CH_4) but the use of improved grasses, like Brachiaria may improve the food conversion efficiency & protein content, therefore it may reduce GHG emission per unit of livestock
- Adoption of Brachiaria would provide better soil coverage and therefore, reduce soil erosion & improve soil quality

Study design

- Using a nationally representative sample of livestock producers:
  - First estimate adoption of different Brachiaria cultivars in Colombia (Eastern plains & Amazon region = 9.6 million ha pastures)
  - Measure impacts on productivity, livelihood & environment associated with adoption of Brachiaria Cultivars in Colombia
- Using expert opinion estimates and area specific data collection:
  - Estimate adoption of Brachiaria cultivars in Peru, Nicaragua, Costa Rica
  - Estimate aggregate economics surplus of the adoption of Brachiaria grasses in Colombia, Peru, Nicaragua & Costa Rica

Research questions addressed

1. What is the current adoption of *Brachiaria* cultivars as measured by percentage of farmers adopting and by the percentage of total grassland area planted?

2. What is the adoption rate across different *Brachiaria* cultivars?

3. What factors have facilitated or restricted the adoption of *Brachiaria* cultivars?

4. What are the livestock productivity and environmental benefits that can be plausibly attributed to the adoption of *Brachiaria* cultivars?

5. Have those impacts vary by farm size?

6. What are the projected adoption and impacts of *Brachiaria* cultivars in other countries in Latin America?

Sample design

- We distinguish between sampling frame for adoption: to estimate the proportion of HH/area under Brachiarias and for measuring impacts: difference in outcomes between adopters & no-adopters

- Our minimum sample size to estimate adoption follows two stage procedure (first PSU & then HH). Then adjust the design effect:

$$n \geq \frac{z_{0.95}^2 NP(1-P)}{(N-1)l^2 + z_{0.95}^2 P(1-P)}$$

$$\text{Deff} = 1 + (b_{opt} - 1)\text{ICC}$$

Sample design

- We used previous studies (Hollmann et al. 2008, Rivas et al.2006) we expect around 20% of adoption of **all** Brachiaria cultivars
- With 38,100 livestock producers & assuming a confidence level of 95%, a precision of 3% & ICC of 0.027, n > 678-840 HH
- We are collecting data to list all PSU for livestock production & will randomly select up to 84 PSU & also randomly select 10 HHs/ PSU
- We will stratify by llanos/Amazon region & small/large ranchers
- Will check distribution of adopters & no-adopters in the sample & check if it meets the sampling requirements of the impact study

Sample frame for estimating impacts

- For identifying impacts (IV as preferred method) we first define the minimum detectable effect in selected outcomes (productivity, income) between adopters & non-adopters

- Following Duflo 2006 we estimate the minimum sample of adopters and non-adopters to be included in the study.

- From previous studies: productivity increases in meat (11-17%) & milk (8-15%). In our calculation we assume 10% (same for income)

- With 95% confidence, power of 80% and ICC 0.027, we would need at least 276 adopters & 276 non-adopters in our sample across 84 clusters (lower bound)

Sample frame for estimating impacts

- As Duflo suggested the procedures for RCT, we may need additional HH in both groups to adjust for the non-experimental nature of this evaluation.
- Also If unbalanced distribution of adopters & non-adopters, we may vary the proportion in our sample (216 vs. 480 preliminary)
- As explained later second preferred estimation method is PSM which requires larger sample size: **use of full adoption sample**

Methodological approach to estimate impacts

- Controlling for selection and placement biases associated with the dissemination of Brachiaria grasses is the main challenge
- Given the time frame, RCT (gold standard) & DiD (panel data) are ruled out: instrumental variables (IV) & PSM are only feasible options
- IV induces quasi-randomization & under certain conditions can identify impacts of the adoption of Brachiaria sp.
- Challenge: identify good instruments: that explains adoption of Brachiaria cultivars but not correlated with productivity, livelihood & environmental outcomes

Methodological approach to estimate impacts

- PSM is easier to implement and if the ignorabiity assumption holds, it can identify impacts of adoption of Brachiaria
- The challenge: in cross-sectional frameworks, the adoption decisions are usually correlated with factors unobserved by analyst
- So our strategy is to use IV as the preferred estimation method assuming that a lot of effort will go into identifying good instruments
- We will keep PSM as an alternative estimation method & try to do a good job minimizing the potential biases due to unobservables

How to identify suitable instruments

- We do not claim that we have already identified the best instruments but know how to search for them:
  - A key source of instruments: strategies & means to disseminate Bhachiaria cultivars: look for random patterns in cultivar dissemination, identify exogenous factors that have affected awareness/access to technology
  - Will also exploit agro-ecological conditions & geo-referenced information.
  - We propose to do extensive consultation with expert groups related to dissemination of knowledge & cultivars of Brachiaria. This will include workshops with forages scientists, extensionists, input dealers & farmer groups

Some candidates for instruments

- **Local population density & pasture density**. Increased population/ pasture density should lower cost of disseminating Brachiaria sp.

- **Localized political turbulence.** Violence might have disrupted supplies of *Brachiaria* grasses, but not related to current productivity

- **Distance to nearest seed supplier of grass forages.** Checking correlation with distance to nearest meat/milk market that may affect productivity.

- **Test Wooldridge (2010) suggestion to use probability to adopt Brachiaria cultivars as instrument of the real adoption of these grasses**

How to reduce potential biases of PSM

- Propose to collect as much as possible farmers' knowledge, attitudes & perceptions of the use of Brachiaria grasses
- KAP indicators will try to measure farmers' risk taking attitudes, knowledge about current national/global issues (such as climate change, deforestation), personal and family aspirations for the future, attitude and perception towards farming
- Data from expert workshops about dissemination efforts of Brachiaria will also be used to estimate propensity to adopt
- The use of full sample from adoption will give robustness to PSM

What are our main outcome variables

- Farm Productivity
  - Quantity of green matter produced (t/year) (field measurement)
  - Quantity of crude protein produced (%) (field measurement)
  - Meat & Milk (Kg/ha/year) (HH survey)
  - Mortality rate of animals (%) (HH survey)
  - Average weight of calves at birth (HH survey)
  - Cow replacement rate (HH survey)
- Farm income
  - Average income from meat production (HH survey)
  - Average income from milk production (HH survey)
  - Average income from dairy sub products (HH survey)

What are our main outcome variables

- Food security & Poverty
  - Household Dietary Diversity Score (HDDS) (HH survey)
  - Progress out of Poverty Index (PPI) (HH survey)
  - Household expenditures (HH survey)
- Environmental outcomes
  - Level of GHG emissions (CH_4/ha) (field measurement)
  - Land carrying capacity (as indicator to free land) (field measurement)
  - Level of environ. footprint per livestock product (field measurement)
  - Belowground carbon sequestration level (field measurement)
  - Annual deforested area (ha) (HH survey)

How we are measuring environmental outcomes?

- CIAT forages & soils programs are currently working under the program Livestock+ that is planning a series of measurements of soils CH_4 & carbon stock that in various regions of Colombia, we are coordinating to have our study areas included.
- Measuring is usually expensive but Livestock+ is proposing a cheaper option that consist in feeding animals (with different grasses or feeding products) and measure methane emissions from animals
- Carbon stock measurements will follow standard protocols
- They are proposing simple procedure to create an index of water filtration on different pastures

Remaining challenges

- Still need to refine the methods & protocol to measure environmental outcomes. Next week organizing a workshop in CIAT to discuss and agree on this. Most importantly need to work in realistic sampling framework for this.
- On the adoption side, experts state that Brachiarias could be recognized among them, even among livestock producers. This might not be the case of Hybrids. May evaluate the feasibility of DNA fingerprinting (cost implication)
- We are discussing with CIAT GIS team on the use of remote sensing. So far this method could distinguish between natural/degraded pastures from Brachiarias but not among Brachiarias. Trying to create synergy with ongoing program in CIAT (Colombia) but may need to do a light field work in other countries


Thank you!!!!