Adoption and Diffusion of Potato Variety Cooperation 88 (C88) in China: Spatial Variability of Productivity Gains and Cost Savings and Value Chain Development

Donors: SIAC 3, SIAC 2.1, SIAC 4.2, RTB (W1-2 and complementary funding), YNU

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Background

- China
  - Largest potato producer in the world
  - Government supporting expanded production of potatoes as staple food
  - Demand for processed potatoes is increasing
- Yunnan Province
  - 10% of Chinese potato production
  - Mountainous, high humidity
  - Major problems with late blight

Background

- Cooperation88 is a high quality, high-yielding late blight resistant variety
- Developed out of a collaboration between CIP and Yunnan Normal University (YNU)
- 1996- C88 named and diffusion began; officially released in 2001
- Claimed to be the most widely grown variety in Yunnan Province
- 2010: C88 area estimated at ~ 400,000 hectares in China
- “Among CIP’s biggest varietal successes to date”

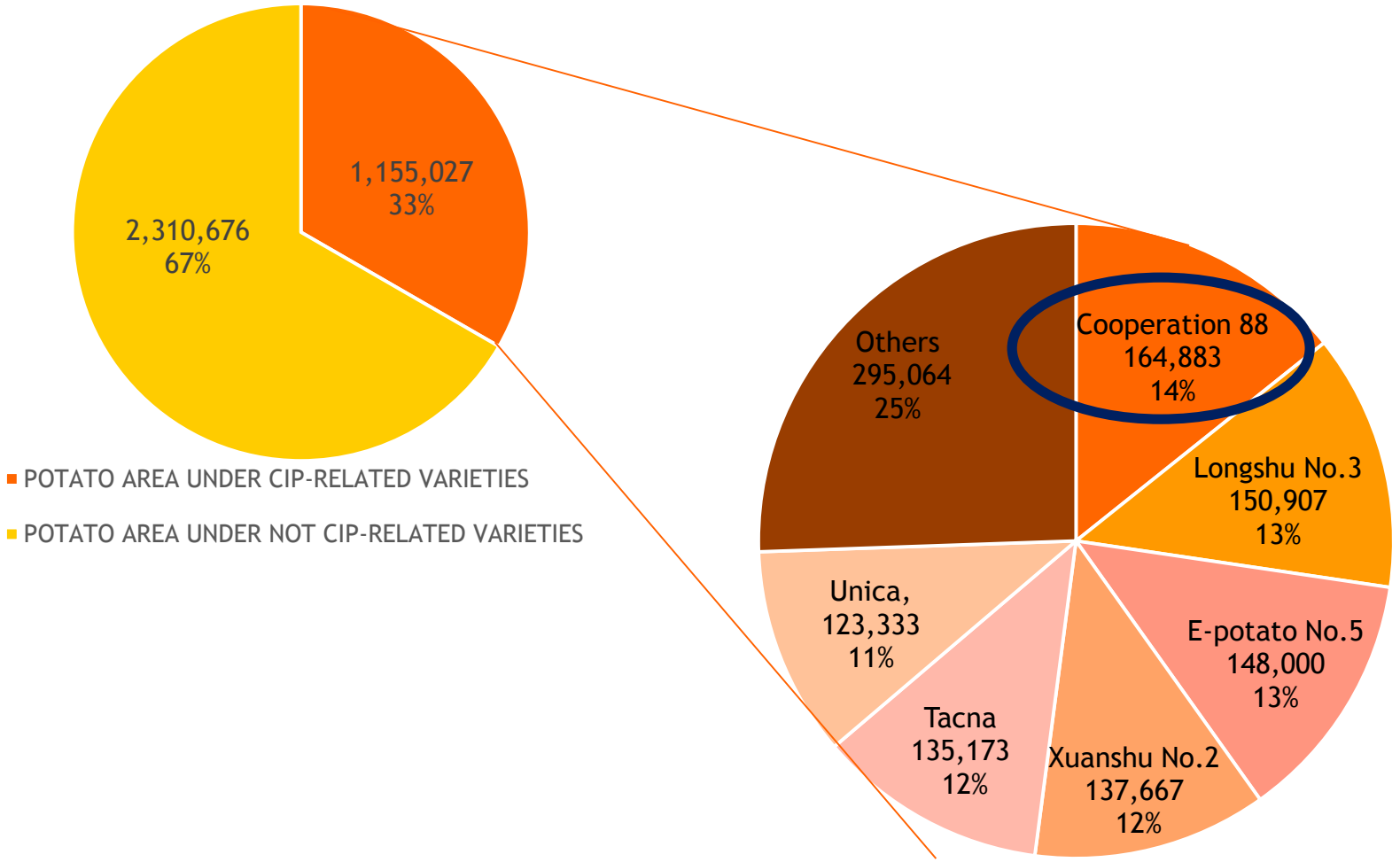
Motivation

- A previous study by Robinson and Srinivasan estimated the economic benefits of C88
  - No analysis of diffusion; adoption estimates based on non-structured expert elicitation
  - Did not account for productivity gains associated with C88
  - Focused heavily on cost savings due to disease resistance, but new studies show that C88 may not be more late blight resistant than other varieties (little evidence that Chinese producers vary their production processes)
- 2014 workshop at CIP (SIAC project) identified C88 impact assessment as an institutional priority

Objectives

- Obtain rigorous estimates of the adoption of potato varieties in Yunnan
- Estimate the economic impacts of C88 diffusion on producers and consumers by comparing yields and costs to those of varieties it replaced
- Estimate market-level impacts of C88 by examining benefits along the value chain
  - Analyze how the potato seed input chain impacts the adoption and spread of C88;
  - Distribution of benefits between the processed and fresh potato markets

SIAC 2.1 expert estimates: Area under most important CIP-related potato varieties in China (12 Provinces - 2016)



Validation of SIAC 2.1 data for Yunnan

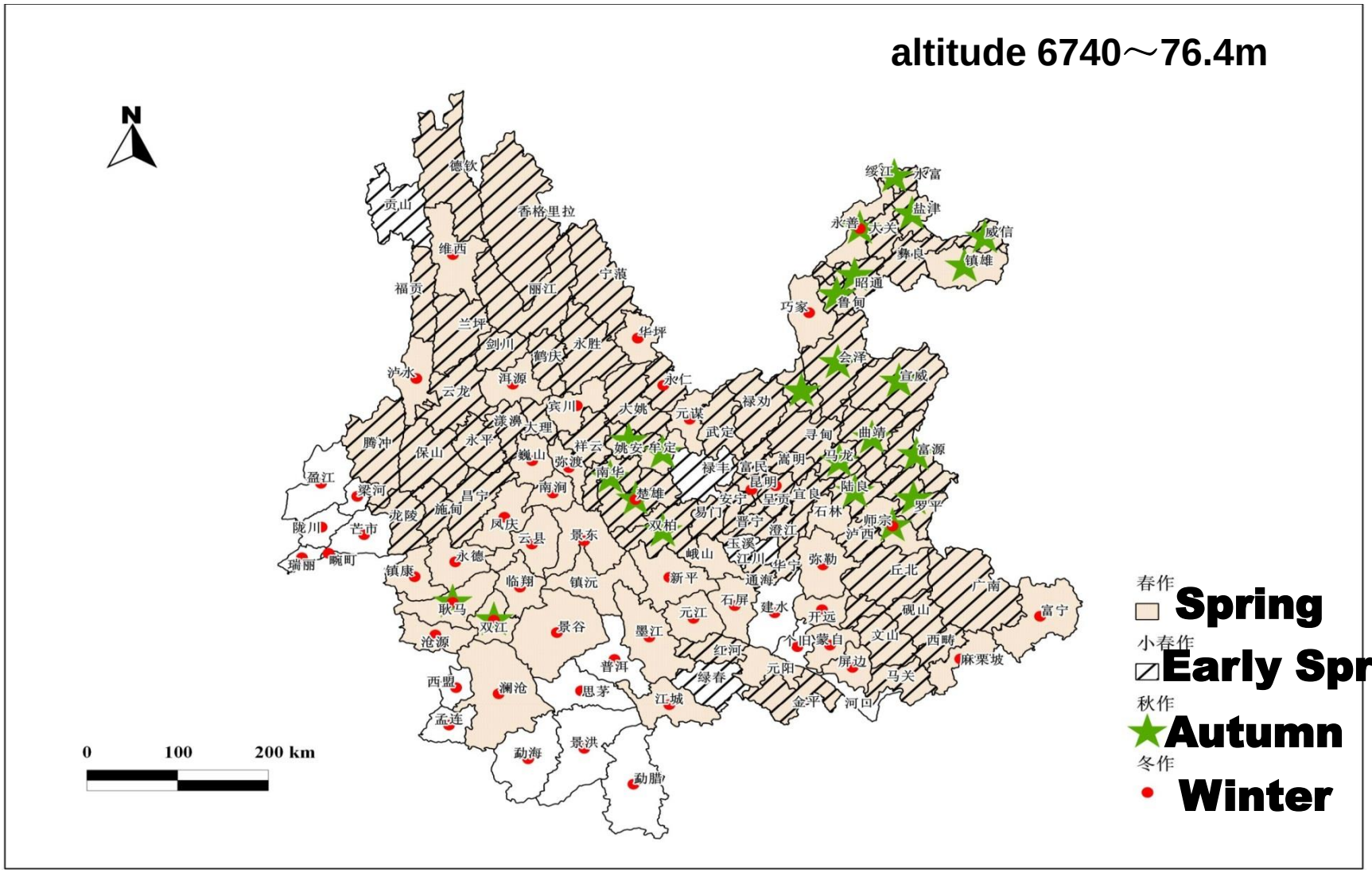
	Crop Area (Ha)	C88	C88 Area (Ha)
EARLY SPRING	86,667	26.9%	23,333
LATE SPRING	396,667	16.7%	66,243
AUTUMN	43,333	7.7%	3,333
WINTER	60,000	55.6%	33,333
	586,667		126,242

Source: SIAC 2.1 expert elicitation workshop, March 2015

Yunnan Province: Potato planting seasons

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring			Sowing							Harvest		
Early Spring		Sowing				Harvest						
Autumn							Sowing					Harvest
Winter			Harvest								Sowing	
Earliest Spring					Harvest							Sowing

Potato year-round production distribution in Yunnan



Methods

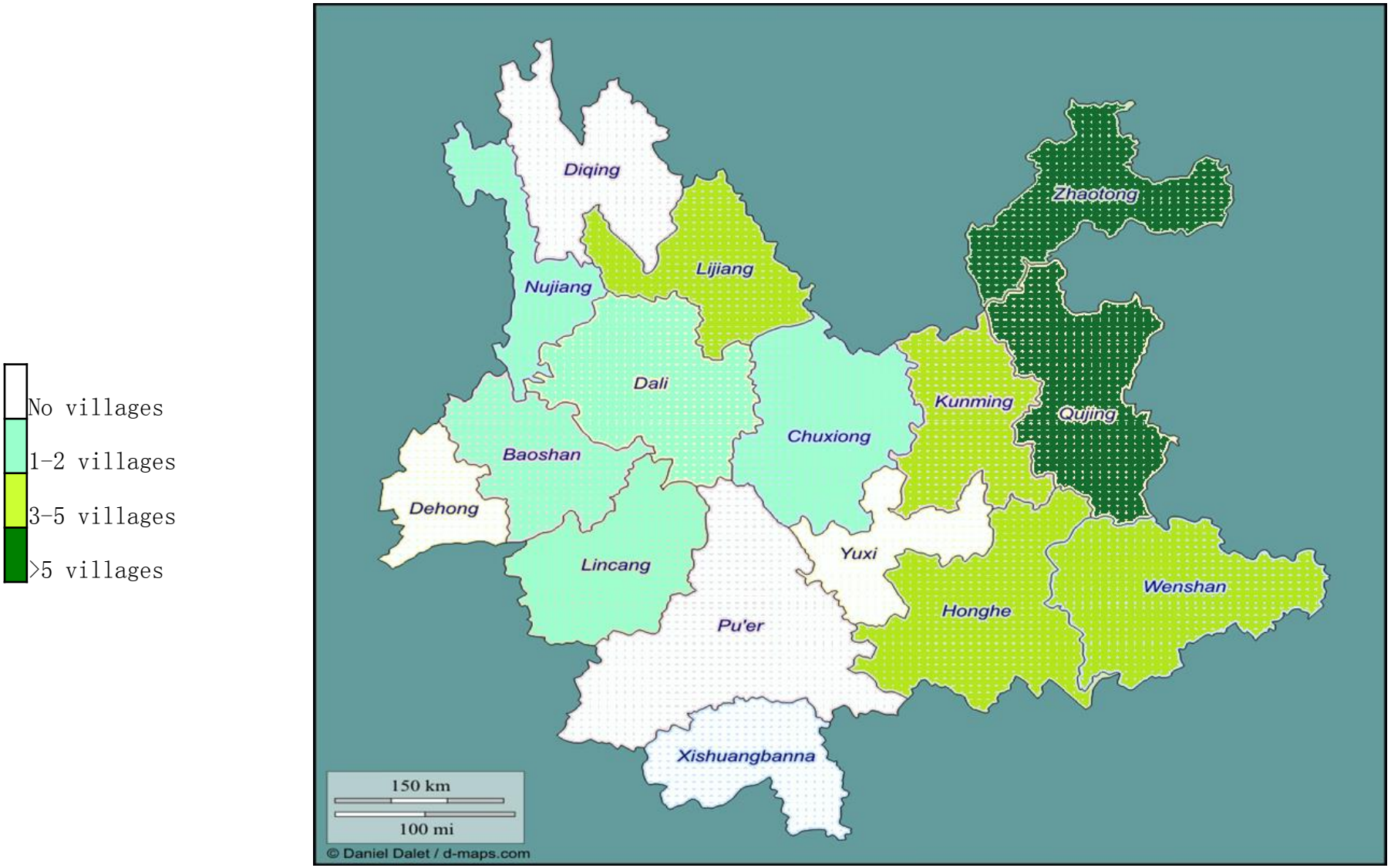
1. Representative sample at the Province level + DNA fingerprinting of a sub-sample
2. Identify and analyze determinants of adoption and disadoption (why C88 spread)
3. Surplus analysis to determine market-related benefits from C88 diffusion
4. Case-study on value-chain benefits

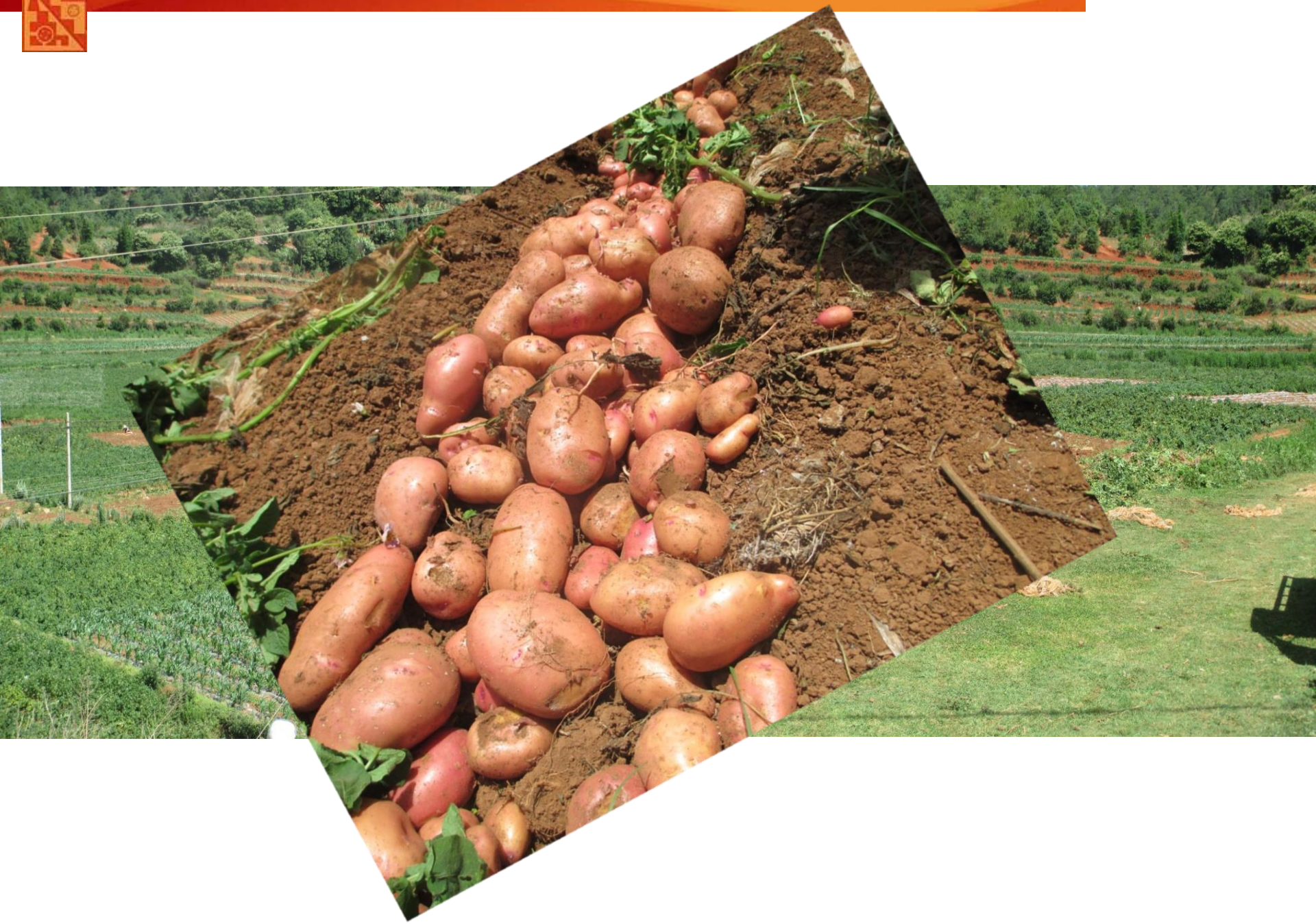
- Mix of quantitative and qualitative methods
- Household and village level surveys to collect data

Data: Household and Community Surveys

- YNU provided entry into communities, enumerators, and logistical support
- 616 Household surveys: Production, household and farm characteristics, social networks, varietal attributes and history of exposure to c88
- 41 Community surveys: Village attributes, prominent varieties, history of adoption, pests and disease, costs of production

Numbers of villages per Prefecture





- **DNA fingerprinting** **to confirm genetic identity of putative C88 plants**
- Protocol developed for dried leaf samples, then extended to tuber samples
- Conducted at the labs of the Yunnan Normal University (Kunming)
- CIP genebank leaders provided supervision of methods and confirmed interpretation of results

PROTOCOL FOR DRIED LEAVES SAMPLES, PRESS DRY

1. Samples ideally are taken from the youngest leaves from the upper third part of a representative plant and contain 3-4 leaves. Tubers can also be collected for DNA extraction

2. Wash leaf samples / potato tubers with tap water and dry with tissue paper in a place protected from rain.

3. Leaves should not be bent when collected or when wrapped in newspaper or placed in a book during the day (secure them in order to not mix samples), while enumerators are in the field. In case of tubers, those can be stored in labeled paper bags

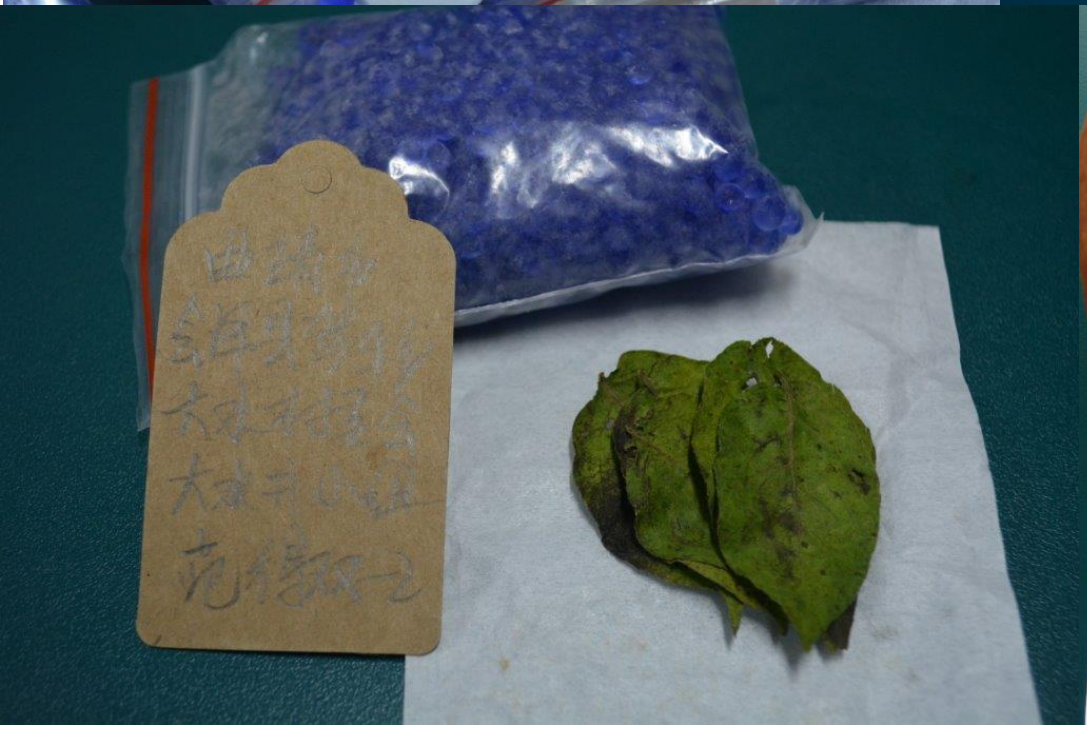
4. Label the page where the leaf sample is placed or the paper bag where the tuber is placed. Label with information of the household and plot it belongs to

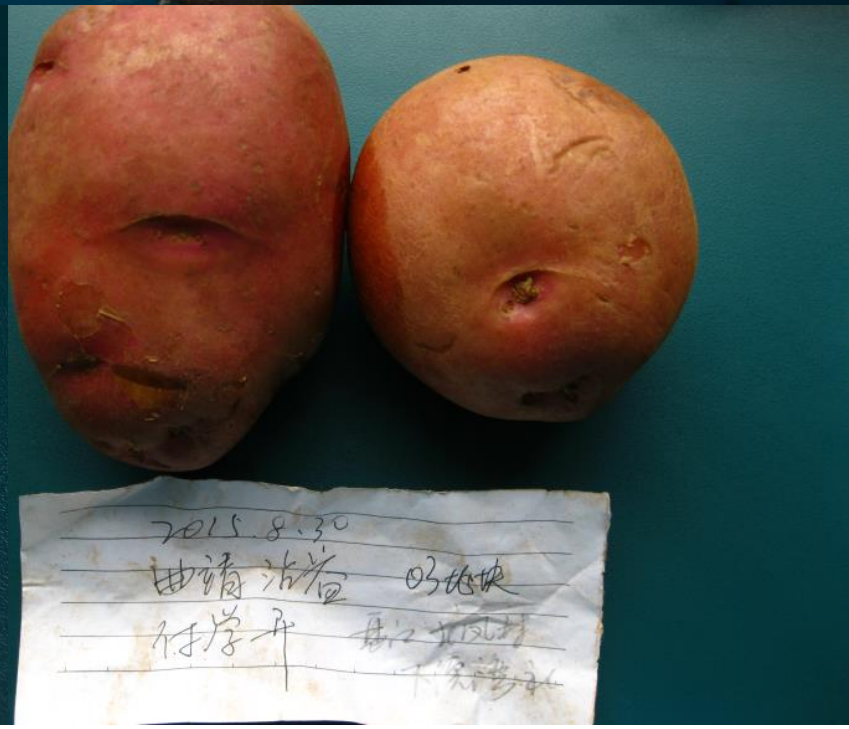
5. Move the sample from book to a drying press with the sample inside newspaper, keeping track of the label to identify samples. Maximum 10-12 samples per drying press., 3 days in the press.

6. Layers: wood, cardboard, newspaper, blotting paper, newspaper with leaves, blotting paper, newspaper,etc. Then repeat your layers etc. replace paper towel underneath and on top of each collected sample to help pull out the moisture in the samples each night

7. Keep dry samples protected from humidity and rain in their respective newspapers in plastic bags with silica.

Silica gel used to conserve leaves





Distribution of sub-sample for DNA fingerprinting

Level	Total surveyed	With leaf sampling	With tuber sampling	With leaf/tuber sampling
Household level	616	88	53	141
Village level	41	7	7	14
County level	22	5	7	12
Prefecture level	10	4	4	7

Procedure used by YNU to get DNA fingerprinting varietal confirmation of C88

1. Declared C88 tuber/leaf sample collection from household survey
2. Visual identification of putative C-88 tuber samples
3. Identification of putative C-88 samples based on cytoplasm genome diversity
4. Identification of putative C-88 samples based on SSR marker analysis of nuclear genome

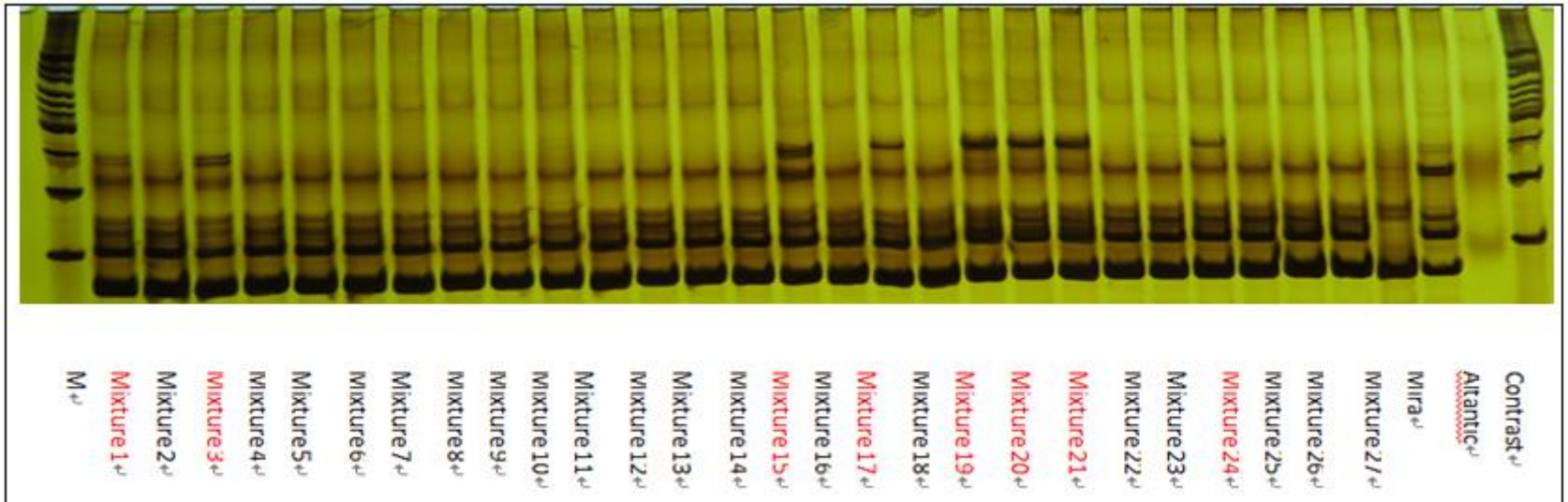


Figure 11 The result of STM0037 amplification detection （M=100bp DNA ladder）

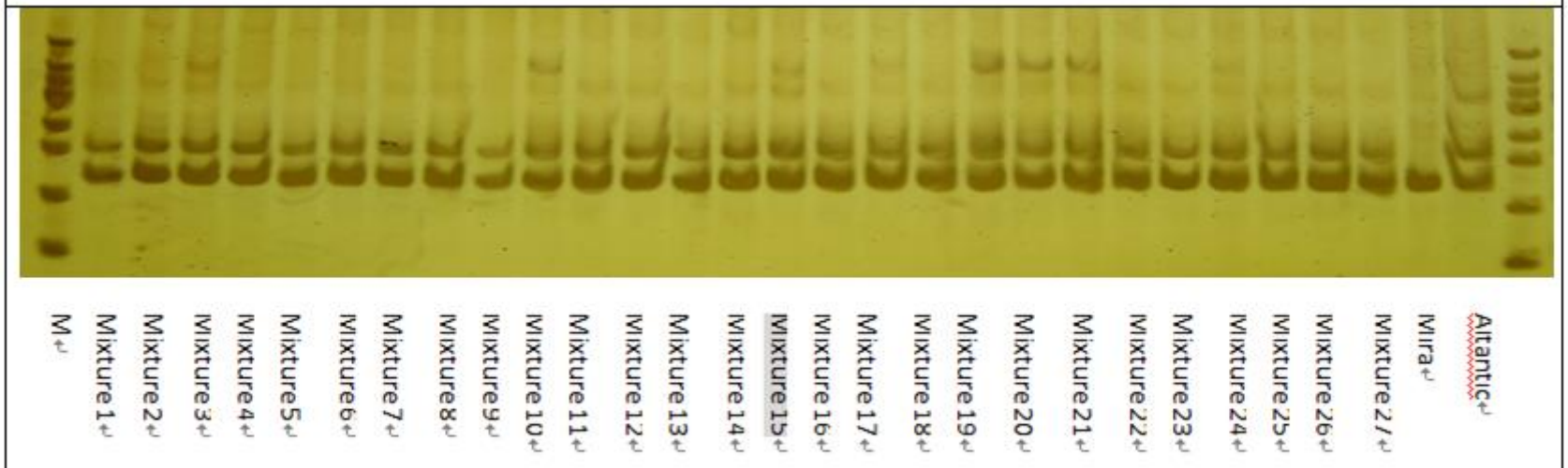


Figure 12 The result of STM3012 amplification detection （M=50bp DNA ladder）

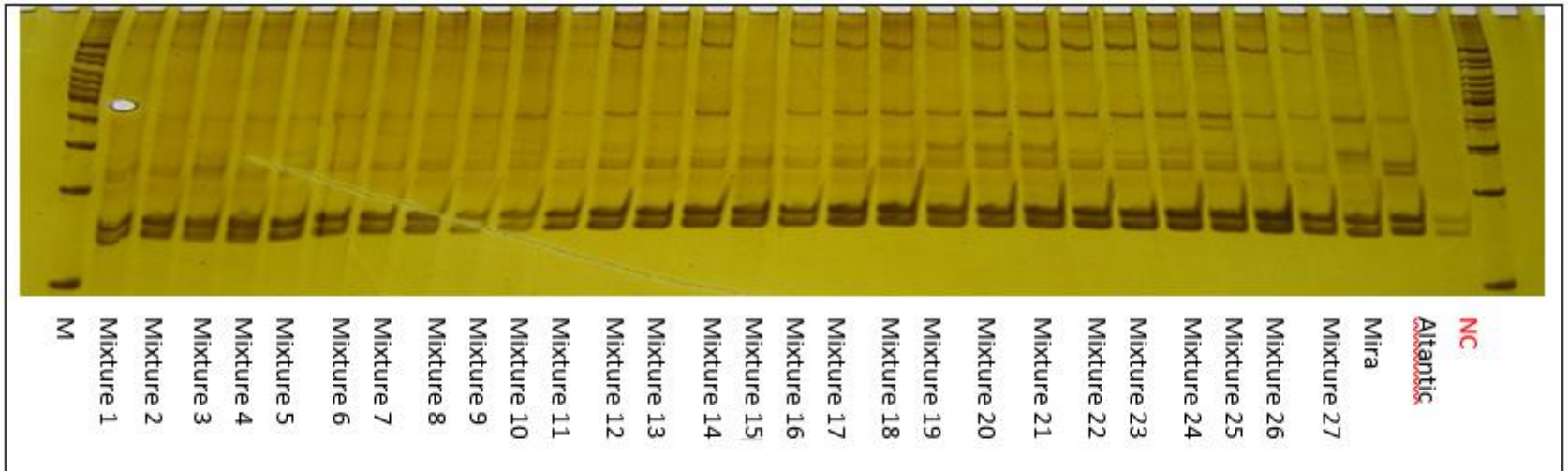


Figure 7 The result of STM1104 amplification detection （M=100bp DNA ladder）

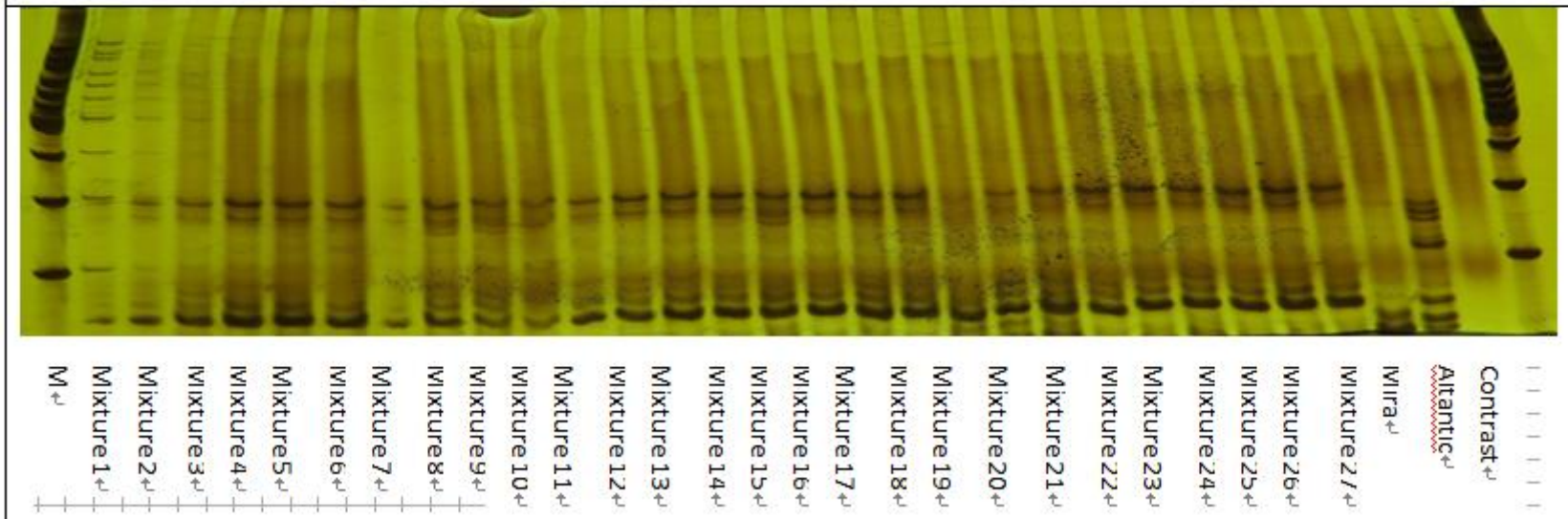


Figure 8 The result of STM1106 amplification detection （M=100bp DNA ladder）

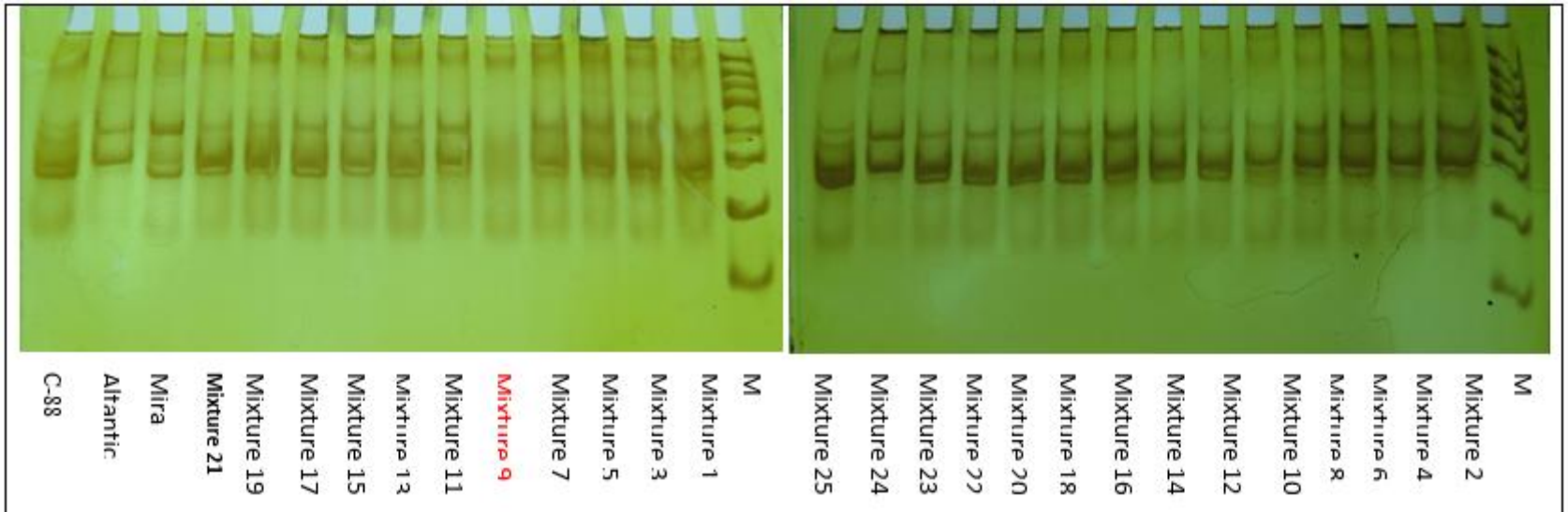


Figure 3 The result of STM2022 amplification detection （M=50bp DNA ladder）

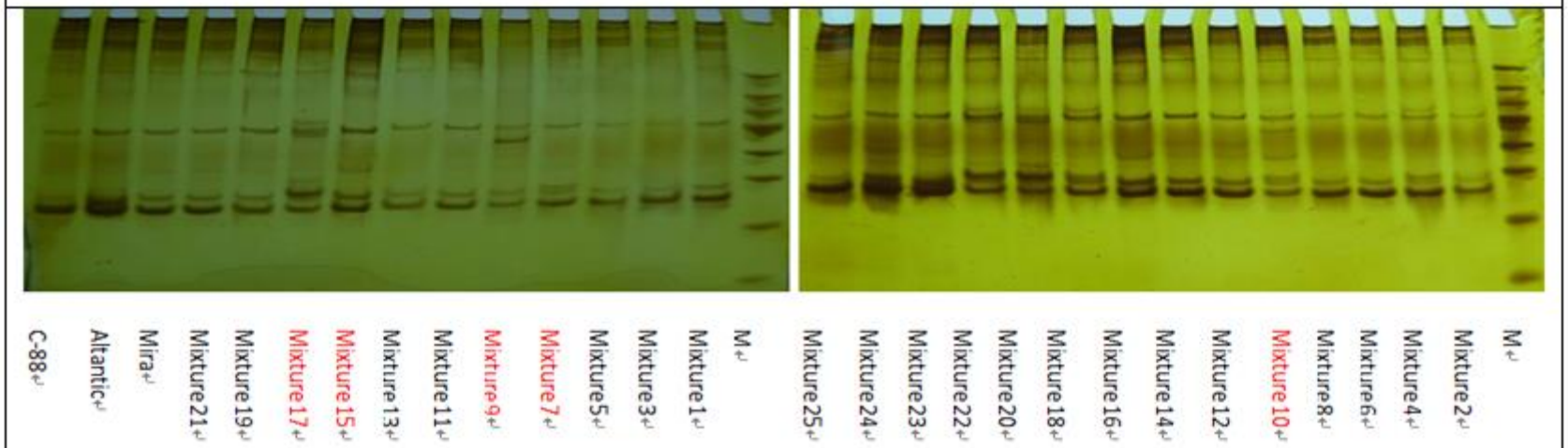
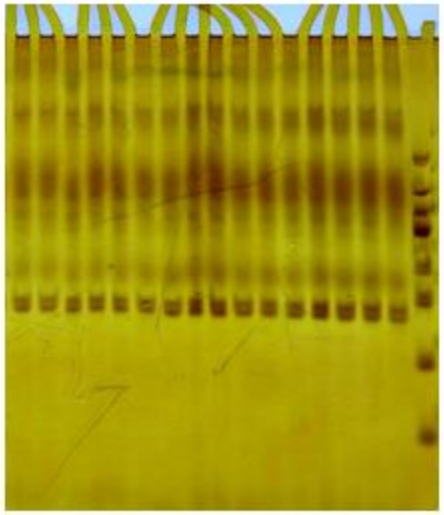
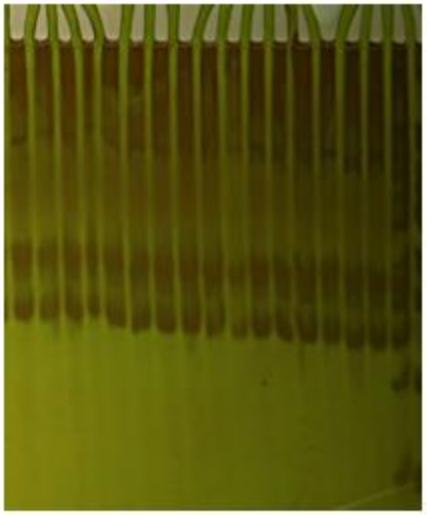


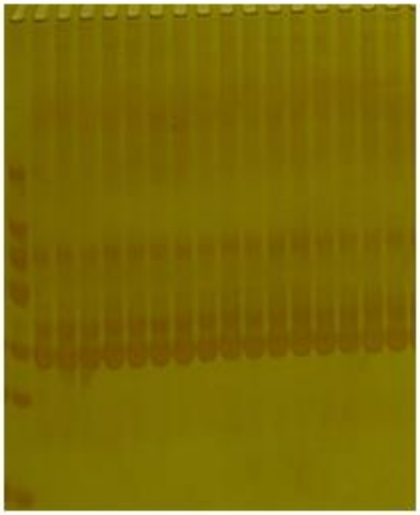
Figure 4 The result of STM3032a amplification detection （M=50bp DNA ladder）



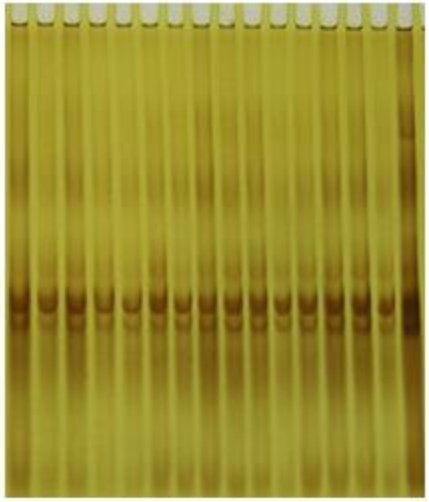
STM1049



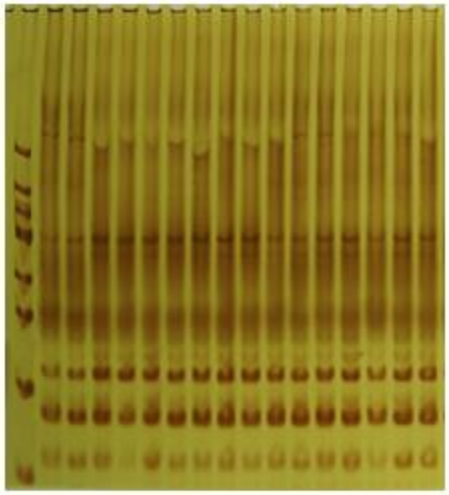
STM1053



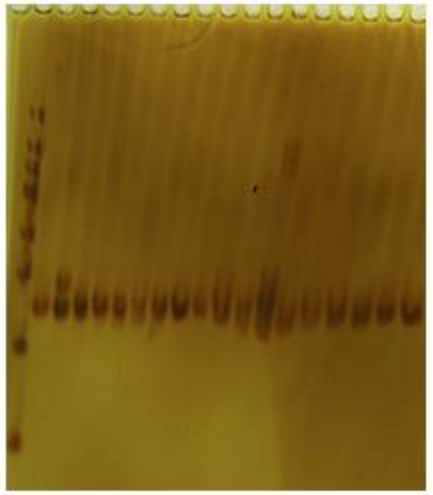
StpoAC58



STM0019a



STM0030



STM 3023a (C-88, Mira,128-143)

Figure 16： the results of 128-143 SSR amplification

Additional analysis: cytoplasmic type detection of samples with Atlantic, Mira and C-88 as check cultivars

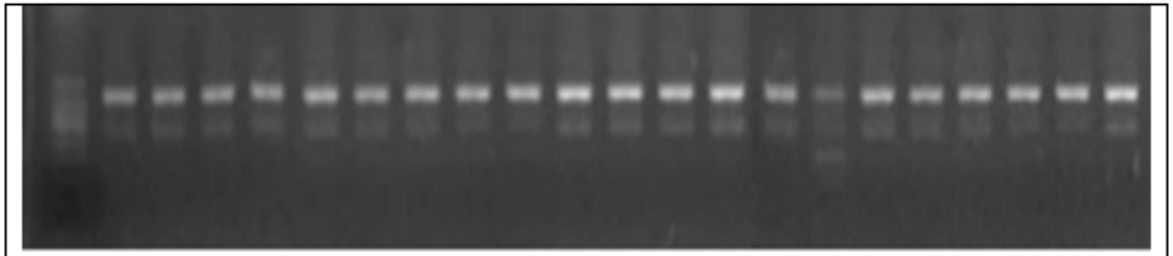


Fig. 1 1-105 混合样 T 引物扩增检测结果

加样顺序(从左至右)：泳道 1：Marker 为 50bp；泳道 2：1-5；泳道 3：6-10；泳道 4：11-15；泳道 5：16-20；泳道 6：21-25；泳道 7：26-30；泳道 8：31-35；泳道 9：36-40；泳道 10：41-45；泳道 11：46-50；泳道 12：51-55；泳道 13：56-60；泳道 14：61-65；泳道 15：66-60；泳道 16：71-75；泳道 17：76-80；泳道 18：81-85；泳道 19：86-90；泳道 20：91-95；泳道 21：96-100；泳道 22：101-105； 其中 Marker（共 9 条带，分子量由上至下分别为：500，400，350，300，250，200，150，100，50bp，其中 300 bp 为最亮带）

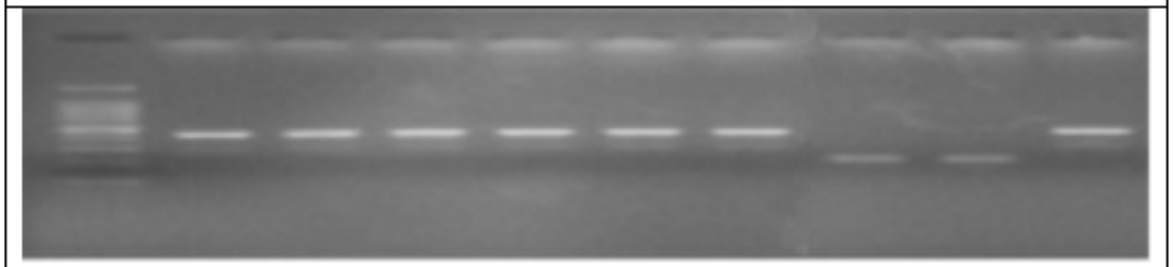


Fig. 2 106-143 样品 T 引物扩增检测结果

加样顺序(从左至右)：泳道 1：Marker 为 100bp；泳道 2：106-110；泳道 3：111-115；泳道 4：116-120；泳道 5：121-127；泳道 6：128-135；泳道 7：136-143；泳道 8：Mira；泳道 9：Atlantic；泳道 10：C-88；其中 Marker（共 11 条带，分子量由上至下分别为：1500，1000，900，800，700，600，500，400，300，200，100bp 其中 500 bp 为最亮带）

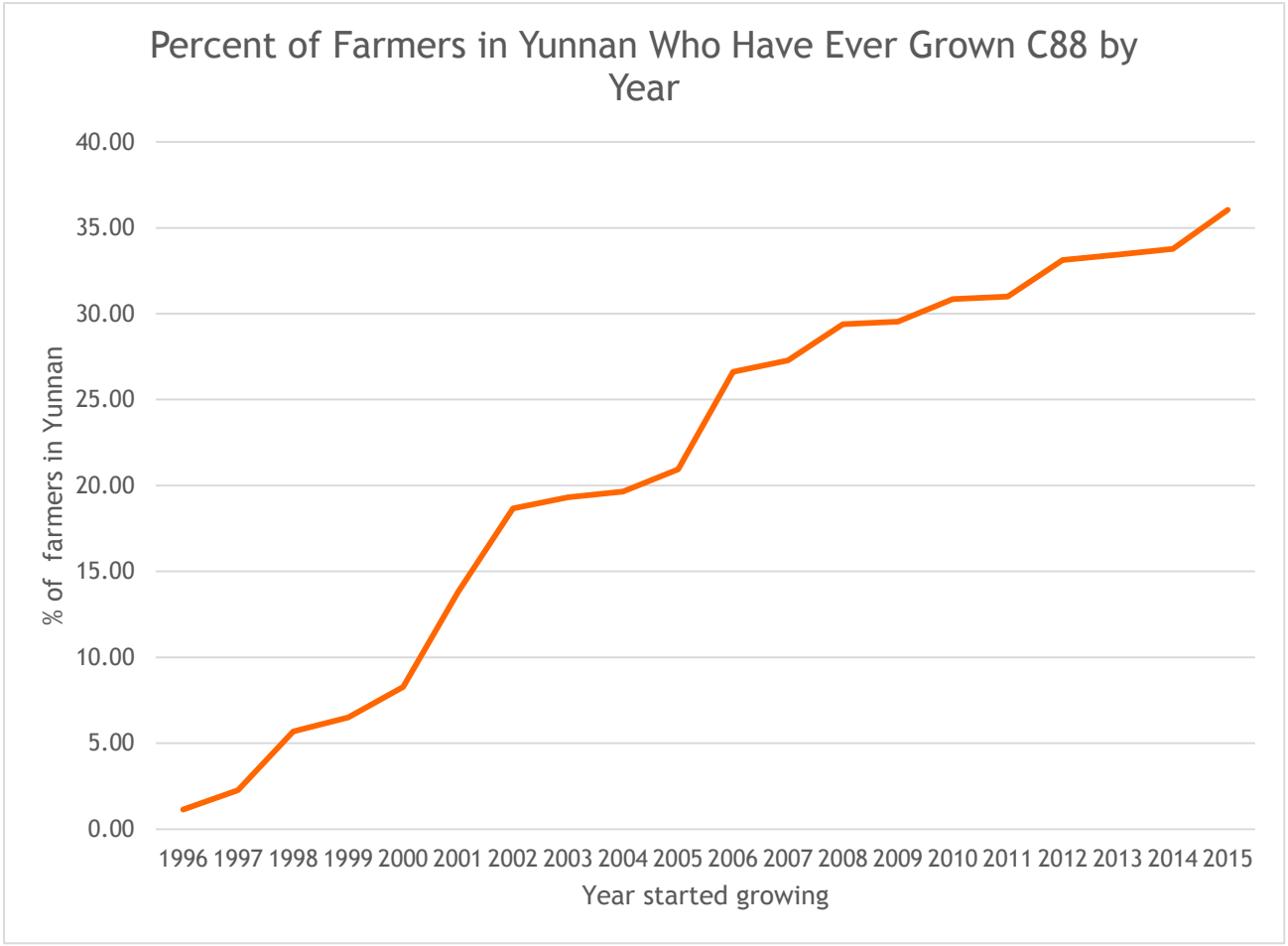
YNU report highlights:

- 615 households surveyed, 141 mentioned planting C88.
- Based on visual observation, only one tuber sample of the C-88 collected from Zhanyi county of Qujing city was found to be mixed with another red-skin cultivar.
- According to the results of cytoplasmic type detection, one leaf sample collected from Ninglang county of Lijiang city had different cytoplasmic type (T/β type).
- Additionally, the SSR marker-based fingerprinting further clarified three samples showed different SSR genotypes at two loci (STM1049 and STM3032a) in comparison with the other samples and the reference C-88.
- **Therefore, it was confirmed that over 97% (137/141) of the fresh samples (leaves and tubers) were C-88**

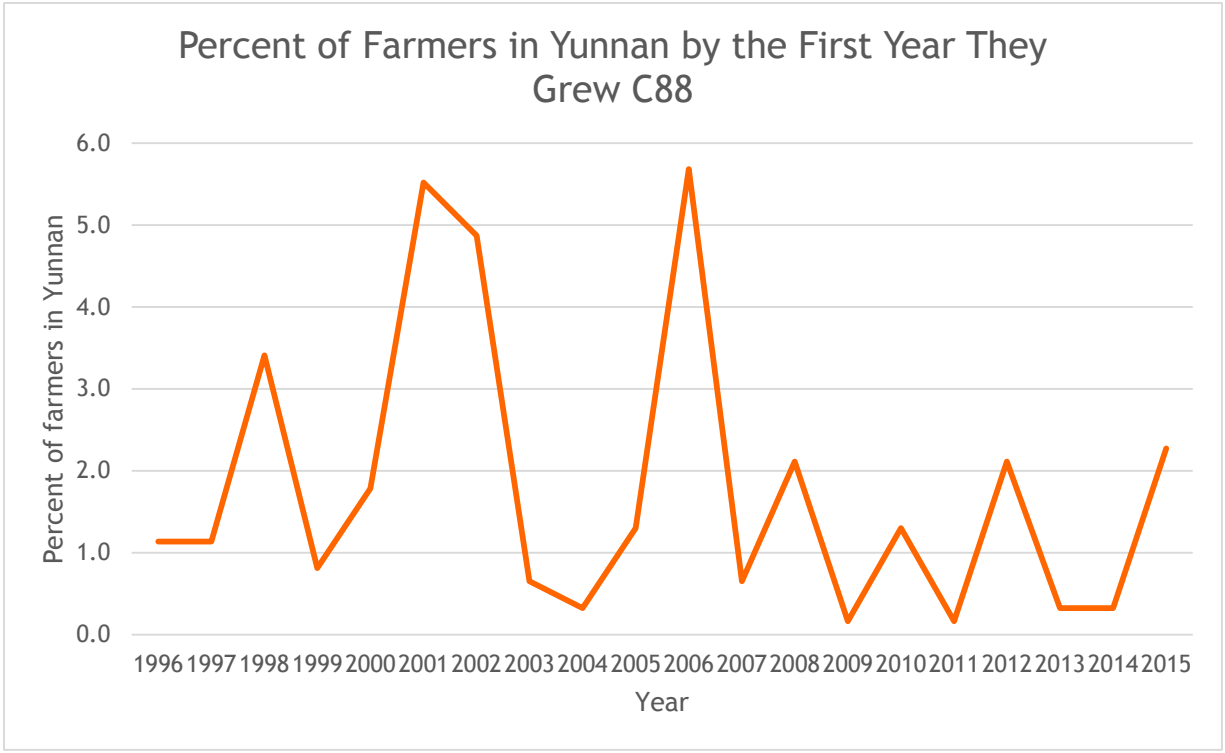
Adoption and diffusion

- Quantitative and qualitative analysis
- Village-level model of exposure to c88
- Household models:
  - Adoption determinants
  - Intensity of adoption
  - Disadoption
- Models include standard set of variables: HH demographics, education, measures of wealth and farm characteristics.
- Additional information on the availability of the variety: When first introduced, sources of information, presence of contracting arrangements (mixed data—HH & village surveys)
- *Do farmers have a choice?* Descriptive analysis about adoption decisions using questions on perceptions about varietal attributes

Diffusion over time



Diffusion over time



Descriptive statistics

Variable	Total sample	Adopters	Non-Adopters
Observations	616	143	473
Age	49	47	50
Education (years)	5	6	5
Experience in potato production (years)	32	29	33
Farming is primary occupation (%)	88.9	96.5	86.7
Participate in a farming organization (%)	11.5	26.6	7
Family size	4	4	4
Farm size (ha)	0.75	1.56	0.51
Potato area (ha)	0.35	0.75	0.22
Visited by extension agent in the last year (%)	34.7	63.6	26

Note on heterogeneity

Gini coefficients

Land area	All	Adopt	Non-adopt
Potato area	.661	.570	.624
Total area	.580	.592	.499

Theil entropy decomposition

$$\sum_{i=1}^{N}(y_i / Y)ln(\frac{y_i / Y}{1/N})$$

	Potato Area	Area
Total	1.014	.912
Within	.844	.765
Between	.170	.148

Econometric results

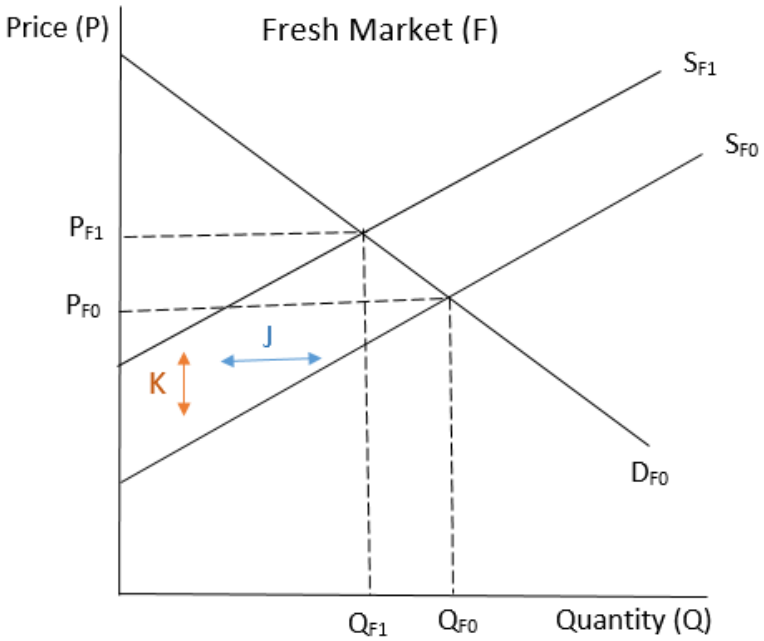
- Current adoption and intensity of adoption (probit, tobit)
  - Household size, land area, commercial orientation all significant and expected signs
  - Disease pressure: role of late blight resistance
  - Location: Farmers in more potato-intensive villages and more distant from metropolitan areas are more likely to plant c88
- Ever adopted; disadopted (probit, Heckman probit)
  - Location critical: Farmers in Prefecture center are equally likely to have grown c88 at a point in time, but much less likely to currently grow c88
  - Concern for late blight—farmers who value late blight resistance are less likely to continue growing c88 over time
  - Commercial farmers are more likely to have disadopted over time
  - "Awareness" important: Of farmers who have heard of c88, ever adoption is independent of distance

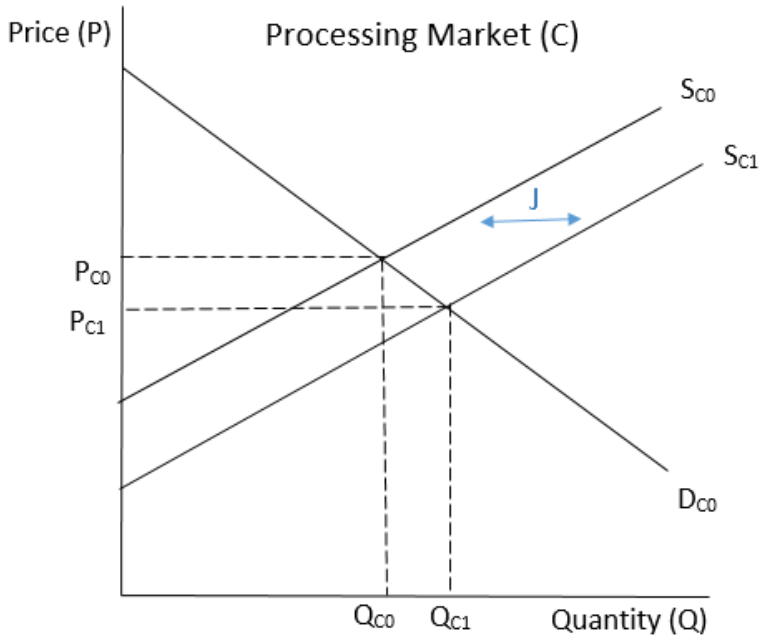
Economic benefits

- Village level surveys to build representative cost of production budgets for both C88 and the counterfactual
- % change in costs of production between C88 and control:
  - Detailed probing during village-KI interviews indicated no cost differential
  - Quality seeds not available in markets; usually provided free
  - Farmers do not vary production processes by variety
- Yield and total production from HH survey
  - Compared to village survey yield estimates (triangulation)
  - Household-level regression: 26% difference in productivity (distance to provincial capital, year c88 first appeared in village serve as instruments; but note challenges)

Economic surplus models

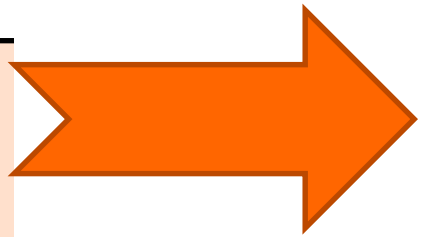
- Good estimates of total production, but multiple uses of output (very difficult to get credible data)
  - Fresh market
  - Processed market
  - Seed savings
  - Animal feed
  - “other”
- Two main markets: fresh and processed
- Fresh mainly consumed locally (closed economy model); processed exported


Price (P)
Fresh Market (F)
S_{F1}
S_{F0}
P_{F1}
P_{F0}
J
K
D_{F0}
Q_{F1}
Q_{F0}
Quantity (Q)

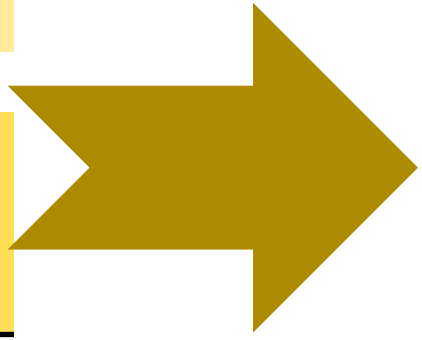

Price (P)
Processing Market (C)
S_{C0}
S_{C1}
J
P_{C0}
P_{C1}
D_{C0}
Q_{C0}
Q_{C1}
Quantity (Q)

Proportion of potato production destined to fresh and processing markets

Category	%
Processing	3
Export to other provinces or countries	37
Loss	8
Feed	15
Seed	18
Fresh consumption	19



Processing: 40%

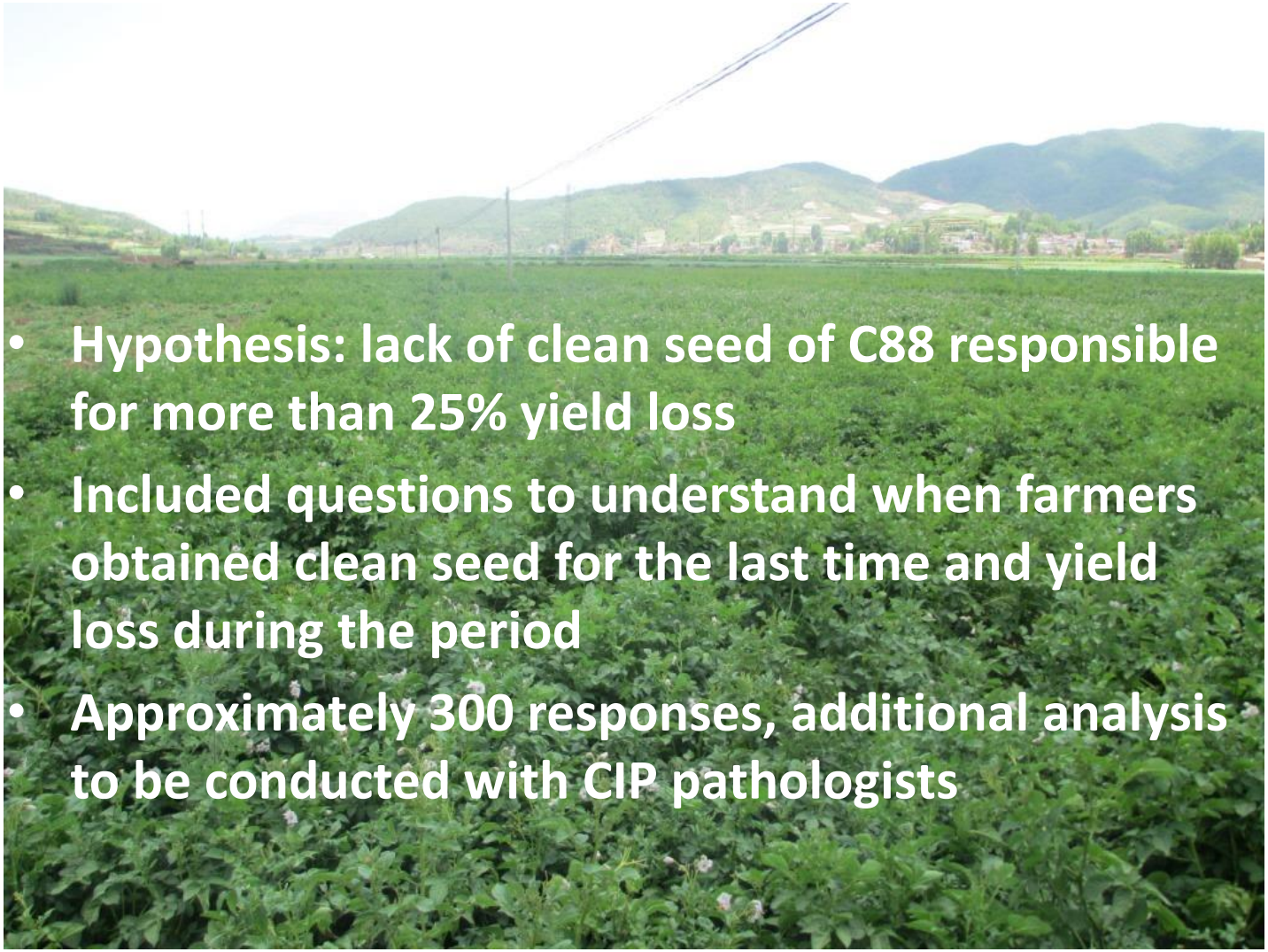


Fresh: 52%

Value chain interviews

- Is diffusion of C88 associated with industry development? Map of value chain development
- Conducted interviews with stakeholders (representatives of processing companies, seed companies, wholesalers, etc.)
- Major findings
  - Lack of seed markets
    - In Yunnan, quality seed is sold to the government and then distributed to farmers at subsidized price
    - Little evidence of private seed markets: Seed degeneration is important
  - Transport to market
    - Common to have unofficial agreements
    - Get to market either through company representative or a "businessman"
  - Potato chip processing companies prefer C88 but struggle to obtain enough quality processed potatoes throughout year, import other varieties (e.g. Atlantic) from northern Provinces
  - Wholesalers like C88 because its high quality fetches a higher price

Seed degeneration problem



- Hypothesis: lack of clean seed of C88 responsible for more than 25% yield loss
- Included questions to understand when farmers obtained clean seed for the last time and yield loss during the period
- Approximately 300 responses, additional analysis to be conducted with CIP pathologists

- Gender questions added in the HH and village questionnaires: In data analysis, gender differentials have not proven to be significant (household composition does not vary)
- Household types: Major distinction between adopters of c88 and non-adopters

Thank you