Exceptional Potato Clones Selected by Filipino Farmers from True Potato Seed: Status after 30 Years

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SHORT COMMUNICATION

Exceptional Potato Clones Selected by Filipino Farmers from True Potato Seed: Status after 30 Years

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Abstract

In a remote mountainous region of the Philippines, farmers selected their own clones from hybrid True Potato Seed (TPS) populations and have maintained them for 30 years without public support. In 1985, the International Potato Center (CIP) initiated on-farm TPS research in the Mount Kanlaon area to help farmers control or reduce the rates of bacterial wilt caused by *Ralstonia solanacearum*. Seedlings were either grown in nursery beds or as transplants in the field. At harvest, farmers not only harvested their crop for either food or for sale but also selected their preferred clones. A survey conducted in 2016 showed that farmers are still growing potato clones selected from TPS and that these clones had spread to numerous areas within and around Mount Kanlaon. Farmers kept these clones because it was profitable because they required minimum inputs and their resistance to various pests and diseases and adverse weather conditions. ELISA tests showed that these clones have excellent virus resistance which partially explains why these clones have been growing for 30 years without a formal seed production program or any government support. Parents used to develop the TPS hybrids included those with virus and *R. solanacearum* resistance.

Resumen

En una región remota montañosa de Filipinas, los agricultores seleccionaron sus propios clones de híbridos de poblaciones de semilla verdadera de papa (TPS) y los han mantenido por 30 años sin respaldo público. En 1985, el Centro Internacional de la Papa (CIP) inició investigación con TPS en el campo, en el área de Monte Kanlaon, para ayudar a los productores a controlar o a reducir los niveles de la marchites bacteriana causada por *Ralstonia solanacearum*. Las plántulas se cultivaron ya en camas de vivero o como trasplantes en el campo. A la cosecha, los agricultores no solo cosecharon su cultivo para alimento o para venta, sino que también seleccionaron sus clones preferidos. Una encuesta conducida en 2016 mostró que los productores están aún cultivando clones de papa seleccionados de TPS, y que esos clones se han dispersado a numerosas áreas dentro y alrededor del Monte Kanlaon. Los agricultores mantuvieron esos clones porque eran rentables a pesar de los mínimos insumos y por su resistencia a varias plagas y enfermedades y a condiciones climáticas adversas. Las pruebas de ELISA mostraron que estos clones tienen excelente resistencia a virus, lo cual parcialmente explica porque estos clones se han estado cultivando por 30 años sin un programa formal de producción de semilla o algún respaldo gubernamental. Los padres utilizados para desarrollar estos híbridos de TPS incluían a aquellos con resistencia a virus y a Rs.

Keywords *Ralstonia solanacearum* · Farmer resilience · Positive selection · Potato · True potato seed · PLRV resistance · PVY resistance

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Introduction

True Potato Seed (TPS) was a major focus of research and on farm evaluation by numerous organizations and countries from 1964 to 1995 (Song et al. 1987; Hoang et al. 1988; Fuglie et al. 2001 and Hardy et al. 1994). China was the

modern day pioneer of using TPS to avoid viral and bacterial diseases in the potato crop from 1964 to 1979 (Song et al. 1987). By the mid-1980s, China embarked on a large-scale program of utilizing tissue culture to rapidly multiply existing and new varieties with the support of CIP. Subsequently, the utilization of TPS by farmers declined and finally ceased. At the present time there are no known varieties being grown from those self-pollinated progenies (personal observations and communications, P. VanderZaag).

The advantages of TPS are many including being free from virus and bacterial diseases. With the support of CIP many efforts on the use of TPS were both in Africa and in Asia (Hardy et al. 1994). A major effort was launched in Eastern India to grow commercial crops from TPS origin seed tubers in the late 1980s. Presently this work continues in the state of Tripura, however no efforts have been made to select clones from the field grown populations (personal communications, Mohinder Kadian).

In the Red River Delta of Vietnam there were two periods of significant adoption of TPS (Hoang et al. 1988 and Fuglie et al. 2001). Today, TPS is no longer utilized in Vietnam and there are no known varieties grown from the TPS hybrids that were grown 20 years ago. In the Philippines, a major effort was successful in Bukidnon, Mindanao to produce small tubers, from TPS seedlings in screen houses, which were used by farmers for commercial potato production (Fernandez et al. 1988). In this mid elevation area of 1000 to 1300 m asl, *R. solanacearum* is the major problem that is both seed tuber borne and soil borne. At present no lasting impact from that work remains in Mindanao (personal communications, B. Fernandez).

TPS was introduced to farmers on the slopes of Mount Kanlaon, in the Philippines, at elevations of just over 1000 m asl, an active volcano, which is the major vegetable growing area on Negros Island. Its varying topography and moderate temperature made it favorable for vegetable production including potatoes. This area is similar to that in Bukidnon where Fernandez et al. (1988) reported on their TPS research and development work.

This study chronicles the historical timeline in farmer's evaluation, utilization and adoption of the clones selected from TPS and the pre-disposing factors that influenced farmer's selection and eventual adoption. The study also highlights the challenges and lessons learned from farmers' experiences.

Materials and Methods

On-Farm Trials

In 1985, CIP Regional staff was requested to visit Mount Kanlaon to assess the farming practices and provide assistance on how to improve commercially grown potato. After an initial visit a CIP staff member, Bianito Susana, nicknamed "Choi", was assigned the task of helping the farmers by controlling or reducing rates of *R. solanacearum* by utilizing TPS. On-farm research was initiated to assess the feasibility of growing TPS. CIP provided TPS of the hybrids: Greta x AVRDC 1287.19 during 1985–1986 and Serrana x 7XY.1 or Serrana x LT7 in 1987. Initially, there were 12 farmer cooperators in August 1985 in Barangays Pula and Malaiba. Farmers were given 1000 seeds each and was given the option to use TPS either as transplants in the field or to grow them in nursery beds. Two farmers opted to grow TPS in nursery beds while the rest of the farmers grew TPS transplants in the field (Susana and VanderZaag 1987). Trials with up to 25 progenies were conducted during the rainy season (August to December 1987) and dry season (January to April 1988). Seeds were sown in banana potlets filled with fertilized sterilized soil. Seedlings were also planted in raised beds. TPS seedlings were transplanted in double row plots at 6 plants m^{-2}. At harvest, most farmers sold the larger tubers and bulked all seed sized tubers for storage and replanted the following season. Some farmers did make their own clonal selections from the large range of genotypes in their TPS transplanted fields. After storage and sprouting, these were replanted as clones with several hills in the following season. Over time the number of selected clones were reduced under the selection pressure of the farmer's growing conditions. Selected clones would also be shared with neighbours who observed the harvests.

Survey in 2016

A survey was conducted from June to July 2016 to determine what farmers did with the tubers selected from TPS back in the 1980s. The survey was conducted in the vegetable growing areas of Barangays (townships) Pula, Malaiba, Lumapao, Cabagtasan, Cudcod and the Canlaon City market. A qualitative research design involving both the semi-structured interview and direct observation was used. The snowball purposive sampling wherein respondents were recommended by key persons was used to identify additional relevant respondents.

There were 30 respondents for the interview. Most of the farmer cooperators of Mr. Susana had passed away; however still 11 farmer cooperators that were still alive were interviewed. The other respondents were: 7 other potato farmers, 5 former potato farmers, son of a deceased potato farmer, son of the deceased former cooperator, one member of the Barangay council; one person from the market; and two potato dealers, and Lorenzo Alejandro, the former Production Technician that served as local counterpart of Mr. Susana. Farm visits were conducted to collect information on growth and yield, resistance to pests (thrips and mites) and diseases, tolerance to environmental stress and other pertinent information. In the absence of exact numeric and other quantifiable

data, the findings were summarized based on the qualitative description of the respondents.

A validation of the research findings was conducted on August 29, 2016 at Pula. The "Research Output Presentation and Planning Dialogue with Farmers" aimed to: present research results on "Exceptional Potato Clones Selected from TPS by Mount Kanlaon Farmers: It's Status after 30 Years; discuss with farmers the threats on potato production and provide possible solutions to improve potato production; and to come up with plans that can be done together with farmers. Attendees were the respondents of the survey, other farmers from the Mount Kanlaon area, Barangay officials, and personnel from the Department of Agriculture.

Virus Detection and Positive Selection of Best Plants

Tubers of locally selected potato clones retrieved from farmers' fields were grown in Potato Systems Research and Training Center for possible multiplication. Tubers of the four most popular clones were sent for virus indexing. Positive selection of apparently healthy plants in fields of one or more of these clones was demonstrated. Healthy plants were marked with a bamboo stick if no neighboring plants showed virus or *R. solanacearum* infection. The goal was to get 100 plants per field and reuse only those selected plants' tubers as seed and use the rest for consumption or sale.

Results and Discussion

On-Farm Trials in 1985 and 1986

The growth and yield of TPS transplants were compared with Generation 1 seed tubers, in the subsequent season, in 7 farmers' fields. The progeny was Greta x AVRDC 1287.19. Generation 1 (G1) seed tubers had higher yield and percentage of marketable tubers compared to TPS transplants across all farmers' fields (Table 1).

On-Farm Trials Evaluating Production of Seed Tubers in High Density Beds

The feasibility of using seedbeds to produce tubers in beds were evaluated. Five on-farm trials were conducted and farmers planted TPS transplants in $5m^2$ beds at 100 transplants/m^2. Survival of transplants across all the farmers beds averaged 65%. The yield was adequate and ranged from 1.2 to 2.5 kg m^2. About half of the tubers produced weighed 10-20 g and 36% weighed less than 10 g. (Table 2).

Performance of Different Progenies

Plant survival of the different progenies was low with a mean of 23%. The highest survival was in the local cultivar that was grown from tubers (Table 3). Initially farmers were inexperienced in growing TPS progenies and latter improved on their management practices. In terms of yield, all the progenies, except Serrana x LT-7 performed better than the local cultivar. The highest yielder was the progeny 381,064.10 x LT-7 with a yield of 25.5 Mg ha^{-1}.

2016 Survey Results on the Selection and Diffusion of Certain Clones

Based on the interview process we learned a great deal of what actually occurred over the past 28 years since Bianito Susana departed. From TPS seedlings, plants with good tuber appearance and yield were selected by individual farmers. Initially,

Table 1 Results of 7 on-farm trials evaluating TPS transplants in late 1985 and Generation 1 seed tubers

Farmer	TPS Transplants					Generation 1 Seed Tubers	
	Sowing Date	Transplanting *		Tuber Yield	Marketable	Tuber Yield**	Marketable Yield
		Date	No.	(Mg ha^{-1})	(%)	(Mg ha^{-1})	(%)
1	15-Aug	25-Sep	700	15	63	22	83
2	28-Aug	2-Oct	633	13	66	24	84
3	29-Aug	30-Sep	506	13	65	19	89
4	6-Sep	3-Oct	546	8	63	12	72
5	4-Sep	1-Oct	295	8	59	15	88
6	10-Sep	10-Oct	132	15	65	21	86
7	14-Oct	15-Nov	482	10	61	16	77
Mean			471	12	63	18	83

The progeny was Greta x AVRDC 1287.1

*Survival of transplants was from 82 to 98%. All 7 trials were transplanted as single hills in double row beds

** Most were planted in March 1986 and harvested in June. Field size ranged from 100 to 500 m^2 in size

Table 2 Results of 5 on-farm trials evaluating the production of seed tubers in beds adjacent to farmer's homes

Farmer	Survival of Transplants (%)	Yield (Kg m^{-2})	Size Distribution (%) by weight (g)		
			above 20	10 to 20	less 10
1	80	2.5	10	50	40
2	80	2.1	13	52	35
3	75	1.9	7	58	35
4	50	1.6	3	57	40
5	40	1.2	3	67	30
Mean	65	1.9	7	57	36

many farmers made their own clonal selections from a large range of genotypes. After sometime, farmers eliminated their poor performing selections and sought the best local selections, often from neighboring farmers or from the market. After a decade or more only a few selections remained. These had tubers with the following descriptions: a clone with violet flowers and tubers with purple eyes, now named "Choi violet"; a clone with white flowers and white tubers now named "Choi white"; a clone that produced numerous but small tubers, "mani-mani"; and a clone with round tuber and yellow flesh, named "Yoyo". Finally, only the first two clones mentioned remained with farmers in Pula. Farmers kept on multiplying these clones because they produced big tubers; had tolerance to diseases; and were resilient to varying weather conditions. Whenever, a farmer asked where you got the seed tubers, the answer was "from Choi".

Potato was first planted in Cabagtasan by a farmer, Rogelio Cogonon who obtained seed potatoes of two clones from Pula, 15 years ago. One of the clones was "Choi violet". The other one was "Yoyo", which is now no longer growing in Pula. In Codcod, they grow Choi violet and Choi white. There the seed was retrieved from a potato merchant many years ago. The diffusion of tubers selected by farmers in Pula spread to other places, either through friends, neighbours, or relatives or were bought by other farmers from farmers or merchants.

The Impact of CIP's Intervention

The intervention by CIP led to the increase in the number of farmers that planted potatoes**.** Farmers were encouraged to plant potato because of availability of planting materials introduced through TPS. CIP provided free planting materials (TPS), other inputs and technical guidance to farmers in Pula and Malaiba, which resulted in most farmers in these two barangays becoming potato farmers. Farmers gave seed tubers of selected clones to neighbors and friends while other farmers bought tubers sold in the market. At present, Pula farmers still grow "Choi white" and "Choi violet". There are three clones including Choi Violet growing in Cabagtasan. In Codcod there are still unnamed clones being grown all originating from Pula.

Table 3 Vigor, growth, and transplants from components of yield of 9 TPS progenies as transplants (January 18–April 21, 1988)

Code	Progeny	Vigor*	Transplants (#)	Survival (%)	Tubers/plant (#)	Average Tuber Weight (g)	Tuber Yield (Mg ha^{-1})
P87010	381,064.10 x LT-7	7	94	24	13	33	25.5
P87025	384,015.30 x 7XY.1	5	108	19	16	24	22.2
P87021	384,015.24 x 7XY.1	7	90	33	12	29	19.9
P87008	381,064.10 x 7XY.1	5	92	13	8	35	16.5
P87016	384,015.10 x 7XY.1	5	64	15	11	24	15
P87055	Serrana x 7XY.1	3	100	6	7	32	12.9
P87011	381,064.12 × 384,551.1	5	120	15	8	23	11
P87012	381,064.3 x 7XY.1	5	74	21	15	11	9.3
P87060	Serrana x LT7	5	138	15	4	15	4
	Local cultivar	3	40	67	3	42	5.2
Mean		5	92	23	10	26.8	14.2

*Score from 1 to 9 with higher values indicating greater vigor

Scenario of Local Potato Production

The resilience of farmers in selecting and maintaining their own clones for almost 30 years without support from any agency is phenomenal. The astute selection of the best clones by individual farmers is notable and the clones that they selected excelled for several abiotic traits (extreme drought and severe rainy seasons annually). Likewise, their culinary qualities are outstanding, as per comments by farmers and merchants.

R. solanacearum was and is a major problem in all study areas. All of the clones selected have a certain level of tolerance. The second most common problem is tuber moth that inflicts damage on tubers during storage. Farmers practice various ways of storing seed potatoes, but never the less all the selected clones have survived. The unavailability of good seeds for planting leaves farmers no options but to plant the tubers they harvested or locally purchased year after year. These clones were already in the field for three decades. In addition, farmers use "uli" or leftovers tubers in the fields that have regrown. Generally, when an interested farmer observes a surviving plant in the field, he will take care of the plant until it matures. The seed tubers are multiplied until the desired number of tubers and replants are obtained. The excellent virus resistance of the surviving selections was not enough to maintain the level of potato production. Farmers became discouraged with the levels of infection with *R. solanacearum*.

Rejuvenating the Local Varieties through Positive Selection

In 2014, a farmer (Gregorio Alquezar) in Pula planted some "Choi white" tubers from neighbors and in February 2015, made available his field for demo trial on positive selection. In April 2015, three of the authors visited this and another potato field. Plant growth was not uniform, there were virus and other diseased plants and mixture of Choi white and Choi violet clones in both fields. Positive selection, which is the selection of the best strongest visually healthy plants with adjacent visually healthy plants were marked with bamboo sticks. There were 100 plants selected in each field. At harvest, the farmers kept the tubers from the selected plants separately for use as seed. In March 2016, tubers were planted and the result was dramatic. Fields looked visually healthy and produced an excellent tuber yield.

Fig. 1 Field in Brgy. Codcod planted to positively selected seed tubers of Choi white

Fig. 2 Most popular clones selected from TPS

In December 2015, positively selected tubers were given to several farmers including Leonisa Impil of Cabagtasan. Her crop was also visually healthy and vigorous (Fig. 1). From the approximately 25 kg of seed tubers given to her, a total of 152 kg were harvested. All of the tubers harvested were kept as seeds and replanted. Uniform growth and good plant stand was observed once again. The use of Positive Selection proved to be an easy way to get a rapid recovery towards healthy seed tubers for growing a commercial crop.

Retrieval and Virus Testing of Selected Clones

Nineteen clones originally selected from TPS in the 1980's were retrieved from different farmers' fields and grown in the greenhouse. Multiplication of the clones was difficult mainly due to *R. solanacearum* infection. After removing duplicates, we retained four: Choi violet (CPF34); Choi white (CPF35); Yoyo yellow (CPF39) and Lumapao white (CPF40) (Fig. 2). These four major clones were tested for 7 viruses (PVA, PVS, PVX, PVY, PotLV, PVM, and PLRV). Three of

Table 4 ELISA virus testing of 4 major clones selected by Mount Kanlaon farmers from TPS, 28–30 years ago (+positive; − negative)

Clone	PVA	PVS	PVX	PVY	PotLV	PVM	PLRV
Choi white	–	+	–	+	–	–	–
Choi violet	–	+	–	–	–	–	–
Yoyo yellow	–	–	–	–	–	+	–
Lumapao white	–	+	–	+	–	–	–

the clones (CPF 34, CPF 35, and CPF 40) had PVS; two clones (CPF 34 and CPF 40) had PVY; and one clone (CPF39) had PVM. The four clones tested were negative for PVA, PVX, PotLV, and PLRV (Table 4). These results clearly show the value of having virus resistance in the parental lines. Only two were positive for PVY with ELISA yet showed no visual symptoms. We don't know which parents provided the resistances to the viruses. The parent, 7XY.1, is immune to PVX and PVY. Serrana has known resistance to PLRV; making it a possible parent (Tables 1, 2 and 3).

Conclusions

The use of TPS provided a wide genetic pool with resistance to viruses, Rs, heat tolerance and other favorable characteristics. With this, farmers had the opportunity to select appropriate varieties based on their preferences. Initially, the most preferred characteristics were marketability and taste. Farmers measure marketability based on demands in the market which is directly influenced by preferences of consumers. Later, farmers selected for other characteristics, including resistance to virus infection, *R. solanacearum,* to typhoons, drought and even low inputs. Through natural selection and farmer selection only the toughest clones survived.

Farmers' involvement in the evaluation and selection of promising clones from TPS is a good example of their willingness to help find solutions to common problems. This is somewhat similar to what occurred in North America during the period from 1850 to 1900 when farmers and botanists did a similar approach to developing new varieties, of which Russet Burbank is the most famous (Plaisted and Hoopes 1989).

Taking off from where they are now, there is a need for a multifaceted approach to improve potato production. As a response, Canlaon Potatoes & Flowers, an enterprising farm with a big heart has as its mandate to provide clean planting material of major crops including potatoes at a small profit. Screen house production of rooted cuttings of these four clones are now provided to farmers.

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