Economic Returns to Research on True Potato Seed in Vietnam

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Between 1993 and 1999, new hybrid progenies of true potato seed (TPS) were adopted by 100,000 small-scale farmers on 3500 ha in Vietnam, or about 10% of total potato (*Solanum tuberosum* L.) area. Most adoption occurred in the Red River Delta in northern Vietnam during the winter crop season. Hybrid TPS is estimated to have increased potato yield by an average of 6.8 t/ha, or 75%, compared with old varieties grown from clonal seed tubers. Aggregate economic benefits from TPS in Vietnam are estimated at about US$1 million per year. The net present value of the investment in TPS research and extension over 1990–2010 is estimated to be between $0.25 million and $2.92 million, yielding a rate of return to research of 29–42%. TPS is estimated to have increased net household income of adopters by $11.00/year, or 1.2%. New sources of improved clonal seed tubers, such as imported seed from China and new improved Vietnamese varieties, may limit further diffusion of TPS in Vietnam.

Improving seed quality has been a key strategy for increasing potato productivity worldwide. Most of these efforts have focused on clonal seed propagation. However, since the 1970s, CIP and other agricultural research institutes have also worked to develop the practical use of true potato seed (TPS) as an alternative seed technology for farmers. TPS is the tiny botanical seed found in the small, tomato-like fruits of the potato plant. The economic advantages perceived to lie in TPS are lower seed cost and higher yield. Using tubers for seed diverts about 10% of the global potato crop from food use to seed. After adding extra production, handling, storage, and other costs, clonal seed can account for 30–70% of purchased inputs and 15–40% of the value of the harvested crop in developing countries (Sadik, 1983). Moreover, viral, bacterial, and other plant pathogens can be transmitted through tubers to the next generation, subsequently reducing plant health and yield. Using TPS avoids both of these limitations, because no portion of the useable harvest needs to be diverted for seed and diseases are much less prevalent in the botanical seed compared with vegetatively propagated material (Sadik, 1983). These factors have generated considerable interest in TPS, especially for use by poor, limited-resource farmers in developing countries.

Many of the field applications of TPS so far, however, have not lived up to this promise. It has been difficult to achieve quality and efficiency in both the production and handling of TPS. Consequently, the cost of TPS to farmers is not insubstantial and the seed itself is sometimes of uncertain quality. Furthermore, few farmers have been able to obtain an economically viable crop from TPS itself.

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Rather, TPS is usually used to generate small seedling tubers (< 30 g/tuber) that are subsequently used as seed to produce a ware potato crop. However, this adds considerably to the cost of using TPS as a seed source. Other disadvantages of TPS include insufficient uniformity in tuber characteristics, a relatively long growing period, high labor requirements in production, and a need for irrigation. In a review of economic assessments of TPS in several developing countries, Chilver et al. (1999) found that TPS provided an economically viable alternative to clonal seed only in cases where the quality and productivity of clonal seed were exceptionally low.

Despite these limitations, TPS has enjoyed some successes. In the mid 1990s, about 100,000 potato farmers in Vietnam's Red River Delta (RRD) adopted hybrid TPS and have continued to use it for the past several years. About 95% of Vietnam's potato production occurs in the RRD during the cool winter months (November–February). Potatoes are grown here as a short duration crop (90–100 days) following two crops of rice in this irrigated delta plain. Between 1993 and 1999, area planted to TPS progenies in the Delta increased to 3500 ha, representing about 10% of Vietnam's total potato area. In this paper we examine the economics of TPS use in the RRD and provide a quantitative assessment of the social benefits and costs of TPS in Vietnam.

Materials and Methods

Potato production and cost data were collected from a survey of farmers in the Red River Delta during the 1999/2000 potato season. The sample consisted of 120 potato farmers in eight villages in four provinces of the RRD. The purpose was to conduct a general needs assessment of potato farmers in the RRD; specific questions on TPS and potato seed were included. Information was also collected on household characteristics and income.

Within this sample, there is a mix of potato seed being used including TPS seedlings, TPS seedling tubers, seed from China and Europe, and new Vietnamese clonal releases. Few farmers in the sample used the old local variety Ackersegen, which was dominant in the RRD until recently. The near absence of Ackersegen reflects its rapid replacement with better sources of seed and new varieties in the 1990s. Comparing seed productivity solely on the basis of the farm survey runs the risk that observed differences may be due to individual or locality effects. To avoid potentially confounding factors, on-farm, farmer-managed trials were conducted with 16 other farmers in four villages. In these trials, each farmer grew potatoes using five seed types on a 10 m^2 plot (2 m^2 per seed type, single replication). The trials were farmer-managed in that farmers chose the amounts of inputs to use for each seed type according to their normal practice. Yield was measured by the authors at harvest. The five seed types used in the trials were

- TPS seedlings (from hybrid TPS II/67 F_1),
- TPS seedling tubers (from F1C0 seed produced from hybrid TPS II/67 F_1 the previous year),
- clonal seed from China (mostly Mira),
- Ackersegen (old local clone), and
- a new Vietnamese clonal release (KT-3).

Results

Potato costs of production and profitability by seed source

Table 1 shows the yields and returns to potato production in a *normal* year for each type of seed, according to farmers interviewed in the survey. These average yields are somewhat higher than those obtained during the 1999/2000 season, but provide a better basis for assessing the economics of potato seed sources in Vietnam because the 1999/2000 season was a relatively poor year for potatoes (Fuglie et al., 2001). Highest average

Table 1. Potato production costs, yields, and economic returns by source of seed in the Red River Delta, Vietnam.

Seed source	TPS nurseries and seedling transplants[1]	TPS seedling tubers	Old local clonal variety (Ackersegen)	Imported clones from China (Mira mostly)	New local clonal variety (KT-3)
Input quantity (per ha)					
Labor (h/ha)	5243	4569	4094	4094	3814
Seed (kg/ha)	0.119	684	1162	1162	1396
TPS seedlings/ha	72716				
Manure (t/ha)	17.7	14.5	13.4	13.4	16.3
N (kg/ha)	120	133	136	136	179
P (kg/ha)	86	84	125	125	83
K (kg/ha)	77	72	82	82	42
Farm-supplied inputs (US$/ha)					
Land	50	50	50	50	50
Labor	749	653	585	585	545
Manure	61	43	33	33	39
Total farm-supplied inputs	860	745	667	667	633
Purchased inputs (US$/ha)					
Nursery plastic cover	8	0	0	0	0
Seed	102	328	256	256	308
Total chemical fertilizer	103	101	116	116	105
Total pesticide	11	14	1	1	16
Total purchased inputs	224	444	373	373	428
Output					
Average yield (t/ha)	11.25	15.79	8.99	12.50	19.90
A:B:C:D (%)[2]	6:30:50:15	36:30:27:7	45:39:16:0	47:27:20:6	39:39:20:2
Average price of yield (US$/t)	95	85	95	95	104
Economic returns (US$/ha)					
Gross value of yield	1070	1336	857	1191	2077
Net income[3]	846	893	484	818	1649
Economic profit[4]	(13)	147	(184)	151	1016

Source: Farm surveys in Red River Delta during 1999/00 winter season.

TPS = True potato seed.

[1] An average of 0.119 kg of TPS sown in 215 m^2 nursery beds is required to produce 72,716 one-month-old TPS seedlings. The seedlings are then transplanted to 1 ha.

[2] Percent size distribution of yield. A = large (> 100 g/tuber), B = medium (50-100 g/tuber), C = small (20-50 g/tuber), D = very small (< 20 g/tuber).

[3] Net income is defined as the gross value of production minus the cost of purchased inputs.

[4] Economic profit is defined as the gross value of production minus the cost of all purchased and farm-supplied inputs (land, labor, and manure).

yield was obtained from new Vietnamese clonal variety KT-3. TPS seedling tubers, TPS transplants, and Chinese seed all gave significantly higher yield than Ackersegen, which produced an average of only 9 t/ha.

Prices received by farmers for their potato crop were somewhat lower for TPS seedling tubers than clonal seed because of the lower quality yield from TPS (i.e., higher proportion of low-valued small tubers in total yield). Note that yield from TPS seedling transplants is primarily used as a seed crop for the following season. Thus, it is relatively high valued despite its large proportion of small tubers. Taking into account yield and market price, the gross value of production was highest for KT-3 (US$2,077/ha (US$1.00 = 14,000 Vietnamese Dong)). Gross value of production for

TPS seedling tubers was significantly lower at US$1,336/ha but compared favorably to Chinese varieties (US$1,191/ha) and was 56% higher than the Ackersegen (US$857/ha).

Production costs for potatoes grown from TPS seedling transplants were substantially below production costs from potatoes grown from tubers due mainly to the lower cost of seed. However, yield from TPS transplants is mainly kept as seed for the following year. The TPS seedling tubers are then used to produce a ware crop. The cost of using TPS seedling tubers was actually higher than the cost of clonal seed. Other input costs were similar except that using TPS transplants required significantly more labor than using tubers as seed. Thus, TPS actually offered no savings in production costs.

Net income from potato production is defined as the gross value of production minus the cost of purchased inputs including seed, chemical fertilizer, and pesticides. Net income is therefore the return to farm-supplied inputs such as land, labor bullock services for land preparation, irrigation water, and manure. We define economic profit from potato production as the gross value of production minus the cost of all inputs, whether purchased or farm-supplied. Net income provides a measure of the contribution of potato production to household livelihood, whereas economic profit provides a measure of the relative profitability of potato production compared with alternative economic activities. Even if net income is large, economic profit may be small or negative for a particular kind of potato seed. In this case, we may expect the use of this type of seed to decline over time as farmers switch to more profitable alternatives. If economic profit is large, then we may expect the activity to increase over time as farmers respond to this more lucrative economic opportunity.

Net income and economic profit were highest for KT-3 and lowest for Ackersegen. The net income and economic profit of TPS seedling tubers are comparable to those of Chinese seed and substantially higher than those of Ackersegen. Producing TPS seedlings generates respectable net income and about breaks even for economic profit. This is not surprising because TPS seedlings are primarily a seed crop, but production from seedling tubers yields a market crop. Given the economic options currently available to RRD farmers, the old local clone Ackersegen is not economically viable. Although it still registers positive net income in a normal year, farmers can get a better return by allocating farm-supplied resources to other types of potato seed or to other economic enterprises. The most profitable potato seed choice is the new Vietnamese variety KT-3, which has been multiplied in farmers' fields since 1996 and was officially released as a variety in 2000. Due to its inherently slow multiplication rate, it is still not widely available to potato growers in the RRD. The high economic profits earned from this variety suggest that adoption of KT-3 will spread rapidly as it becomes more available.

The results of the farm survey and on-farm trials comparing productivity of alternative sources of potato seed show that when TPS first became available to farmers in the RRD, it gave a substantial increase to farm income over Ackersegen, the predominant variety at that time. These findings suggest that in the next few years area planted to Ackersegen will continue to fall, area planted to TPS and Chinese seed may remain steady, and area planted to new Vietnamese clones will increase. Aggregate potato area in the RRD may also gradually increase.

Economic rate of return to TPS research and extension

The increased yield achieved by TPS over old clonal varieties (namely, Ackersegen) and the large area planted to TPS generated significant economic benefits for farm families and the rural economy in the

RRD. The evidence from the farm survey reported above indicated that hybrid TPS seedling tubers outyielded Ackersegen by an average of 6.8 t/ha and increased economic profit by US$331/ha in a normal year. Aggregating over 3500 ha, economic benefits from TPS total US$1.16 million/ year. Potato production increased by 6%, about 22,100 t/yr.

To compare aggregate economic benefits to costs, we constructed estimates of public investments in hybrid TPS research and extension in Vietnam since this activity began in 1990. These included investments in personnel, materials, land, and buildings by the Vietnamese Government; research expenditures by CIP; and funds provided between 1993 and 2000 by the Asian Development Bank (ADB) for a special project to promote hybrid TPS. Investment costs are expected to fall after 2000 following the end of ADB support for TPS research and extension in Vietnam. In addition, we forecast benefit and cost streams to 2010 under three alternative scenarios:

1. There are no more net benefits from TPS after 2000 (due, for instance, to the widespread availability of clonal seed from China with similar productivity).
2. Benefits from TPS gradually decline to 0 between 2001 and 2010.
3. Benefits from TPS remain constant at US$1.075 million/yr through 2010.

In each scenario, we assume that between 2001 and 2010 research is reduced but extension efforts continue.

Table 2 shows the estimated aggregate benefit and cost streams together with estimates of benefit-cost analysis of the investment in TPS research and extension. Assuming that there are no additional benefits from TPS after 2000 (scenario 1), the present value of the net economic benefits to Vietnam are US$426,000 (10% discount rate) or US$250,000 (15% discount rate). This implies about US$1.30-1.40 in benefits for every US$1 invested in research and extension. The other scenarios result in higher estimates of net present value because there continue to be benefits from TPS between 2001–2010. Under scenario 3, where TPS benefits are assumed to continue at a constant level between 2001 and 2010, the net present value at the 10% discount rate is US$2.97 million. The rate of return to research and extension is 28.6% under scenario 1 and around 40% under scenarios 2 and 3.

Impact of TPS on family livelihoods

Farm families who adopted TPS retained most of the economic benefits of TPS diffusion in Vietnam. Although a 6% increase in local production may be expected to put downward pressure on prices (thereby transferring some benefits to potato consumers), this was cushioned by the increasing importance of potato trade with China (Fuglie et al., 2001). Further, a significant share of employment and income benefits appears to have been retained by female household members. During the winter season, there is substantial migration by male adults from rural areas seeking seasonal off-farm employment. Thus, women predominate in the production of winter crops in the RRD. An indicator of the role of women in TPS is the importance of village women's groups in providing training and in promoting and extending TPS technology, which was observed by the authors during field research.

Given the small average size of potato plots (360 m^2) and the large number of farm families who adopted TPS (about 100,000), benefits per household are estimated to be US$11.00/household per yr, or US$2.20/person per year). Among our farm sample, this amounts to an increase of 1.9% in agricultural income (including the value of commodities consumed at home) and a 1.2% increase in total income (including income from non-farm activities). Since much of this income is earned and controlled by female household members, a relatively large

Table 2. Benefit-cost analysis of true potato seed (TPS) research and extension in Vietnam (constant US$'000).

Year (season)	Aggregate net benefits to farmers[1]			Investment in research and extension	Net economic benefits to Vietnam[1]		
	Scen. 1	Scen. 2	Scen. 3		Scen. 1	Scen. 2	Scen. 3
1990/91	0	0	0	78	(78)	(78)	(78)
1991/92	0	0	0	78	(78)	(78)	(78)
1992/93	0	0	0	92	(92)	(92)	(92)
1993/94	0	0	0	105	(105)	(105)	(105)
1994/95	5	5	5	132	(126)	(126)	(126)
1995/96	28	28	28	185	(157)	(157)	(157)
1996/97	198	198	198	185	13	13	13
1997/98	1237	1237	1237	185	1052	1052	1052
1998/99	976	976	976	185	790	790	790
1999/00	1075	1075	1075	185	889	889	889
2000/01	0	967	1075	185	(185)	782	889
2001/02	0	860	1075	147	(147)	713	928
2002/03	0	752	1075	147	(147)	606	928
2003/04	0	645	1075	134	(134)	510	940
2004/05	0	537	1075	134	(134)	403	940
2005/06	0	430	1075	93	(93)	337	982
2006/07	0	322	1075	93	(93)	230	982
2007/08	0	215	1075	93	(93)	122	982
2008/09	0	107	1075	93	(93)	15	982
2009/10	0	0	1075	93	(93)	(93)	982
2010/11	0	0	0	78	(78)	(78)	(78)
Present value							
10% discount rate	1526	2869	4073	1100	426	1769	2972
15% discount rate	1037	1786	2370	787	250	999	1584
Benefit-cost ratio (10% discount rate)					1.39	2.61	3.70
Benefit-cost ratio (15% discount rate)					1.32	2.27	3.01
Internal rate of return, 1990-2010					28.6%	38.9%	41.6%

[1] Scenario 1: no TPS benefits after 2000; Scenario 2: TPS benefits decline to 0 between 2001 and 2010; Scenario 3: TPS benefits constant between 2001 and 2010.

share of this income was probably devoted to childcare and other household activities under the primary responsibility of women.

Summary and Conclusions

Hybrid TPS has played an important role in meeting farmers' needs for improved potato seed in Vietnam. Its popularity is driven by the higher average yield it offers compared with old, degenerated clonal varieties.

Further, the diffusion of TPS in Vietnam has been aided by a strong research and extension system and village cooperatives that organize TPS distribution, contract TPS seedling production, and store a portion of TPS seedling tubers for use as seed in subsequent seasons. Nevertheless, in the new land tenure system now prevalent throughout Vietnam, the decision to adopt TPS is made by individual farmers. TPS progenies will continue to be used in Vietnam so long as they offer

economic returns at least equal to if not higher than returns from alternative economic activities.

In the mid- to late-1990s, Vietnamese potato farmers began to benefit from wider access to new sources of clonal potato seed in addition to the new hybrid TPS progenies. Potato imported from China and diverted for seed use has become a low-cost seed source, although Chinese seed quality varies. Seed imported from Europe yields well, but is relatively expensive and degenerates quickly under tropical conditions. New high-yielding, disease-resistant clonal varieties developed by Vietnamese breeders from CIP breeding material show considerable promise. It appears likely that area planted with this diverse set of improved potato varieties and seed sources will increase in the next several years and continue to replace the old clonal variety, Ackersegen. Hybrid TPS will likely continue to have a role to play in Vietnam for the next decade, although area planted with TPS may not expand much further. TPS suffers from disadvantages such as higher labor requirements and a longer growing season. Unless further improvements are made in TPS technology to overcome these constraints, improvements in clonal varieties and seed systems are likely to eventually replace TPS in Vietnam.

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