

The Economic Impact of True Potato Seed in Vietnam

Keith O. Fuglie¹, Do Thi Bich Nga², Dao Huy Chien³ and Nguyen Thi Hoa⁴

Abstract

Between 1993 and 1999, new hybrid progenies of true potato seed (TPS) were adopted by small-scale farmers on 3,500 hectares in Vietnam, or about 10% of the total potato 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 clonal varieties. Aggregate farm benefits from TPS in Vietnam are estimated to be US \$1.075 million per year. The net present value of the investment in TPS research and extension in 1990-2010 is estimated to be between \$250,000 and \$2.972 million, yielding a rate of return to research of 29-42%. The most important beneficiaries have been the nearly 100,000 rural households that adopted TPS. TPS is estimated to have increased net household income by US \$11.06/year, or by 1.2%, among adopters. New sources of improved clonal seed, such as imported potato seed from China and new improved Vietnamese varieties, may limit further diffusion of TPS in Vietnam.

Introduction

Improving seed quality has been a key strategy for increasing potato productivity worldwide. Most efforts to improve potato seed quality have focused on clonal seed propagation. However, since the 1970s, the International Potato Center (CIP) and other agricultural research institutes have also worked to develop the practical utilization 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 perceived economic advantages of 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, in each generation that the potato plant is exposed to viral, bacterial and other plant pathogens, these diseases can be transmitted through the tubers to the next generation, subsequently reducing plant health and yield. Using TPS avoids both of these limitations, since no portion of the useable harvest needs to be diverted for seed and diseases are much less prevalent in the botanical seed compared with vegetative propagation 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 proven difficult to achieve quality and efficiency in the production and handling of TPS. As a result, the cost to farmers of TPS is not insubstantial and is sometimes of

¹ Agricultural economist, International Potato Center, Bogor, Indonesia

² Plant breeder/agronomist, Root Crop Research Center, Vietnam Agricultural Science Institute, Hanoi

³ Director, Root Crop Research Center, Vietnam Agricultural Science Institute, Hanoi

⁴ Researcher, Root Crop Research Center, Vietnam Agricultural Science Institute, Hanoi

uncertain quality. Furthermore, few farmers have been able to obtain an economically viable crop from TPS itself. Rather, TPS is usually used to generate small seedling tubers (<30 g/tuber) which 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 that have emerged from the use of TPS include insufficient uniformity in tuber characteristics, a relatively long growing period and high labor requirements in production. 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 adopted TPS and have continued to use it for the past several years. Between 1993 and 1999, area planted to TPS progenies increased to 3,500 hectares, representing about 10% of Vietnam's total potato area. The purpose of this study is to examine the economics of TPS utilization in the Red River Delta and to provide a quantitative assessment of the social benefits and costs of TPS in Vietnam. In the next section of the paper, we briefly discuss the role of potato in Vietnam's agricultural economy and the history of TPS development in Vietnam. We then present the results from farm surveys and on-farm trials conducted during the 1999-2000 potato season, in which we evaluated the benefits and costs of producing potatoes from TPS progenies and various clonal varieties. The third section of the paper presents estimates of the aggregate benefits of TPS and the economic rate of return to the investment in TPS research and extension in Vietnam. The final section presents a summary of and conclusions from this study.

The Potato in Vietnam's Agricultural Economy

Potatoes were introduced to Vietnam in the late 19th Century but did not expand to more than a few thousand hectares until the 1970s. Currently, about 95% of potato production in Vietnam occurs in the Red River Delta (RRD) during the dry winter season between November and February. In this low lying plain (0-30 m asl) with about 580,000 hectares of cropland, two crops of irrigated rice are grown each year: a spring crop between March and June and an autumn crop between July and October. In the 1970s, the adoption of high-yielding, short-duration rice varieties, especially for the autumn crop, left 80 to 90 days in which a short-duration winter crop could be grown. When a combination of poor rice harvests, war and international isolation in the late 1970s led to a worsening food situation, Vietnam made a major effort to increase winter potato production in the agricultural collectives of the RRD. Between 1975 and 1979, potato area expanded from 18,000 hectares to 105,000 hectares, but the lack of good quality seed caused average yield to fall below 7 t/ha, of which 30 to 40% had to be kept for seed for the next year's crop. Potato area subsequently fell to around 30,000 hectares by the early 1980s. After that, it gradually increased to over 37,000 hectares by the late 1990s. Farmers used predominantly old European cultivars that had been introduced during the early part of the 20th Century, especially the German variety Ackersegen, known locally as 'Thuongtin'. Ackersegen is an early bulking variety with long seed dormancy and is therefore suited to the RRD. Farmers could produce a crop in 80 to 90 days and store

seed in rustic conditions for nine months until the following planting (although storage losses were around 40% of initial weight). However, susceptibility to viruses, bacterial wilt and late blight diseases resulted in low yields of only 8 to 10 t/ha. To solve the seed problem, Vietnamese potato researchers began to experiment with new seed technologies in the late 1970s. In the Dalat Highlands in southern Vietnam, which has about 400 hectares of potatoes, farmers adopted tissue culture and rapid multiplication techniques to produce disease-free plantlets and substantially increased yield (Uyen and Vander Zaag, 1983). In the Red River Delta, open-pollinated (OP) progenies of TPS were introduced to farmers in the mid 1980s and adoption reached 700 hectares by 1987 (Table 10.1). However, poor tuber quality and low yield caused farmers to abandon OP TPS progenies in subsequent years. In 1990, researchers began testing CIP and Indian progenies of hybrid TPS. Hybrid TPS progenies were identified that gave reasonably good yield, uniform quality, were relatively early bulking and had some resistance to late blight. The first hybrid TPS progenies were extended to farmers in the 1993/1994 season. By the 1997/1998 winter season, 560 hectares had been transplanted with hybrid TPS seedlings raised in nursery beds and 3,740 hectares had been planted with seedling tubers harvested from a previous year. Poor weather conditions caused by El Niño reduced TPS area to 3,200 hectares in 1998-1999. Area planted to TPS recovered somewhat to 3,500 hectares in 1999-2000. TPS production is especially important in Thai Binh Province, where TPS has spread to more than one-third of the province's total potato area. Thai Binh accounted for two-thirds of all TPS area in Vietnam in 1999-2000. The most popular hybrid TPS progenies in Vietnam are HPS II/67 and 7/67, which were officially released in Vietnam in 1998 as 'Hong Ha 2' and 'Hong Ha 7' respectively. The dissemination of TPS in Vietnam received strong support from the agricultural research and extension system and village cooperatives. Figure 10.1 shows the main TPS distribution and production system in the RRD. TPS is either imported or produced locally by Vietnamese agricultural research institutions and provided to provincial agricultural extension centers. The agricultural extension centers provide TPS to village agricultural cooperatives. The cooperatives contract with farmers to produce TPS seedlings in nursery beds during October-November. The cooperatives then distribute the 30-day old seedlings to other farmers in the cooperative who transplant the seedlings to produce a crop. Between 5 and 25% of the harvested tubers are sufficiently large to be sold as ware potatoes, but most are kept by farmers or the extension service for use as seed for next year's crop. The following year, the seedling tubers are sown to produce a ware crop, with 10 to 25% (small tubers) retained as seed for one additional generation. Few seedling tubers are kept for more than two generations. Notwithstanding the important role of government agencies and village cooperatives in TPS diffusion, the decision to adopt TPS rests with the farm household. In 1981, Vietnam began to break up its agricultural collectives and to give individual rural households more control over production decisions. The State initially contracted with individual farmers to grow specified crops at pre-established prices (Pingali and Xuan, 1992). In 1988, further reforms were introduced that provided rural households with long-term, inheritable leases to land and privatized output markets so that prices reflected market supply and demand. This market orientation prevailed at the time when hybrid TPS was introduced to farmers in 1993.

Policy reforms in Vietnam's economy have wider implications for rural farmers. Trade and investment liberalization in other sectors of the economy led to increased economy-wide growth, which increased demand

for farm products and created more opportunities for non-farm employment for rural residents. Rural households began to supplement their agricultural incomes by taking seasonal off-farm employment, engaging in petty trade and working in rural non-farm enterprises. However, the pressure to intensify agricultural production remains strong. The average farm size in the RRD is only 0.25 ha/household (about 0.05 ha/capita) and permanent rural-to-urban migration is restricted by government policy. Although family planning substantially reduced the rate of population growth in the 1980s and 1990s, population momentum from past population growth is likely to lead to a further deterioration in land availability per capita in the early decades of the 21st Century. One consequence of the more liberal economic environment is that Vietnamese farmers are benefiting from new sources of potato seed. In the 1990s, potato imports from China increased substantially. Potatoes from China are principally imported as ware potatoes but a significant share is diverted for use as seed. Tung (2000) estimated the amount of potato seed imported from China in 1999 to be about 10,000 tonnes, although this may be an underestimation since much of this trade goes unreported. In addition, some certified seed from Europe is imported. European seed is usually multiplied one generation (January to March) before being used as seed for ware potato production in the winter season. The rapid build-up of plant diseases and short seed dormancy of European varieties prevents farmers from using it as seed for subsequent generations. Finally, new clonal varieties selected from CIP material have recently been released in Vietnam, such as KT-3 and P-3. These varieties are well adapted to local conditions: they bulk early, have good seed storage characteristics and continue to yield well after several generations of use. KT-3, in particular, appears to have some resistance to viruses, which allows farmers to use it for several generations without experiencing yield reductions. The new clonal varieties from China, Europe and Vietnam breeders, together with TPS, have begun to replace Ackersegen as the dominant potato variety in the Red River Delta. Another factor that will influence the availability of potato varieties in the RRD is the growth of cold storage capacity for potato seed. Chien et al. report in this volume that cold storage capacity for potato seed increased from 20 tonnes in 1994 to 605 tonnes in 2000 and that this growth will likely continue in coming years. With cold storage, it is possible to use varieties with shorter dormancy (as sprouting can be controlled either by temperature or chemically) and provide seed in better physiological condition. This should expand the range of potato varieties available for Vietnamese potato growers.

Farm Profitability of True Potato Seed

In this section, we report the results from field research conducted in the RRD during 1999-2000 to compare the productivity of alternative sources of potato seed. Farmer surveys and on-farm trials were used to assess the productivity and profitability of TPS seedlings, TPS seedling tubers, the predominant local cultivar (Ackersegen), potato seed imported from China, potato seed imported from Holland and new clonal varieties recently developed by Vietnamese agricultural research institutions (KT-3 and P-3).

Farm survey data collection

Potato production and cost data were collected from farmers using two survey instruments. In the first survey, 24 farmers from four villages in four provinces of the RRD were interviewed about household characteristics, income, farming operations and potato production. The four villages selected for this survey corresponded to the sites selected for on-farm trials (described below) and are areas where TPS adoption has occurred. The sample included the four farmers who collaborated in the on-farm trials plus two others in each site who used clonal seed instead of TPS.

The second survey instrument is a representative sample of 120 potato farmers in eight villages in four provinces of the RRD. The purpose of this survey was to conduct a general needs assessment of potato farmers in the RRD, but specific questions on TPS and potato seed were included. In this survey, 80 farmers kept detailed farm management records of their potato production during the 1999-2000 season. This survey also collected data on household characteristics and income.

Together, these surveys provide data on potato crop budgets for 1999-2000 from a representative sample of 144 farmers in the RRD. Within this sample, there is a mix of different types of potato seed being used, including TPS seedlings, TPS seedling tubers, seed from China and Europe and new Vietnamese clonal releases. Interestingly, few farmers in the sample used the old local variety Ackersegen, which was the dominant variety in the RRD until recently. The near absence of Ackersegen from the farm sample reflects its rapid replacement with better sources of seed and new varieties in the 1990s. While a good mix of seed sources is represented in the farm survey, a single farmer is unlikely to use more than one or two types of seed. In fact, there is a tendency for one seed type to dominate in a particular village. Thus, 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 farmers in four villages. In the trials, each farmer grew potatoes using five different seed types on a 10 m² plot (2 m² per seed type, single replication). The trials were farmer-managed in that farmers themselves 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 HPS II/67 F1 true potato seed);
- TPS seedling tubers (from C0 seed produced from HPS II/67 F1 true potato seed the previous year);
- Diamant (imported from Holland and replicated once the previous spring);
- Ackersegen (old local clone);
- New Vietnamese clonal releases (KT3) or clonal seed from China (variety nondescript), depending on which was more predominant in the particular trial site.

Some general findings from the survey

Farm size and the size of potato plots are fairly uniform across households in the RRD. This is due to the legacy of radical land reform that collectivized farming in the 1950s and then established equitable long-term land leases with rural households in the 1980s. In the farm sample, average cropland per household is 0.22 ha (0.05 ha/capita) and average cropping intensity is 2.37. These averages are very close to those reported by

government statistical sources for the RRD as a whole (Department of Agriculture, Forestry and Fisheries, 1999). Nearly all land is sown to two crops of rice each year and about 37% to a third winter crop, of which potato is the most important. Constraints on expanding winter crop area include poor drainage in low lying fields of the Delta and lack of good quality potato seed. The average size of a household potato plot was 0.036 ha (360 m², or 1 sao). The largest potato plot recording in the survey was 0.234 ha (6.5 sao). Since about 37,000 ha of potatoes are currently grown in the RRD, this implies that about 1 million out of a total of 2.65 million agricultural households in Vietnam's Red River Delta are engaged in potato production.

Potatoes are a very labor intensive crop in the RRD. Farm management records show that about 4,500 hours of work are devoted to one hectare of potatoes, or about six persons/ha/day for the entire three-month winter cropping season. This implies that potato production in the RRD provided full-time employment for more than 220,000 farm workers during the winter season. Nearly all labor was family labor. The seasonal off-farm migration of adult male members of rural households means that winter cropping is often the responsibility of female members of the household, who also often retain control of the earnings from the crop.

At harvest, potatoes are sorted by size. The largest (greater than 100 g/tuber) are usually sold to traders, while medium and small tubers are used for home consumption or stored for seed. Very small and damaged tubers are feed for farm animals. According to the farm survey, about 25% of the potato crop was sold, 29% kept for home consumption, 32% fed to animals and 14% kept for seed. A large share of the harvest from TPS seedlings was kept as seed (90%), while a relatively large portion of the harvest from TPS seedling tubers was used for home consumption or fed to livestock due to its relatively small tuber size.

In the farm survey, we asked farmers to estimate their net income for the previous year from agricultural and non-agricultural sources. For agricultural income, we derived net income as the total value of marketable yield (whether sold or kept for own use) minus the cost of purchased inputs. Average annual net income among the sample was US \$186/capita, of which 70% was derived from agriculture and 30% from non-farm activities. Potatoes contributed 16.3% of agricultural net income and 7.4% of total net income for these farm households.

Potato costs of production and profitability by source of seed

The farm survey results regarding yields, gross values of production, input costs and income per hectare for each type of potato seed are shown in Table 10.2. The highest average yields during the 1999-2000 season reported by farmers in the survey were obtained from new Vietnamese clonal varieties KT-3 and P-3 (15.5 t/ha) and imported European seed (15.1 t/ha). Seed from China yielded 14 t/ha and TPS seedling tubers produced 13.8 t/ha. However, none of these average yields are statistically different from one another. The yield from TPS seedlings was significantly lower at 9.4 t/ha. The harvest from TPS seedlings is primarily used for seed for the next season.

The gross value of production depends not only on yield but tuber quality. Prices received by farmers for their potato crop varied according to tuber size and use. For ware potatoes, large tubers (>100 g/tuber) received the highest market price (2000 VND/kg),

with mid-size tubers (50-100 g/tuber) prices at about 20% lower. Small tubers (<50 g/tuber) were generally not sold but were either used for seed or fed to livestock. TPS seedling tubers (the harvest from TPS seedlings), although generally small in size, were priced relatively high because of their value as seed for next year's crop. The harvest from TPS seedling tubers was sold mostly as ware potatoes but received a lower average price than clonal varieties because of a smaller proportion of large tubers. Taking into account yield and market prices, the gross value of production was highest for new Vietnamese clonal varieties and European varieties (about 23 million VND/ha) and was significantly higher than that from Chinese varieties (18.6 million VND/ha) and from TPS seedling tubers (16.3 million VND/ha).

The use of TPS sown into nurseries and then transplanted into potato fields fulfilled the promise of TPS to reduce potato seed costs substantially. To plant one hectare with TPS seedlings required 215 m² of nursery beds sown with 119 grams of TPS. At US \$800/kg for TPS, this amounts to only 1.4 million VND/ha for seed, compared with 3.6 million VND/ha to 7.9 million VND/ha for clonal seed. The use of TPS seedlings, however, involved significantly higher labor use (5,243 hours/ha compared with 3,814 to 4,374 hours/ha for clonal seed). TPS seedlings require more labor particularly for nursery bed cultivation, transplanting and irrigation. TPS seedlings received higher doses of manure, similar quantities of chemical fertilizer and somewhat lower quantities of pesticide than other seed types. Fungicide use was about one-third lower than most other seed types⁵, which may be due to higher resistance to late blight in the TPS varieties.

Costs for all purchased inputs (seed, chemical fertilizers and pesticides) were highest for farmers using imported European seed and lowest for TPS seedlings, mainly due to differences in the cost of seed. Seed costs using TPS seedling tubers were significantly lower than seed costs using imported seed, but comparable to seed costs using Chinese seed and new Vietnamese clonal varieties. For all types of seed, farmers planted 50,000 to 70,000 tubers or seedlings per hectare. However, only about 700 kg/ha of TPS seedling tubers were required for seed due to the relatively small size of the seedling tubers, compared to about 1,400 kg/ha for clonal varieties but the price of TPS seedling tuber seed was also relatively high so that seed costs per hectare were about the same as Chinese seed and new Vietnamese clones. Labor and manure use and expenditures for chemical fertilizer and pesticides were not significantly different across the four seed types, with the exception of low pesticide inputs reported for Chinese seed (see footnote 6).

'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 supplied by the farm. To estimate economic profit requires that an opportunity cost be assessed for inputs supplied by the farm. However, these opportunity costs can vary widely from one farm household to another or from one village to another.

⁵ Pesticide expenditures on imported European clones, new local clones and TPS seedling tubers amounted to between 200,000 VND/ha and 233,000 VND/ha, compared with 154,000 VND/ha for TPS seedlings. The exception is users of Chinese seed who reported little or no pesticide use. The apparent low use of pesticides on plots planted with Chinese seed may not be representative of farmers in the RRD, however. Most of these observations came from one village in the survey where average plot size was exceptionally small (only 136 m² per plot).

For example, we found that, in some villages near Hanoi, the opportunity cost of land, family labor and farmyard manure tended to be relatively high due to the increased availability of non-farm work and more intensive vegetable production to meet urban demand. Prices paid for purchased inputs, on the other hand, are fairly constant across households since these inputs are more easily traded over a wide geographic area. For our present purpose, we use a constant 'representative' set of opportunity costs to value the cost of farm-supplied inputs and market prices for purchased inputs.

Net income provides a measure of the contribution of potato production to household livelihood, while 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 this activity to increase over time as farmers respond to this more lucrative economic opportunity.

Net income and economic profit were highest for the new Vietnamese clonal varieties and lowest for TPS. In fact, the economic profits of TPS seedlings and TPS seedling tubers are negative, although net incomes from TPS are positive. The net income and economic profits for potatoes grown from imported European or Chinese seed fall between those for new Vietnamese clonal varieties and TPS and are both positive. These findings imply that potatoes are a profitable crop for farmers in the RRD and that area planted to potatoes is likely to expand over time. Much of that growth is likely to occur with new Vietnamese varieties since they show the largest profit.

Nevertheless, there are some factors that could change these conclusions. First, the profitability of imported European seed may be overestimated in Table 10.2. We have used prices paid by farmers to estimate the cost of imported seed but, in some cases, this is subsidized by government or private schemes to promote potatoes or assist farmers. If the full cost of using seed from Europe were counted, its apparent profitability would decline. Second, if the quality of seed imported from China could be assured, its value and profitability would likely be enhanced. Farmers reported to us that Chinese seed was highly variable in quality; some gave good yield but others were heavily infected with diseases and gave low yield. Establishing a quality certification scheme for seed from China could significantly improve its value to Vietnamese farmers. Third and most important for TPS, the 1999-2000 winter season was not a 'typical' year because untimely rains in October-November delayed planting. A short growing season is especially detrimental for TPS because its growing requirements are somewhat longer than clonal varieties.

In our interviews with the 24 farmers from the villages where we conducted on-farm trials, we asked farmers to estimate the average yield in a normal year according to seed source based on their past experiences. The yield estimates reported in Table 10.3 confirm that 1999-2000 was particularly unfavorable for TPS. Yield reported by farmers and recorded in the on-farm trials in 1999-2000 were similar across seed types. Further, yield from clonal varieties in 1999-2000 was not substantially different from 'normal' yields reported by farmers. However, yields from TPS seedlings

and TPS seedling tubers were significantly lower compared with 'normal' yield. Yield from TPS seedlings was about 2 t/ha below normal yield and yield from TPS seedling tubers was between 2 t/ha to 3.5 t/ha below normal yield.

If we use the yield estimates from a normal year instead of the yields reported for the 1999-2000 season, the economics of TPS improves. The net income and economic profit of TPS seedling tubers are comparable to those of Chinese seed and substantially higher than those of the old local clone Ackersegen (Table 10.4). Producing TPS seedlings generates respectable net income and about breaks even for economic profit. This should not be surprising since TPS seedlings are primarily a seedcrop, while production from seedling tubers yields a market crop. Given the economic options currently available to farmers in the Red River Delta, 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. KT-3 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 Red River Delta. The high economic profits earned from this variety suggest that adoption of KT-3 will spread rapidly as it becomes more available to farmers.

The results of the farm surveys and on-farm trials comparing productivity of alternative sources of potato seed show that when TPS first became available to farmers in the Red River Delta, it gave a substantial increase to farm income over the predominant variety at that time (Ackersegen). In a normal year, TPS seedling tubers increased yield by 6.8 t/ha, net farm income by 5.7 million VND/ha and economic profit by 4.6 million VND/ha. Even in an unfavorable year like 1999-2000, TPS performed better than the old local clone. More recently, imported potato seed from China and Europe and new local clonal varieties have become available, further increasing the options available to farmers. In a normal year, TPS appears to compete well with Chinese seed, although Chinese seed outperformed TPS in 1999-2000 when untimely rains delayed planting. However, the uncertain quality of Chinese seed does not mean it is a less risky choice for farmers compared with TPS. By far the best performer, however, is the new local clone KT-3, which gave yields of nearly 20 t/ha in less than 90 DAP. 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 Red River Delta may also gradually increase.

Economics of TPS in Vietnam compared with other countries

The costs and benefits of TPS for farmers in Vietnam differ in some important aspects from other countries where TPS has been tried or is being used. In this section, we compare yields, costs of production and economic returns from TPS in Vietnam with those from TPS in Indonesia and several locations in India, drawing upon the results reported in Chilver et al. (1999).

One important difference is that Vietnamese farmers have been able to reduce their TPS seeding rates below seeding rates used elsewhere (Table 10.5). Farmers in the RRD require only about 120 grams of TPS to produce enough TPS seedlings to plant one hectare, compared with 200 to 340 grams required in India. When Vietnamese farmers first adopted TPS in 1993/1994, TPS requirements were similarly high but TPS use per hectare was steadily reduced as Vietnamese farmers improved their management of nursery beds and transplanting. It appears they have achieved higher rates of seedling survival compared with farmers elsewhere and have thus been able to lower their production costs from TPS substantially (Chien et al., 2000). The quantity of seedling tubers used in Vietnam is also significantly lower than in Indonesia and India (Table 10.6). Other input use (fertilizers and pesticides) is also lower in Vietnam, although labor use is probably higher.

Another important difference is that normal crop yield from TPS seedlings in Vietnam is substantially lower than that reported in India (Table 10.5). Yield from TPS seedling tubers is also below that reported in three out of four locations in India but higher than yield achieved in Indonesia (Table 10.6).

One reason for the relatively low yields in Vietnam is the short winter growing season. Farmers in the RRD only have 75 to 85 days between sowing TPS seedlings or seedling tubers and harvesting the crop. In locations where more time is available to grow a crop from TPS, farmers are able to use inputs more intensively and achieve significantly higher yield.

Chilver et al. (1999) hypothesized that TPS would be an economically viable alternative to clonal seed in situations where TPS could achieve at least a comparable yield and where clonal seed costs exceeded 22% of the gross value of production. In Vietnam, seed costs using the old clonal variety, Ackersegen, amounted to 24-29% of gross production value. Moreover, TPS outyielded Ackersegen by around 75%. This explains why farmers were eager to replace Ackersegen with TPS. With new Vietnamese clonal varieties and seed from China, TPS no longer enjoys a yield advantage and clonal seed costs have fallen to below 20% of the gross value of production. This suggests that TPS will have more difficulty competing with these alternatives. This may explain why TPS area did not expand after 1996, when new sources of potato seed became more widely available.

Aggregate Social Benefits and Costs of TPS in Vietnam

Economic rate of return to TPS research and extension

The improved yield achieved by TPS over the old clonal variety Ackersegen and the large area planted to TPS generated significant economic benefits for farm families and the rural economy in Vietnam's Red River Delta. The evidence from the farm survey reported above indicated that hybrid TPS seedling tuber outyielded the dominant variety

it replaced (Ackersegen) by an average of 6.8 t/ha and increased economic profit by 4.6 million VND/ha in a normal year. Aggregating over 3,500 hectares, economic benefits from TPS total 15,000 million VND/year, or US \$1.075 million/year.⁶ Potato production increased by about 22,100 mt/year, or by 6%.

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 funding provided during 1993-2000 by the Asian Development Bank (ADB) project for promoting 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 project benefit and cost streams forward to 2010 assuming three alternative scenarios: 1) there are no more net benefits from TPS after 2000 (due, say, to the widespread availability of clonal seed from China with similar productivity); 2) benefits from TPS gradually decline to 0 between 2001 and 2010; and 3) benefits from TPS remain constant at US\$1.075 million/year through 2010. In each scenario, we assume that, between 2001 and 2010, research is reduced but extension efforts continue. This implies that the present value of research and extension is US \$1,100,000 (10% discount rate) or US \$787,000 (15% discount rate).

Table 10.7 shows the estimated aggregate benefit and cost streams together with preliminary 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 million (15% discount rate). This implies about US\$ 1.3 to 1.4 of benefits per US \$ 1 in investment 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 these scenarios. Under scenario 3, where TPS benefits are assumed to continue at a constant level between 2001 and 2010, the net present value of the project to Vietnam 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.

Who has benefited from TPS in Vietnam?

The diffusion of new agricultural technology can affect the livelihoods of many different groups of people. Farmers who adopt the new technology are the most visible beneficiaries. Consumers can also benefit from increased market supplies and lower prices. Traders benefit from a larger volume of marketed commodities and products to and from rural communities to urban areas. Input suppliers such as seed growers and agricultural chemical and machinery companies may benefit from increased demand for their products. However, some groups may be adversely affected by new technology. Farmers who do not adopt new technology may face lower output prices or higher input costs with no offsetting improvement in productivity. New technology may be biased in a land-saving or labor-saving direction, which has implications for the share of economic

⁶ In estimating aggregate economic benefits, we only count the increase in economic profit from the area planted to TPS seedling tubers. We assume that area planted with TPS seedlings (primarily a seed crop for the next season) produced no net economic benefits to Vietnam (which the economic cost calculated for a normal year suggest - see Table 11.4). We assume it requires 250 ha of TPS seedlings to produce sufficient seed for 3,250 hectares planted with seedling tubers. Aggregate net benefits to farmers are found by multiplying 4.630 million VND/ha by 3,250 ha planted with TPS seedling tubers.

benefits that accrue as implicit or explicit payments to land or labor. Some input suppliers may suffer losses if the new technology substitutes for their products. Some poor consumers, too, could be negatively affected, if for example a new technology resulted in improved product quality such that low quality but more affordable food became less available.

Economic models can be constructed to assess such impacts provided there exists sufficient detail about the structure of demand, supply and price determination in the output and input markets affected by a new technology. At the present time, we do not have adequate information for such a quantitative assessment for technical change in potatoes in Vietnam. Instead, we must rely on more qualitative judgments to assess distributional implications of TPS in Vietnam.

First, it appears that the farm families who adopted TPS retained most of the economic benefits. Although a 6% increase in local production may be expected to put downward pressure on prices, increased market integration with southern China during the 1990s implies that the effective size of the potato market is much larger than the Red River Delta alone. The effect of changes in potato supply in the RRD is cushioned by the ebb and flow of potato imports from China.

Among farm families who adopted TPS, a significant share of employment and income benefits appear 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 in the RRD observed by the authors during field research.

Impact of TPS on family livelihoods

Based on the above assessment, we can estimate the effect of TPS adoption on the livelihoods of farm families in the RRD. Given the small average size of potato plots (360 m²) and the large number of farm families who adopted TPS (about 100,000), benefits per household are estimated to be 155,000 VND/household/year (US \$11.06/household/year, or US \$2.21 per 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 members of the household, we can expect that a relatively large share of this income was 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' need for improved potato seed in Vietnam. Its popularity is driven by the higher average yield it offers farmers over yield from old, degenerated clonal varieties. In this study, we estimate that hybrid TPS seedling tubers increased yield by an average of 6.8 t/ha, or 75%, compared with the predominant variety grown in Vietnam until recently (Ackersegen). However, TPS did not substantially reduce potato seed costs. Although the cost per hectare of TPS sown in

nurseries and transplanted to fields is indeed low, the crop from transplanted TPS seedlings is mainly a seedcrop. The seed cost using TPS seedling tubers, which is used to produce a marketable crop, is comparable to the seed cost using local clonal seed. Between 1994 and 1999, hybrid TPS progenies diffused to 3,500 hectares, or about 10% of Vietnam's total potato area. TPS is grown on about 100,000 small farms mainly in the Red River Delta in northern Vietnam. Aggregate economic benefits to Vietnamese farmers are estimated at about US \$1.075 million per year, or about US \$11/capita among households adopting TPS. This is equivalent to about 1.2% of the average annual income of farm households in the Red River Delta. After taking into account the investment costs in TPS research and extension, we estimate the net present value of TPS in Vietnam at between \$250,000 to \$2.972 million, depending on the discount rate and scenarios for future TPS use. Between US\$ 1.3-3.7 of benefits were generated for every US\$ 1 spent on research and extension. The internal rate of return to TPS research and extension is estimated at between 28.6-41.6%.

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 for as long as they offer economic returns at least equal to, if not above, 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 is of variable quality. 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. It is likely that hybrid TPS will 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 some disadvantages such as higher labor requirements and a longer duration 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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Table 0.1 Potato production and TPS area in Vietnam

Year (season)	Total production	Area harvested	Yield	TPS area ⁷	
	tonnes	ha	t/ha	ha	% of total area
1982-1983	291,376	32,140	9.1	0	0
1983-1984	188,085	31,230	6	0	0
1984-1985	305,882	23,540	13	7	0
1985-1986	378,157	33,140	11.4	230	0.7
1986-1987	343,966	39,890	8.6	700	1.8
1987-1988	333,758	37,840	8.8	0	0
1988-1989	333,758	32,980	10.1	0	0
1989-1990	367,232	36,760	10	0	0
1990-1991	288,063	31,936	9	0	0
1991-1992	259,282	25,748	10.1	0	0
1992-1993	259,917	27,245	9.5	0	0
1993-1994	241,081	26,233	9.2	4	0
1994-1995	251,388	27,747	9.1	28	0.1
1995-1996	340,272	32,687	10.4	157	0.5
1996-1997	352,331	31,972	11	900	2.8
1997-1998	371,069	37,672	9.9	4,300	11.4
1998-1999	370,000	37,000	10	3,200	8.6
1999-2000	370,000	37,000	10	3,500	9.5

Source: National production, area and yield are from FAO databases (1999 and 2000 are estimates). Area for OP TPS progenies is from Dam and Ho (1995) and area for hybrid TPS progenies is from Chien et al. (2000).

⁷ The diffusion of TPS during 1985-1987 were open-pollinated progenies. These were discontinued due to low yield. Diffusion from 1994-2000 are Hybrid TPS progenies.

Figure 0.1 TPS distribution and production system in Vietnam

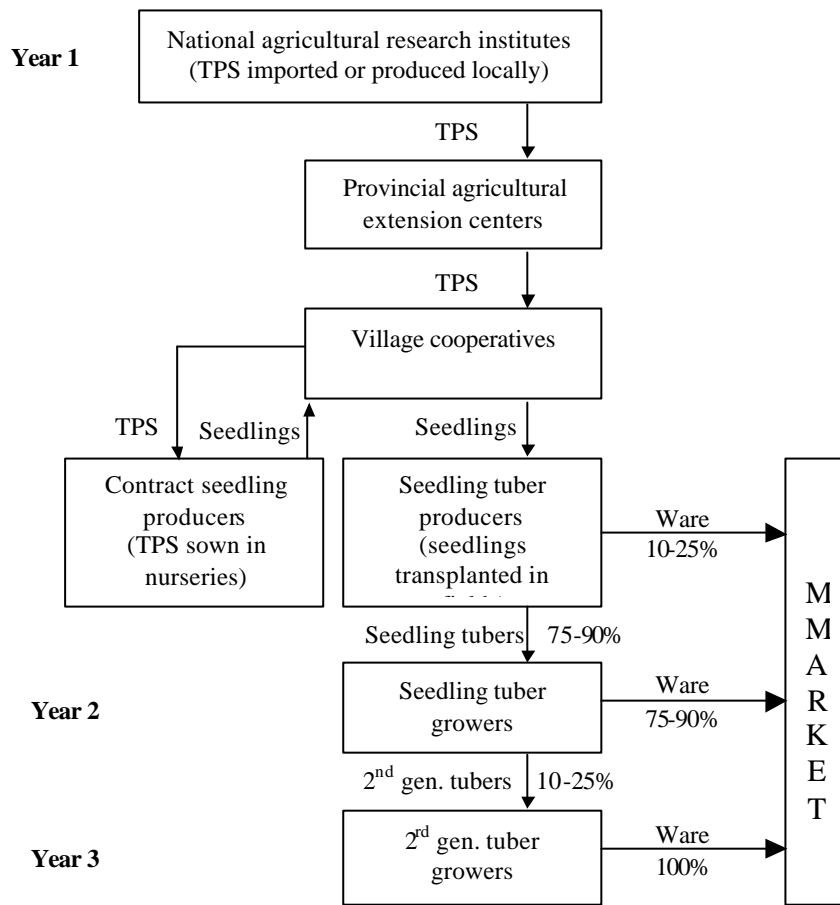


Table 0.2 Potato production costs, yields and economic returns by source of seed for the 1999-2000 season in the Red River Delta, Vietnam

Source of seed	TPS nurseries and seedling transplants ⁸	TPS seedling tubers	Imported clone from Holland	Imported clone from China	New Vietnamese clonal varieties
Number of observations	18	38	23	10	15
Average plot size (m ²)	403	307	322	136	493
<i>Input Quantity (per ha)</i>					
Labor (hours/ha)	5,243	4,569	4,374	4,094	3,814
Seed (kg/ha)	0.119	684	1,564	1,162	1,396
TPS seedlings/ha	72,716				
Manure (t/ha)	17.7	14.5	18.7	13.4	16.3
Urea (kg/ha)	267	296	336	302	397
TSP (kg/ha)	429	419	460	626	415
KCL (kg/ha)	193	179	187	205	106
<i>Input Cost ('000 VND/ha)</i>					
Land	694	694	694	694	694
Labor	10,485	9,139	8,747	8,188	7,629
Manure	857	599	546	457	543
Nursery plastic cover	107	0	0	0	0
Seed	1,432	4,594	7,925	3,584	4,306
Total chemical fertilizer	1,441	1,416	1,661	1,630	1,466
Total pesticide	154	201	233	12	219
Total purchased inputs	3,135	6,210	9,820	5,226	5,991
<i>Output</i>					
Average yield (kg/ha)	9,397	13,778	15,056	13,963	15,538
Stn. Dev. of yield (kg/ha)	3,177	3,891	5,570	3,266	5,594
A:B:C:D (%) ⁹	5:23:38:21	35:29:25:13	41:41:17:4	30:30:35:5	27:30:14:1
Average price of yield (VND/kg)	1,332	1,185	1,534	1,334	1,461
<i>Economic Returns ('000 VND/ha)</i>					
Gross value of yield	12,518	16,331	23,103	18,631	22,698
Net income ¹⁰	9,383	10,120	13,283	13,405	16,707
Economic profit ¹¹	-2,654	-312	3,295	3,102	7,841

Source: Farm surveys in Red River Delta during 1999-2000 winter season.

Exchange rate: 14,000 VND = US \$ 1.00.

⁸ An average of 0.119 kg of TPS sown in 215 m² of TPS nursery beds is required to produce 72,716 one-month-old TPS seedlings. The seedlings are then transplanted to 1 ha.

⁹ Percent size distribution of yield. A=large (>100 g/tuber), B=medium (50-100 g/tuber), C=small (20-50g/tuber), D=very small (<20g/tuber)

¹⁰ Net income is defined as the gross value of production minus the cost of purchased inputs.

¹¹ Economic profit is defined as the gross value of production minus the cost of all purchased and farm-supplied inputs.

Table 0.3 Potato yield comparisons seed of seed in the Red River Delta, Vietnam (t/ha)

Seed type	Farmer yield estimates for the 1999-2000 season	On-farm trials conducted in 1999-2000 season	Farmer yield estimates for a normal year
TPS seedlings	9.4	9.2	11.2
TPS seedling tubers	13.8	12.2	15.8
Ackersegen	na	9.5	9
Chinese seed	14	11.6	12.5
Dutch seed	15.1	17	na
New Vietnamese clones ¹²	15.5	19.2	19.9

Source: Farm surveys and on-farm trials in Red River Delta during 1999-2000 winter season. na not available

¹² Farmer yield estimates for new Vietnamese clones for the 1999/2000 season are the average for KT-3 and P-3. Only KT-3 was used in the on-farm trials and to elicit farmer estimates for a normal year. KT-3 recorded a significantly higher average yield than P-3.

Table 0.4 Economic returns to potato production in a normal year in the Red River Delta, Vietnam

Seed type	Net income ('000 VND/ha)	Economic profit ('000 VND/ha)
TPS seedlings	11,849	-188
TPS seedling tubers	12,495	2,062
Ackersegen ¹³ (old local clone)	6,771	-2,569
Chinese seed	11,453	2,113
KT-3 (new Vietnamese clone)	23,089	14,223

Source: Derived from Table 10.2 and Table 10.3.

¹³ We assume the same cost of production for Ackersegen and Chinese seed.

Table 0.5 Economics of potato production using TPS seedlings for seed in Vietnam and India

	Vietnam	India NE Plains	India NE Hills
Inputs			
TPS seeding rate (grams/ha)	119	340	210
TPS seed price (\$/kg)	800	625	625
TPS seed cost (\$/ha)	95	212	131
Fertilizer (\$/ha)	103	200	134
Pesticide (\$/ha)	11	44	52
Nursery materials	8		
Total purchased inputs (\$/ha)	224	456	317
Output			
Yield (kg/ha)	11,200	19,800	17,500
Average price of yield (\$/mt)	95	63	98
Gross value of production (\$/ha)	1,064	1,247	1,715
Net income (\$/ha)	840	791	1,398

Source: For Vietnam, Table 10.2; for India (Chilver et al., 1999)

Table 0.6 Economics of potato production using TPS seedling tubers for seed in Vietnam, Indonesia and India

	Vietnam	Indonesia	India			
			NE plains	NE hills	NC plains	Deccan Plateau
Inputs						
Seed rate (kg/ha)	684	1,150	1,200	1,600	3,000	840
Seed price (\$/mt)	514	800	263	250	119	188
Seed cost (\$/ha)	328	916	200	400	356	158
Fertilizer (\$/ha)	101	218	20	134	84	172
Pesticides (\$/ha)	14	258	44	80	6	40
Total inputs (\$/ha)	444	1,392	264	614	446	370
Output						
Yield (kg/ha)	15,300	11,800	26,800	28,300	33,300	12,100
Average price of yield (\$/mt)	85	356	75	105	63	103
Gross value of production (\$/ha)	1,301	4,204	2,012	2,968	2,093	1,245
Net income (\$/ha)	857	2,812	1,748	2,354	1,647	875

Source: For Vietnam, Table 10.2; for Indonesia and India (Chilver et al., 1999).

Table 0.7 Benefit-cost analysis of TPS research and extension in Vietnam, 1990-2010

(figures in constant '000 US \$)

Year (season)	Aggregate Net Benefits to Farmers			Investment in Research and Extension	Net Economic Benefits to Vietnam		
	Scen. 1	Scen. 2	Scen. 3		Scen. 1	Scen. 2	Scen. 3
1990-1991	0	0	0	78	(78)	(78)	(78)
1991-1992	0	0	0	78	(78)	(78)	(78)
1992-1993	0	0	0	92	(92)	(92)	(92)
1993-1994	0	0	0	105	(105)	(105)	(105)
1994-1995	5	5	5	132	(126)	(126)	(126)
1995-1996	28	28	28	185	(157)	(157)	(157)
1996-1997	198	198	198	185	13	13	13
1997-1998	1,237	1,237	1,237	185	1,052	1,052	1,052
1998-1999	976	976	976	185	790	790	790
1999-2000	1,075	1,075	1,075	185	889	889	889
2000-2001	0	967	1,075	185	(185)	782	889
2001-2002	0	860	1,075	147	(147)	713	928
2002-2003	0	752	1,075	147	(147)	606	928
2003-2004	0	645	1,075	134	(134)	510	940
2004-2005	0	537	1,075	134	(134)	403	940
2005-2006	0	430	1,075	93	(93)	337	982
2006-2007	0	322	1,075	93	(93)	230	982
2007-2008	0	215	1,075	93	(93)	122	982
2008-2009	0	107	1,075	93	(93)	15	982
2009-2010	0	0	1,075	93	(93)	(93)	982
Present value:							
10% disc. rate	1,526	2,869	4,073	1,100	426	1,769	2,972
15% disc. rate	1,037	1,786	2,370	787	250	999	1,584
Benefit-cost ratio:							
10% disc. rate					1.39	2.61	3.70
15% disc. rate					1.32	2.27	3.01
Internal rate of return							
					28.6%	38.9%	41.6%

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