TRUE POTATO SEED FOR POTATO PRODUCTION - WHAT ARE THE PROSPECTS?

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ABSTRACT:

In 1975, we found in our breeding program that potato crops can be produced from botanical or "true" potato seed (TPS) when it is seeded directly into fields or used to grow transplants. These crops need the full growing season in the Columbia Basin, from April to November. Some plants produce tubers with size and quality satisfactory for commerce. However, tubers on many plants are too small or have unacceptable quality factors. Yields are generally 30 to 60% of those expected from crops grown from tuber seed. Every plant is genetically different so there is much variation in important horticultural and cooking characteristics.

For developing countries with a long growing season and a lack of certified tuber seed, TPS culture has possibilities. TPS is disease free and easy to ship and store. The International Potato Center in Peru is emphasizing research on development of TPS cultivars and methods of using them. Promising results are being obtained in many developing nations. However, prospects of using TPS culture for potato production in North America and the rest of the Northern Hemisphere are not good at this time. Rapid propagation from tissue-cultured, in-vitro plantlets is a better alternative in both developed and developing countries.

Field Crops from True Potato Seed Possible in Columbia Basin

When the tomato breeding program at Prosser was redirected to potato breeding, we decided to try some tomato breeding methods on potatoes. The International 185 precision seeder previously used for direct sowing tomato seed in fields was effective in drilling true potato seed (TPS). Smaller holes were drilled in the periphery of blank seedplates to accommodate TPS, which is much smaller than tomato seed. Fortunately, herbicides used for tomatoes, pebulate (Tillam) + napropamide (Devrinol), also worked well for selective weed control in germinating TPS. This gave the tiny, slow-growing potato seedlings a few weeks to reach competitive size without being smothered by vigorous weeds.

This Presentation is part of the Proceedings of the 1988 Washington State Potato Conference & Trade Fair.

Although germination of TPS extended over a period of several weeks and produced seedlings by mid-summer with a wide range of sizes, we were successful in cultivating and eventually hilling the plants so stolons would form and produce tubers. It took the full Columbia Basin summer season (some 200 days), but surprisingly the direct-seeded TPS plants produced some commercial-sized tubers. Most plants produced small and/or inferior tubers but a few produced excellent yields of nice tubers. Over the past 10 years most of our breeding selections have come from such TPS field-grown progenies. These seedling progenies are purposely exposed to various diseases, pests, and environmental stresses. By exposing hundreds of thousands of seedlings to such "stress" factors it has been possible to select a wide array of genotypes with various combinations of resistance to the destructive factors that cause multi-million dollar annual losses to the Northwest potato industry.

Potato Culture from TPS Has Become a Popular Research Subject

We reported our success with TPS culture and suggested this method be tried in developing countries where lack of certified tuber seed greatly inhibits potato production. TPS culture was soon adopted by the International Potato Center in Lima, Peru, as one of their primary research thrusts. They have many scientists working worldwide to produce acceptable TPS cultivars, develop seed production technology, and refine TPS planting and plant growing methods so that TPS culture might become a common agricultural practice. Their enthusiasm about prospects of TPS culture in developing countries is infectious and causes researchers, growers, and industry people in other parts of the world to wonder if this method would be useful, even where tuber seed is readily available. Even in the United States some are wondering if they should try TPS or be researching or investing in research on TPS breeding and culture.

Not Likely that TPS Culture Will Become Important in North America

We have had 12 years of experience in growing potato crops from TPS, testing hundreds of lines both as transplants and seeded directly into fields. These crops have been grown on a wide range of soil types, using various irrigation practices, several planting methods, and several herbicides and cultivating and hilling methods. Our successful cultural methods have been published in various U.S. and international journals. We have pointed out the advantages of field-grown TPS crops in a breeding program, where a few superior hills (clones) are saved for evaulation as potential vegetatively-propagated cultivars. Our conclusion is that the use of certified tuber seed is far better than TPS when such tuber seed is readily available.

A list of advantages and disadvantages of using certified seed tubers and TPS to produce a crop of potatoes is shown in Table 1.

Table 1. Advantages and disadvantages of using certified seed tubers and true potato seed (TPS) to produce a potato crop.

Seed Tubers	TPS
Advantages	
Easy to plant and raise crop	Small handful of seed per acre
Normal length growing season	Seed is generally disease free
Produces uniform crops that maximize land productivity	Seed is easy and cheap to transport and store
Yields uniform, high quality raw product	
Disadvantages	
Requires about 2000 lbs of seed per acre	Requires precautions in planting, cultivating, and weed control
Difficult and expensive to produce or obtain "clean" seed	TPS often dormant so emerges over long period
Difficult and expensive to transport and store seed tubers	Normally requires two-step propagating procedure (transplants)
	Requires at least 1/3 longer growing season.
	Produces low yields of small tubers
	Tubers are variable in yield and quality characteristics
	When TPS used to produce disease-free seed tubers in sheltered environment they are still genetically variable

The many disadvantages of TPS crops make it unlikely that TPS will be used to produce commercial crops in North American or other potato producing countries in the Northern Hemisphere. The special care and long season required to grow a TPS crop and the low yields of small, variable tubers makes this a very undesirable alternative. To illustrate these points Table 2 shows results of a 1984 trial where 83 F_1 and F_2 TPS progenies were planted and their performance was compared with two tuber-planted cultivars, Russet Burbank and Kennebec.

Plots were harvested 137 and 194 days after planting. Data for the best 11 TPS lines is shown along with the mean of all 83 entries. The TPS lines were very late and produced low yields of small tubers, even after a very long (194 days) season. In general larger numbers of tubers were produced on the TPS crop and specific gravities were inferior. However, the specific gravity in a few lines was equivalent to that of the tuber-propagated cultivars.

Table 2. Performance of two tuber-planted cultivars, Russet Burbank and Kennebec, and 83 TPS lines when planted at the same time and harvested 137 and 194 days after planting.

Line	Planted	Yield T/A	Nr tubers (per yd)	Ave wt (oz)	Sp. Gr. (1.0-)
Harvested 137 days after planting					
R. Burbank	tubers	23	27	5.4	95
Kennebec	tubers	19	34	5.5	86
Mass X	F_1TPS	9	50	1.4	77
IP 411	F_1TPS	4	22	1.3	66
IP 412	F_1TPS	4	24	1.3	57
Michimac	F_2TPS	11	68	1.2	75
Wn 705-11	F_2TPS	4	32	0.8	78
WnC 316-1	F_2TPS	10	56	1.5	83
WnC 612-13	F_2TPS	7	49	1.1	90
B8686-8	F_2TPS	5	27	1.4	85
A503-42	F_2TPS	4	37	0.8	71
A69850-4	F_2TPS	9	77	1.0	75
Neb 12-72-2	F_2TPS	9	57	1.2	72
Mean of 83 entries		4	35	1.0	77
Harvested 194 days after planting					
R. Burbank	tubers	25	30	6.6	88
Kennebec	tubers	26	24	8.3	87
Mass X	F_1TPS	12	42	2.3	83
IP 411	F_1TPS	22	77	2.2	70
IP 412	F_1TPS	23	81	2.4	63
Michimac	F_2TPS	17	58	2.5	73
Wn 705-11	F_2TPS	15	51	2.3	77
WnC 316-1	F_2TPS	14	52	2.1	79
WnC 612-13	F_2TPS	14	45	2.4	86
B8686-8	F_2TPS	15	46	2.6	80
A503-42	F_2TPS	15	56	2.1	75
A69850-4	F_2TPS	15	68	1.7	76
Neb 12-72-2	F_2TPS	14	72	1.6	69
Mean of 83 entries		11	48	1.8	74

TPS May Be Useful in Developing Countries Where Quality Tuber Seed is Difficult to Obtain

Where certified tuber seed is not available or is very expensive to obtain and/or maintain in good condition, there are obvious advantages to needing only a small quantity of TPS that is disease-free and can be easily shipped and stored. In such places the consumer is usually not concerned with uniformity of raw product as long as he can obtain sufficient to feed his family. Because of lack of disease-free tuber seed, many growers in these countries plant badly-diseased tubers from their previous year's crop and, consequently, obtain very low yields and poor quality. When compared with such crops, TPS crops produce higher yields and better quality so offer a real advantage. It appears that even in these countries TPS will be used primarily to produce minitubers by planting thick stands under screening of various kinds so spread of diseases and pests can be kept to a minimum. These relatively disease-free minitubers will then serve as tuber seed to grow crops for consumption. Each family may grow their own minitubers, but certain growers will probably specialize in minituber production and supply their neighbors. Reports are appearing in the literature of successful TPS ventures of this nature in many nations of the world.

Rapid Propagation from Tissue Cultured Plantlets is Best Alternative

Use of TPS in developing countries, though promising, will probably be transitory. Its chances of success will always be diminished by the fact that a TPS population is a mixture of superior and inferior genotypes. The ideal situation would be to have only plants of a superior genotype so maximum production could be realized from each spot in a field where a plant was growing. Methods are presently available by which this ideal can be reached.

The technology of tissue culture is now well established and its utility has been established in potatoes on a commercial scale. Using tissue culture as the source of seed for potato crops offers all the advantages of both certified tuber seed and TPS, with few disadvantages (Table 3).

Table 3. Advantages and disadvantages of using tissue-cultured plantlets as the nuclear seed source when producing a crop of potatoes.

Advantages
Need start with one or only a few tissue-cultured plantlets in test tubes.
Plantlets are disease free.
Plantlets are easy and cheap to transport and store.
Can use traditional transplant growing and planting methods.
Requires only normal length of growing season.
Can grow disease-free minitubers in sheltered environment.
Minitubers produce same uniformity and quality as tuber seed of cultivar.
Disadvantages
Requires some skill, equipment, and facilities to reproduce plantlets and transplants.

A single superior potato plant or genotype can be readily freed of all diseases and pests by meristem culturing and can be maintained indefinitely in this condition in test tubes as plantlets. When needed, an in vitro plantlet or plantlets can be shipped easily and cheaply to any place in the world. These plantlets can then be maintained in the new location as a nuclear seed source indefinitely. A single plantlet can be increased rapidly to produce hundreds or even thousands of transplants that can be used for growing a crop for seed or consumption. This increase can be done in vitro in flasks, jars, or petri plates, or by using the plantlets to produce potted mother plants from which to obtain transplants by "stem cutting." Transplants from in vitro propagation or stem cutting can be grown in a dense population like TPS transplants, under screening, to produce disease-free minitubers to be used as tuber seed. These minitubers will produce a better crop for consumption than TPS-derived minitubers. Every spot in the grower's field will have the same genetically-superior plants with the potential to produce maximum possible yields. Since all plants are genetically the same, the crop will be relatively uniform in all desired qualities.

Tissue-cultured plants are already becoming and will increasingly become the primary nuclear source of potato seed worldwide, in both developed and developing nations. Potato production from TPS will probably go down in history as an interesting possibility but one that has too many negatives associated with it to be practical.