Intervarietal Hybridization for Potato Production from True Potato Seed (TPS)

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ABSTRACT

Different breeding methods were used to generate TPS progenies having the necessary characteristics for the production of good tuber yield with acceptable phenotypic uniformity in color, size, shape, and maturity. Based on combining ability studies involving several clones and cultivars from the CIP lowland tropic populations and other sources, a number of good progenitors were identified. These parental lines were further intercrossed to obtain different groups of TPS families, which were evaluated in a replicated trial for their yield and agronomic performance at CIP's experimental stations in Lima and San Ramon. The results showed that there were several TPS families which gave a marketable tuber yield of more than 1 kg per plant and uniformity rating ranging from acceptable to excellent. The yield and uniformity of some of the TPS families were as good as that of commercial varieties produced from seed tubers.

Introduction

The traditional method of propagating potatoes involves the utilization of tubers. Normally it takes about 2 tons of seed tubers to plant one hectare of land. According to Accatino and Malagamba (1982), this represents 40% to 70% of the cost of production of potatoes, especially in the developing countries of the world. Another economic factor in the use of tuber seed is its high cost and the inconveniences of storage and transportation. Furthermore, the method of vegetative propagation has the disadvantages of promoting the transfer of viruses and other tuber-borne pathogens from season to season.

An alternative method of potato propagation which has the potential of minimizing most of the problems associated with seed tubers is the use of true potato seed (TPS). The International Potato Center (CIP) has undertaken an overall research effort to exploit the potential of this technology and thus make potato a low cost food crop in many of the developing countries.

Basically, there are two types of TPS populations which can be utilized for the commercial propagation of potato: (1) open-pollinated populations, and (2) hybrid populations. In general, the hybrid TPS populations appear to be superior in yield and uniformity of tubers than the open-pollinated populations. Comparing hybrid and open-pollinated TPS progenies, Accatino (1980) and Bedi (1979) observed that most hybrid TPS progenies gave significantly higher marketable tuber yields and uniformity than the open-pollinated progenies. Haverkort (1982) obtained similar results in Rwanda.

Although seed production aspects of open-pollinated TPS progenies are less expensive and more convenient to the farmer, the hybrid TPS progenies are more appealing especially in countries where labor cost is not high. Use of TPS derived from controlled hybridization provides the possibility of improving and incorporating desirable characteristics in TPS populations.

This study was undertaken to develop high yielding and uniform TPS progenies through hybridization of tetraploid cultivars and advanced clones.

Materials and Methods

A total of 48 hybrid TPS progenies were developed from advanced tetraploid clones adapted to lowland tropic conditions. This involved crossing of each of the 12 male parents to each of the four different female clones, resulting in 48 TPS families. These TPS progenies were evaluated in two replications at La Molina, Peru, during the winter season of 1981.

Another group of 100 TPS progenies were derived by crossing selected tetraploid advanced clones from both the highland tropic and lowland tropic projects of CIP. These progenies were evaluated in 1982 in a replicated trial at La Molina (240 masl) and San Ramon (800 masl).

In all the trials the botanical seeds were first sown in flats and germinated seedlings were transferred into jiffy-7 pots after about 15 days. After 4 weeks of growth, the seedlings were transplanted into the field in jiffy pots at a spacing of 35 cm between plants in the row and 75 cm between rows. A total of 40 seedlings per family in each replication was used in all the trials. Crops were harvested in 90 and 100 days in San Ramon and La Molina, respectively.

Field observations on plant survival, vegetative vigor of uniformity, and maturity were made at different intervals during the growing period. At the time of harvest, the yield on a per hill basis and uniformity with respect to color, size, and shape of tubers were recorded.

Results and Discussion

Tuber Yield

Results on yield and uniformity of tubers of portions of the TPS progenies evaluated in La Molina in 1981 are summarized in Table 1. It is evident from this table that there were large differences between TPS families in yield of tubers. In this trial, 12 TPS families gave an average marketable tuber yield of more than 1.0 kg per plant and about 0.2 kg of unmarketable smaller size tubers which may be satisfactory for further planting. Marketability was mainly based on the size of the tubers. In general, tuber sizes of about 50 grams or more were considered marketable. Some of the yields in the range of 1.0 kg per plant will be equivalent to about 40.0 tons per hectare, assuming a stand of about 40,000 seedlings on one hectare of land. This result is quite comparable to other TPS yield results reported by Bedi (1979), Martin (1982), and Mendoza (1981).

Table 1. Tuber yield and uniformity traits of true potato seed (TPS) families obtained from crosses of lowland tropic adapted tetraploid parental lines, La Molina, winter 1981.

Pedigree of TPS Family	Tuber Yield (kg/plant) Marketable	Unmarketable	Tuber Uniformity*
1. 377964.3 x 378017.2	1.17	.01	4
2. 377891.19 x "	1.31	.08	5
3. 377885.15 x "	1.03	.10	4
4. 377257.1 x "	0.84	.23	3
5. 377887.59 x 377904.1	1.31	.15	4
6. 378015.7 x "	1.52	.10	3
7. 377933.13 x "	1.33	.20	3
8. 377950.14 x "	0.96	.15	2
9. 377922.15 x 377964.5	1.12	.11	4
10. 377935.27 x "	1.16	.07	5
11. 377887.17 x "	1.11	.07	3
12. 377939.5 x "	0.78	.11	2
13. 377887.74 x 377920.37	1.05	.20	4
14. 377883.8 x "	0.82	.16	3
15. 377885.15 x "	1.12	.12	3
16. 377887.17 x "	0.85	.13	3
17. 377835.3 x 377877.6	0.60	.16	1
18. 377877.19 x "	0.74	.17	2
19. 377887.25 x "	1.11	.08	3
20. 377871.22 x "	0.59	.02	2
$\overline{X}$	1.03	.12	

* Based on scale of 1 = least uniform to 5 = highly uniform.

In the 1982 trial of 100 TPS families, the majority gave satisfactory tuber yields and had acceptable uniformity. Table 2 shows 56% of TPS families in La Molina and 30% in San Ramon gave a tuber yield of 0.5 kg or more per plant. As compared to the four open-pollinated TPS families, 72% of the hybrid TPS families in La Molina and 59% in San Ramon gave higher tuber yields (Tables 2 and 3).

On the basis of the yield data obtained from the two locations, a strong family-environment interaction for yield became evident. There were only a few TPS families which gave high yields in both locations.

Tuber Uniformity

At time of harvest, tubers from each TPS family were evaluated for uniformity in skin color, size, and shape. As shown in Tables 1 and 3, several TPS families had the necessary phenotypic uniformity of color of skin, size, and shape of the tubers. Some TPS families had tubers almost as uniform as standard varieties propagated from seed tubers. Similar results were obtained by Mendoza (1979) who has shown that TPS progenies with adequate phenotypic uniformity can be obtained from intervarietal mating of selected tetraploid parents.

Table 2. Distribution of TPS families according to their tuber yields per plant in two locations, winter 1982.

Yield Group (kg/plant)	No. of TPS families	
	La Molina	San Ramon
< 0.2	8	7
≥ 0.2	11	10
≥ 0.3	9	24
≥ 0.4	16	29
≥ 0.5	17	23
≥ 0.6	13	5
≥ 0.7	16	1
≥ 0.8	4	1
≥ 0.9	1	-
≥ 1.0	5	-
Total	100	100

Plant Survival, Foliage Uniformity Vigor, and Maturity

Maintaining optimum stands in TPS progenies appeared to be one of the major problems, especially at lower altitudes. As can be seen in Table 4, the percentage of seedling survival in the field ranged from 45% to 85% under La Molina winter conditions. However, the majority of the TPS families had a plant stand of about 75%. According to Elango (personal communication, 1982) the significant reduction of plant stand in TPS families may be mainly attributed to the post-emergence damping-off disease complex caused by a combination of biological and environmental factors such as *Rhizoctonia solani* and high soil temperature.

In terms of foliage vigor and uniformity in the field, the TPS families showed considerable variations. In most TPS families, vegetative growth was uniform with satisfactory vigor (Table 4).

It is worth mentioning, however, that there was always some degree of segregation for flower color within any given TPS family. This is to be expected in a segregating population of potatoes. The difference in seedling vigor was also evident in the screenhouse. Seedlings from some TPS families were considerably more vigorous and became ready much earlier, than other families. It is reasonable to expect that seedlings with high vigor will have a better chance of survival in the field than less vigorous seedlings.

Early maturity is one of the important attributes in the use of TPS for the commercial propagation of potatoes. In general, TPS progenies derived from tropically adapted clones appear to be earlier in maturity than others. On the basis of maturity data obtained from various types of TPS families under San Ramon and

La Molina conditions, it appears that the development of TPS progenies, which can mature in less than 100 days from transplanting, is possible.

Table 3. Tuber yield (kg/plant) and uniformity of TPS families evaluated in La Molina (LM) and San Ramon (SR), winter 1982.

Pedigree of TPS Family	Yield (kg/plant)		Uniformity*					
			Color		Size		Shape	
	LM	SR	LM	SR	LM	SR	LM	SR
1. Serrana x India 832	0.52	0.47	3	4	2	2	2	3
2. Atzimba x Katahdin	0.40	0.34	4	3	2	2	2	2
3. Atzimba x DTO-33	0.30	0.45	2	3	1	2	1	2
4. DTO-2 x India 1058	0.41	0.43	4	3	2	2	2	2
5. AL-204 x 378017.2	0.75	0.39	4	4	3	2	3	3
6. CFK-69-1 x 378017.2	0.72	0.45	4	4	3	3	2	3
7. AL-204 x R 128.6	0.76	0.33	3	2	3	2	2	2
8. BR 63.65 x R 128.6	1.10	0.37	3	3	2	3	3	2
9. CFK-69-1 x 7XY.1	0.40	0.60	4	3	1	2	2	2
10. 376932.6 x 7XY.1	0.60	0.59	4	4	1	2	2	2
11. India 832 x 7XY.1	0.55	0.59	3	4	2	2	3	3
12. CFK-69-1 x AL-204	0.41	0.51	3	3	2	2	2	2
13. PSP-30-10 x Trop. bulk	1.09	0.41	4	4	3	3	3	2
14. MS-35-22 x 377904.10	1.06	0.97	3	3	3	3	3	2
15. BR 69.84 x 377904.10	0.79	0.84	2	3	2	2	2	2
16. 377427.1 x 377904.10	1.04	0.44	3	3	3	2	3	2
17. 377904.10 x 377427.1	1.06	0.54	2	3	3	2	3	2
18. DTO-28 x Trop. bulk	0.80	0.53	3	3	3	3	2	2
19. Atzimba x R 128.6	0.71	0.27	4	2	3	2	3	2
20. Atzimba x DTO-28	0.49	0.42	3	3	3	2	3	2
21. DTO-28 x R 128.6	0.78	0.42	3	2	3	3	2	2
22. DTO-33 OP	0.27	0.29	2	2	2	1	1	1
23. DTO-28 OP	0.33	0.23	2	1	2	1	1	1
24. Atzimba OP	0.29	0.37	2	2	1	1	1	2
25. 7XY.1 OP	0.15	0.19	1	1	1	1	1	1
$\overline{X}$	0.63	0.45						

*Based on scale of 1 = least uniform 5 = highly uniform.

Table 4. Field survival, foliage vigor and uniformity, and maturity of TPS families evaluated in La Molina during winter 1982.

Pedigree of TPS Families	Average No. of Seedlings		Vigor and Uniformity*		Maturity†
	Planted	Harvested	40 days	70 days	
1. Serrana x India 832	40	28	3	3	L
2. Atzimba x Katahdin	40	22	2	3	MS
3. DTO-2 x India 1058	40	35	3	4	MS
4. AL-204 x 378017.2	40	29	4	5	E
5. AL-204 x R 128.6	40	32	4	5	MS
6. CFK-69-1 x 7X1.1	40	30	3	3	MS
7. CFK-69-1 x AL-204	40	25	3	4	MS
8. PSP-30.10 x Trop. bk.	40	35	5	5	L
9. MS-35-22 x 377904.10	40	32	5	5	MS
10. 377904.10 x 377427.1	40	33	5	5	L
11. Atzimba x R 128.6	40	34	4	4	L
12. Atzimba x DTO-28	40	29	3	3	L
13. DTO-28 x R 128.6	40	31	4	4	MS
14. 7XY.1 OP	40	24	1	2	MS
15. Atzimba OP	40	18	2	3	L
16. DTO-33 OP	40	30	2	3	E

*Based on scale of 1 = least vigorous and uniform to 5 = highly vigorous and uniform.

†E = early; MS = mid-season; L = late.

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