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Genetic improvement for yield and tuber size in Andigena potatoes (*Solanum tuberosum* subsp *andigena*) after one cycle of recurrent selection

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ABSTRACT

Improvement of Andigena genotypes for tuber characters was attempted by making Andigena × Andigena crosses. Andigena accessions could be considerably improved for characters like yield and tuber size by crossing among themselves. Progenies of different cross types like full-sibs, half-sibs, back crosses and cross between unrelated parents among the improved Andigena clones of first cycle of selection were evaluated for tuber characters related to yield to know the best approach for further improvement of Andigena clones for these characters. Half-sibs and crosses between unrelated parents progenies were significantly better than full-sibs and back crosses progenies for the characters yield and average tuber weight, suggesting thereby that for further improvement of Andigena it is important to maintain heterozygosity. The results of the present study show that recurrent selection technique can be useful for improvement of Andigena genotypes.

Key words : Back crosses, Full-sib crosses, Half-sib crosses, Improved andigena, Potato, Recurrent selection, *Solanum tuberosum*, Tuber weight, Yield

Potato breeding programmes based on *Solanum tuberosum* L. have a narrow genetic base (Bradshaw and Ramsay 2005, Kumar *et al.* 2011). Most breeders agree that it is increasingly difficult to obtain improvement in yield and other traits from among recombinants produced by crossing presently available parental clones. Primitive cultivated potatoes of *Solanum tuberosum* group Andigena are being used to broaden the genetic base of group Tuberosum material. Andigena is a rich source of genetic diversity. Short day adapted Andigena accessions can be useful parents in breeding programmes for short day sub-tropical environment. The immediate usefulness of Andigena material is in the form of Tuberosum × Andigena (T × A) hybrids. The potential of Andigena accessions in increasing yield in T × A crosses due to heterosis, is well-established (Gopal *et al.* 2000, Kumar and Kang 2006). However, Andigena selections in crosses with clones of *Solanum tuberosum* group Tuberosum (Tai and Tarn 1980) result in late maturity and small tubers. Thus there is need to prebreed for early maturity/bulking and then involve the improved Andigena clones in hybridization with Tuberosum parents. Furumoto (1991) reported that improved Andigena germplasm was more useful than raw Andigena for introgression in temperate germplasm. By making crosses among Andigena accessions, improved Andigena clones with better tuber size, yield and with desired characters like uniformally white or red tubers with shallow eyes can be developed. We attempted Andigena × Andigena crosses to breed improved Andigena clones better than best Andigena accessions JEX/B 998 available in Andigena germplasm for tuber characters like tuber size and yield. From these crosses we could select improved Andigena clones which were much better than the parents and best Andigena accession JEX/B 998, but these were not better than best commercial variety belonging to group Tuberosum. To know the best approach to further improve Andigena we evaluated progenies of different cross types among improved Andigena clone in next cycle. The findings of this 11 years study are reported here.

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MATERIALS AND METHODS

First cycle of recurrent selection

Crosses were made between Andigena (*Solanum tuberosum* ssp andigena) genotypes in July 1997 and July 1998 at the Central Potato Research Station, Kufri ($31^0 08'$N, 77⁰ 18'E, 2 530 m amsl). Seedlings and subsequent clonal generations were raised at the Central Potato Research Station Jalandhar (31⁰ 02'N, 75⁰ 02'E, 237 m amsl). Seedlings of each cross at the 6-7-leave stage were transplanted to field. At harvest, these were subjected to selection for tuber characters like skin colour, eye depth. Clones were evaluated in first, second and third clonal generations in observational rows and further subjected to selection for tuber characters like shape, size, eye depth, cracking and skin colour. In the 2002–2003, 2003–2004 and 2004–2005 autumn crop seasons, selected clones were evaluated in trials laid out in Randomised Complete Block Design with three replications, plot sizes ranging over seasons from 5.4 to 9.0 square metres and planted in rows with intra- and inter-row spacing of 20 and 60 cm, respectively. Normal management and pest control practices were carried out. In replicated clonal generations haulm cutting was done at 75 and 90 days after planting. In other earlier clonal generations haulm cutting was done only at 90 days. The crop was harvested in each season 20 days after haulm cutting. At the time of harvest, data were recorded on yield (kilogram per plot), tuber number (per plot), average tuber weight (g), tuber shape, tuber skin colour, eye depth and flesh colour.

Second cycle of recurrent selection

Crosses were made between improved Andigena selections from first cycle in July 2003 and 2004 as full-sibs, half-sibs, back crosses and crosses among unrelated (by pedigree) selections. Seedlings of each cross at the 6-7-leave stage were transplanted to field. At harvest 3 tubers per seedling for each of 30 randomly selected plants per progeny were retained to form three replications of first clonal generation. The same procedure was applied to form material for second clonal generation (SCG). In the 2006–2007 and 2007–2008 autumn crop seasons, progenies were evaluated in trials laid out in Randomised Complete Block Design with three replications and a plot size of 5.4 square metres comprising 3 rows planted at intra- and inter- row spacing of 20 and 60 cm, respectively. Normal management and pest control practices were carried out. Haulm cutting of the crop was done 90 days after planting. The crop was harvested in each season 20 days after haulm cutting. At the time of harvest, data were recorded on total yield (kilograms per plot), marketable yield (kilograms per plot), tuber number (per plot) and percent tuber dry matter. For percent dry matter estimation, 500 g tubers pieces were cut into small pieces and oven-dried at 80^{O}C to a constant weight.

RESULTS AND DISCUSSION

Performance of clones selected in first cycle of selection

The first cycle of selection from 1997 to 2005 resulted in selection of 20 clones (Table 1). Among the parental Andigena clone best Andigena parent was JEX/B 998 with high average tuber weight, high yield and red round tubers. Most of the selected clones of first cycle had significantly higher yield than best Andigena accession JEX/B 998. At 75 days harvest, the percent increase in yield and average tuber weight of the selected clones ranged between –5.6-31.6% and –16.5-66.3, respectively. As compared to the 9.4-28.6 tonnes/ha yield of parents, tuber yield of the selected clones ranged between 27.00 to 37.6 tonnes/ha. Average tuber weight of selected clones at 75 days harvest ranged between 42.9 to 85.5 g as compared to parental range of 11.3-51.4 g. At 90 days harvest, the percent increase in yield and average tuber weight of the selected clones ranged between 0-38.6% and –17.8-101.5%, respectively. Clones A.98-98 and A.97-29 were the best among the selected clones for tuber yield. Yield of the selected clones at 90 days ranged between 35.4-49.0 tonnes/ha as compared to 17.3-35.4 tonnes/ha of the parents. Average tuber weight of selected clones ranged between 43.4-106.4 g as compared to parental range of 23.5-59.6 g. The highest yielding commercial cultivar at 75 days harvest was Kufri Ashoka and selected Andigena clones A.97-18, A.97-29, A.98-70, A.98-178, A.98-188, A.98-65 and A.98-136 yielded at par with this. A.97-29, A.98-58, A.98-54, A.98-188, A.98-98, A.98-104 and A.98-136 had average tuber weight significantly higher than Kufri Ashoka at 75 days harvest. At 90 days harvest, the highest yielding commercial cultivar was Kufri Pukhraj and Andigena clones A.97-29 and A.98-98 yielded at par with this. Average tuber weight of the selected Andigena clones A.97-29, A.98-188, A.98-98 and A.98-104 was significantly higher than Kufri Pukhraj.

The gains in yield and average tuber weight obtained after selection for these characters in first cycle of selection reflect that prebreeding of Andigena could effectively improve these characters. These results are in agreement to previous reports (Simmonds 1966, Rasco 1980, Furumoto *et al*. 1991). Simmonds (1966) reported a considerable improvement in tuberization percentage, tuber yield, average tuber weight, and tuber number after two cycles of selection. Rasco (1980) found major gains in tuber weight per plant between 0 and 2 cycles. Furumoto *et al*. (1991) reported high gains in yield and average tuber weight in two cycles of recurrent selection. In Europe and America broadening of the Tuberosum genebase was undertaken by creating long-day adapted Neo-Tuberosum (N-T) from large populations of Andigena. This took six or more cycles of recurrent mass selection. Simmonds, in England, was the first to begin this work, followed shortly after by Plaisted, in the U.S., and Tarn, in Canada. Varieties with N-T in their pedigrees include the New York releases Rosa, which is 50% N-T, and Eva, 25% N-T.

Performance of progenies of different types of crosses among clones selected from first cycle of selection

The average progeny means and range within progenies

Table 1 Yield performance and average tuber weight of improved Andigena clones based on pooled data of three years

Clone/control	75 days harvest		75 days harvest		90 days harvest		90 days harvest	
	Yield (tonnes/ ha)	% increase over JEX/B 998	Average tuber weight (g)	% increase over JEX/B 998	Yield (tonnes/ ha)	% increase over JEX/B 998	Average tuber weight (g)	% increase over JEX/B 998
A.97-8	32.1	12.2	50.9	–1.0	41.1	16.2	61.8	17.0
A.97-15	33.7	17.9	43.0	–16.3	43.1	21.8	57.7	9.3
A.97-18	35.0	22.4	61.3	19.3	40.2	13.7	63.4	20.1
A.97-29	37.6	31.6	80.7	57.0	48.4	36.8	98.0	85.6
A.98-47	32.8	14.8	52.0	1.2	44.7	26.3	63.5	20.3
A.98-48	29.6	3.5	52.1	1.4	36.8	4.0	61.0	15.5
A.98-49	27.0	–5.6	57.5	11.9	37.4	5.8	64.9	22.9
A.98-58	28.7	0.4	69.0	34.2	38.8	9.6	73.2	38.6
A.98-70	35.4	23.7	43.2	–16.0	40.7	15.0	43.4	–17.8
A.98-178	36.8	28.6	62.4	21.4	46.1	30.4	78.7	49.1
A.98-188	35.6	24.4	82.2	59.9	46.2	30.7	106.4	101.5
A.98-54	31.5	10.1	63.1	22.8	45.5	28.3	72.2	36.7
A.98-65	35.3	23.3	53.1	3.3	42.2	19.4	57.7	9.3
A.98-98	33.2	16.0	80.6	56.8	49.0	38.6	88.1	66.9
A.98-104	28.8	0.8	85.5	66.3	37.7	6.6	88.6	67.8
A.98-136	35.4	23.8	66.6	29.6	47.4	34.0	78.9	49.4
A.98-160	33.1	15.8	52.7	2.5	42.2	19.3	67.4	27.7
A.98-165	29.0	1.4	48.6	–5.4	40.0	13.1	58.6	11.0
A.98-169	33.0	15.5	42.9	–16.5	41.2	16.6	61.5	16.5
A.98-166	28.6	0.0	51.4	0.0	35.4	0.0	52.8	0.0
Mean	32.6	14.0	59.9	16.6	42.2	19.3	69.9	32.4
Range	27-37.6	–5.6-31.6	42.9-85.5	–16.5-66.3	35.4-49.0	0.0-38.6	43.4-106.4	-17.8-101.5
JEX/B 998	28.6		51.4		35.4		52.8	
Kufri Ashoka	36.7		58.2					
Kufri Pukhraj					50.5		81.7	
CD (P = 0.05)	1.82		4.4		2.25		5.4	

Table 2 Average progeny means and range for progeny performance for different characters in different cross types based on pooled data of two seasons

Character	Parental crosses	Full-sib crosses	Half-sib crosses	Crosses between unrelated parents	Back crosses
Average progeny performance					
Tuber number/plot	370.6	384.1	406.3	403.4	388.0
Marketable yield (kg/plot)	14.80	15.90	19.40	19.96	16.72
Total yield (kg/plot)	15.78	16.83	20.29	20.86	17.70
Average tuber weight(g)	43.11	44.61	50.51	52.82	46.37
Per cent tuber dry weight	17.9	17.5	17.5	17.2	17.1
Range for progeny performance					
Tuber number/plot	307–444	251–509	356–468	314–669	296–462
Marketable yield (kg/plot)	13.2–16.8	11.6–21.1	17.7–21.2	17.5–21.9	13.1–20.4
Total yield (kg/plot)	14.1–17.9	12.3–22.2	18.6–22.1	18.5–22.9	13.9–21.5
Average tuber weight (g)	38.3–52.4	30.8–55.1	40.8–59.1	34.3–71.8	35.2–61.7
Percent tuber dry weight	17.8–17.9	15.8–19.1	14.7–19.1	15.6–19.3	14.9–18.6

of different cross types for tuber number, marketable yield, total yield, average tuber weight and percent tuber dry matter are given in Table 2. The range of progeny means in full-sibs, half-sibs, back-crosses and cross between unrelated parents

Table 3 Differences in different cross types for five characters based on pooled data of two seasons

Character	Difference in progeny means									
	PC-FS	PC-HS	PC-UP	PC-BC	FS-HS	FS-UP	FS-BC	HS-UP	HS-BC	UP-BC
Tuber number/plot	–13.5	–35.7	–2.8	–17.4	–22.2	–19.3	–3.9	2.9	18.3	15.4
Marketable yield (kg/plot)	–1.1	–4.6**	–5.16**	–1.92*	–3.5**	–4.05**	–1.82	–0.56	2.72**	3.23**
Total yield (kg/plot)	–1.05	–4.51**	–5.08**	–1.92*	–3.46**	–4.03**	–0.87	–0.57	2.59**	3.16**
Average tuber weight (g)	–1.50	–7.40*	–9.71**	–3.26*	–5.90**	8.21**	–1.76	–0.31	4.14*	6.45**
Percent tuber dry weight	0.4	0.4	0.7	0.8	0.0	0.3	0.4	0.3	0.4	0.1

Significance tested by t -Test (two sample assuming unequal variances)
**P*= 0.05; ***P*= 0.01; PC, parental crosses; FS, full-sib crosses; HS, half-sib crosses; UP, crosses between unrelated parent; BC, back crosses

for average tuber weight and percent tuber dry matter were in general higher than that for parental crosses. The range of progeny means for tuber number, marketable yield and total yield in different types of progenies except half-sibs were also higher than that for parental crosses. Half-sibs, back crosses and crosses between unrelated parents were significantly better than the parental crosses for the characters marketable yield, total yield and average tuber weight (Table 3). Half-sibs and crosses between unrelated parents were significantly better than full-sibs and back crosses progenies for the characters marketable yield, total yield and average tuber weight. For tuber number and percent tuber dry matter, no difference was observed among different types of progenies for progeny mean.

Lower yield and average tuber weight in full-sibs and back cross progenies as compared to half-sibs and cross between unrelated parents reflect the negative effect of inbreeding on these characters in Andigena. Inbreeding is known to adversely affect the performance of potato populations (Shonnard and Peloquin 1991) because in clonally propagated tetraploid potato heterozygosity is very important to exploit heterosis or hybrid vigour. Theoretically, the inbreeding coefficient (F) expected in cross among unrelated parents, half-sibs, full-sibs and back crosses are 0.000, 0.125, 0.250 and 0.250, respectively. Less F means comparatively more heterozygosity. So, the progeny performances of different types of crosses among improved Andigena clones suggest that for further improvement it is important to maintain heterozygosity. For improvement of Andigena with more cycles of recurrent selection Andigena × Andigena crosses among unrelated or comparatively less related accessions is more likely to be useful.

REFERENCES

Bradshaw J E and Ramsay G. 2005. Utilisation of the Commonwealth Potato collection in potato breeding. *Euphytica* **146**: 9–19.

Furumoto O, Plaisted R L and Ewing E E. 1991. Comparison of two techniques for introgression of unadapted andigena germplasm into temperate germplasm. *American Potato Journal* **68**: 391–404.

Gopal J, Chahal G S and Minocha J L. 2000. Progeny mean, heterosis and heterobeltiosis in *Solanum tuberosum* × *tuberosum* and *S. tuberosum* × *andigena* families under a short day sub-tropic environment. *Potato Research* **43**: 61–70.

Kumar R and Kang G S. 2006. Usefulness of Andigena (*Solanum tuberosum* ssp. andigena) genotypes as parents in breeding early bulking potato cultivars. *Euphytica* **150**: 107–15.

Kumar R, Kang G S, Pandey S K and Gopal J. 2011. Genetic base and relatedness of Indian early maturing potato (*Solanum tuberosum*) selections. *Journal of Agricultural Science* **149**: 217–25.

Rasco E T, Plaisted R L and Ewing E E. 1980. Photoperiod response and earliness of *S. tuberosum* ssp *andigena* after six cycles of recurrent selection for adaptation to long days. *American Potato Journal* **57**:435-47. Note Erratum *American Potato Journal* **58**: 50.

Shonnard G C and Peloquin S J. 1991. Performance of true potato seed families. 1. Effect of level of inbreeding. *Potato Research* **34**: 397–407.

Simmonds N W. 1966. Studies of the tetraploid potatoes. III. Progress in the experimental re-creation of the Tuberosum group. *Journal of Linnaean Society (Botany)* **59**: 279–88.

Tai G C C and Tarn T R. 1980. Multivariate analysis of potato hybrids, 2. Discrimination between Tuberosum-Andigena hybrid families and their relationship to their parents. *Canadian Journal of Genetics and Cytology* **22**: 279–86.