

COMPARISON OF OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES FOR TUBER YIELD AND UNIFORMITY

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ABSTRACT

A series of field evaluations were carried out at Sita Eliya during three consecutive yala seasons (1987, 1988 and 1989) to select open pollinated (OP) and hybrid parents of potato that produce progenies with high tuber yield and uniformity. Estimation of general combining ability (GCA) effects for seedling tuber yields, of promising parents in the locally made crosses, showed that the male, OP parent 260/39 and the female parents Sita, Atzimba and 25/40 had significantly high GCA effects. In general, the 4x X 4x progenies were found to be significantly higher yielding than the OP and 4x (4x X 2x) progenies. The locally developed 4x X 4x progenies of Sita X 260/39, Atzimba X 260/39 and 25/40 X 260/39 emerged as promising with respect to seedling vigour, high tuber yield and acceptable tuber uniformity. It was also found that greater uniformity of seedling tubers can be obtained by selecting both parents with white, round and shallow-eyed tubers.

KEY WORDS: GCA effects, Hybrid TPS, Open pollinated TPS, Potato, Seedling tubers, TPS progenies

INTRODUCTION

The commonly cultivated potato, *Solanum tuberosum* (L) is an autotetraploid which has four basic sets of chromosomes ($2n = 4x = 48$) instead of the normal two; therefore, during sexual reproduction, the highly heterozygous parent lines produce numerous types of male and female gametes. These, through uncontrolled random mating, give rise to F_1 populations that segregate widely for plant traits (tetrasomic inheritance). A true potato seed (TPS) progeny or family produced either through open pollination (OP) or hybridization is thus a large collection of single plants that differ in their genetic constitution (genotypes). Hence, non-uniformity of tuber characteristics within a TPS population is a problem that has to be overcome in order to use TPS as an alternative method for potato production (Golmirzaie and Mendoza, 1988).

Selection of suitable progenies for uniformity, in economically important traits, is based on the selection of parent lines that are capable of producing high yielding progenies with sufficient phenotypic uniformity in tuber characteristics such as shape, colour, depth of eyes, plant type and maturity (Thompson and Mendoza, 1984).

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On comparing the performance of a large number of single crosses as well as bulk crosses and multi-lines along with selfed and OP material, Mendoza (1984) found significant differences in favour of hybrid material with respect to germination, transplant survival and tuber yield. On the other hand, a very notable advantage of OP progenies is that TPS production does not require controlled hand pollination, and the cost of producing OP seed is only a small fraction compared with hybrid seed.

Golmirzaie and Mendoza (1985) stated that it is possible to obtain progenies from $4x \times 4x$ crosses with acceptable uniformity and high yield, especially if the parental lines have a wide genetic background. Mendoza (1983) reported that for using TPS in commercial potato production, it is important to identify parental clones with a high general combining ability (GCA) for tuber yield and tuber uniformity. Uniform tuber colour in a TPS progeny can be attained by selecting parent lines that lack anthocyanin pigmentation in tubers (Salaman, 1926), a trait that precludes the possibility of segregating for tuber colour, and hence produce only white tubers. Therefore, the purpose of this study was to select open pollinated and hybrid parents that produce progenies with good seedling vigour, high tuber yield and high tuber uniformity.

MATERIALS AND METHODS

Hybridization

Hybrid TPS production by hand pollination using the inter-tetraploid ($4x \times 4x$) breeding scheme was initiated in yala 1986. Nineteen crosses were made with the three best OP lines or genotypes 16/17, 27/40 and 260/39 (Abeytunge, 1992) as male parents and eleven other female parents. Seven of the female parents used were Isna, Sita, Atzimba, 25/40 and the three International Potato Centre (CIP) clones, 575003 (SE1), 676028 (SE8) and 575005 (SE14), selected for their profuse flowering, self incompatibility, local adaptability, and white, round and shallow-eyed tubers. Isna and Sita are varieties recommended for cultivation in Sri Lanka and Atzimba is a late blight (*Phytophthora infestans*) resistant TPS parent from CIP while the line 25/40 is a selection from the previous studies. The remaining four female parents were OP lines 17/13, 110/26, 14/83 and 10/19. Five reciprocal crosses were also made using the three OP lines 16/17, 27/40 and 260/39.

In yala 1987, seventeen inter-tetraploid crosses were made, with five male parents and 12 female parents. The five male parents included the three used in the previous year and two other OP lines, 12.10/85B and the commercial variety Desiree, which produces TPS in the mid country of Sri Lanka. The female parents included the seven self incompatible clones and the two OP lines 17/13 and 110/26 used in the previous year; and the OPs Tollocan and 12/34; and the self incompatible CIP clones CFK 69.1. Five reciprocal crosses were also made among the OP lines 27/40, 260/39 and Desiree. Table 1 gives the list of crosses made in 1986 and 1987.

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

Table 1. Crosses made of promising female and male potato lines in 1986 and 1987 - ARS, Sita Eliya

1986	1987
Crosses between self incompatible lines and promising male parents	
Isna X 260/39	Isna X Desiree
Isna X 27/40	Sita X 16/17
Isna X 16/17	Sita X 260/39
Sita X 260/39	Atzimba X 260/39
Sita X 27/40	Atzimba X 16/17
Sita X 16/17	Atzimba X 12/10.85B
Atzimba X 260/39	25/40 X 260/39
25/40 X 260/39	SE1 X 27/40
25/40 X 16/17	SE1 X 12/10.85B
SE1 X 260/39	SE8 X 27/40
SE8 X 260/39	SE14 X 260/39
SE8 X 16/17	CFK 69.1 X 260/39
SE14 X 260/39	CFK 69.1 X 27/40
Crosses between OP lines and promising male parents	
17/13 X 260/39	17/13 X 12/10.85B
17/13 X 16/17	110/26 X 12/10.85B
110/26 X 260/39	Tollocan X 260/39
110/26 X 16/17	12/34 X 16/17
14/83 X 16/17	
10/19 X 16/17	
Reciprocal crosses made among OP parents	
16/17 X 260/39	27/40 X Desiree
260/39 X 16/17	Desiree X 27/40
16/17 X 27/40	27/40 X 260/39
27/40 X 16/17	Desiree X 260/39
260/39 X 27/40	260/39 X 16/17

Evaluation of OP and hybrid TPS progenies

These hybrids were evaluated in the field during yala '87, '88 and '89 at the Agricultural Research Station (ARS), Sita Eliya (6°58'N; 80°46'E and 2060m above mean sea level).

Yala 1987: The hybrid TPS of the 24 crosses, made in 1986 along with 9 hybrid TPS progenies from CIP and four locally selected OP, TPS progenies were tested in yala 1987. Six of the CIP crosses were of 4x X 4x origin while other six were three-way hybrids of 4x (4x X 2x) origin, where the male parents (DTO 28 and DTO 33) resulted from tetraploid - diploid hybrids. The true seeds of the 37 progenies were sown in nurseries made with sterilised substrate consisting of subsoil, well-rotted farmyard manure or compost and sand in the ratio of 1:1:1. Standard cultural management practices and plant protection procedures for raising a TPS crop were followed according to the Technoguide of Abeytunge and Abeytunge (1988). The seedlings of the 37 progenies were transplanted at the rate of 75 plants/m² in raised beds of size 2m² (2 x 1m) in a RCBD with two replicates. Visual observations on seedling vigour were recorded at 4 and 8 weeks after transplanting. Scoring for field resistance to late blight was done using the British Mycological Society Key (FAO, 1973). Relative maturity of the progenies was rated, on the degree of senescence of vines in 50% of the plants in a treatment (Huaman *et al.*, 1977). The total weight and number of seedling tubers at harvest were recorded for statistical analysis. The tuber uniformity in each progeny was visually assessed on a 1-4 scale of increasing uniformity, taking into account the skin colour, tuber shape and depth of eyes.

Yala 1988: The hybrid TPS of the 22 crosses made in yala 1987 were evaluated with six OP, TPS progenies during yala 1988. Seedlings of all the 28 progenies were transplanted at a spacing of 0.45m x 0.1m in 3m² plots consisting of ridges and furrows. There were 22 plants/m² and the treatments were arranged in a RCBD with three replications. Due to considerable difficulties arising from bringing large amounts of disease-free soil from elsewhere for earthing-up at regular intervals, for the raised bed method, the ridge and furrow method was used from this season onwards. The total tuber weight, number of tubers and tuber uniformity were recorded as before.

Yala 1989: In yala 1989, hybrid TPS of five promising local 4x X 4x crosses were tested with 10 introduced TPS progenies that consisted of four 4 x X 4x crosses, one three-way hybrid, and one OP from CIP, and four 4x X 4x crosses from India. Seedlings of the 15 progenies were transplanted at a spacing of 0.45m X 0.1m in 4.05 m² plots consisting of ridges and furrows. There were 22 plants/m² and the treatments were replicated three times in a RCBD. Tuber yield, tuber number and tuber uniformity were recorded as before. The tuber sizes were classified into three categories; ≥ 45 mm, 45-25 mm and ≤ 25 mm, using two grids of mesh size 45 mm² and 25 mm². Seedling vigour of each progeny was assessed by visually rating the plant cover per plot as a percentage of ground cover at 55 days after transplanting. The field resistance to late blight was recorded as before.

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

The General Combining Ability (GCA) effects

GCA for yield of the selected parents in experiments done in yala 87 and 88, was determined by comparing the mean of samples having a common male or female parent, with the mean of the entire population consisting of all treatments in the particular experiment using the t-statistic given below.

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

where $\bar{x}$ = mean of the sample; μ = mean of the population; s = standard deviation of the population; n = number of observations and $s/\sqrt{n}$ = standard error of the mean. If $\bar{x}$ is significantly greater than μ , the common parent (either male or female) in the sample is selected as having a good GCA effect. This statistic has also been used by Rowel *et al.* (1986)

RESULTS AND DISCUSSION

Evaluation of OP and hybrid TPS progenies

Yala 1987: Tuber yields and agronomic characteristics of the 37 different progenies evaluated in yala 1987 are presented in Table 2. The mean tuber yields among the treatments differed significantly ($P = 0.05$). Some $4x \times 4x$ progenies were uniform and gave higher tuber yields than OP and $4x(4x \times 2x)$ progenies. Mendoza (1979) and Peloquin (1979) have also reported similar findings where selected inter-tetraploid crosses were described as capable of producing uniform and high yielding progenies. Out of the local $4x \times 4x$ progenies, Atzimba X 260/39, Sita X 260/39, SE1 x 260/39, 25/40 X 260/39 and Isna X 16/17 gave high yields ranging from 56.1 to 68.2 t/ha, with uniform tubers, good seedling vigour, slight to fair resistance to late blight, and were early maturing. Out of the CIP $4x \times 4x$ crosses, Atzimba X 104. 12LB gave the highest yield of 78.8 t/ha followed by the second potential cross, Atzimba X LT-7 (62.5 t/ha). Both these progenies had uniform tubers, good seedling vigour and fair resistance to late blight; they were also early maturing.

Although, the $4x \times 4x$ progenies of Isna X 27/40 and Sita X 27/40 (local crosses), and the three CIP $4x \times 4x$ progenies of Atzimba X R128.6, Serrana X R128.6 and Atzimba X 4.1D1 gave very high yields (>65 t/ha), they lacked the desired tuber uniformity, which was considered an important criterion in the selection of TPS progenies for seed potato production. This was due to one or both parents being red-tubered. The remaining $4x \times 4x$ progenies were also considered unsuitable due to their non-uniform seedling tubers or poor to medium seedling vigour, or susceptibility to late blight, or long age.

Table 2. Performance of hybrid and OP, TPS progenies during yala 1987 - ARS, Sita Eliya

TPS progenies	Total yield (t/ha)	Mean tuber		Tuber uniformity*	Seedling vigour	Relative maturity**	Late blight resistance***
		no/m ²	wt(g)				
Local crosses							
(4x X 4x)							
17/13 X 260/39	53.0	405	13.1	nu	Good	3	SR
110/26 X 260/39	44.2	335	13.2	u	Good	3	SR
Sita X 260/39	65.5	501	13.1	u	Good	2	SR
Isna X 260/39	49.2	393	12.5	u	Medium	3	S
16/17 X 260/39	39.7	267	14.9	u	Good	1	SR
SE8 X 260/39	51.7	378	13.7	u	Poor	1	S
25/40 X 260/39	62.7	474	13.2	u	Good	1	FR
Atzimba X 260/39	68.2	525	13.0	u	Good	1	FR
SE14 X 260/39	59.7	467	12.9	u	Medium	4	FR
SE1 X 260/39	65.0	514	12.6	u	Good	1	FR
16/17 X 27/40	43.1	280	15.4	nu	Medium	3	SR
260/39 X 27/40	53.0	412	12.8	nu	Medium	4	SR
Sita X 27/40	67.0	505	13.3	nu	Good	2	FR
Isna X 27/40	76.7	553	13.9	nu	Good	3	FR
17/13 X 16/17	53.2	410	13.0	nu	Good	4	SR
110/26 X 16/17	38.6	260	14.8	u	Good	3	SR
14/83 X 16/17	36.7	250	14.6	u	Medium	3	SR
25/40 X 16/17	42.1	271	15.5	u	Medium	1	SR
SE8 X 16/17	51.7	402	12.9	u	Medium	4	S
260/39 X 16/17	39.2	308	12.7	u	Medium	3	S
Sita X 16/17	61.0	476	12.8	u	Medium	4	FR
Isna X 16/17	56.1	403	13.9	u	Good	1	FR
10/19 X 16/17	49.2	353	13.9	u	Medium	4	SR
27/40 X 16/17	40.5	349	11.6	nu	Medium	3	FR

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

Table 2. (Continued)

TPS progenies	Total yield (t/ha)	Mean tuber		Tuber uniformity*	Seedling vigour	Relative maturity**	Late blight resistance***
		no/m ²	wt(g)				
CIP crosses							
(4x X 4x)							
Atzimba X 104.12LB	78.8	533	13.7	u	Good	1	FR
Atzimba X R.128.6	75.8	596	12.7	nu	Good	2	FR
Atzimba X L.T-7	62.5	441	14.2	u	Good	2	FR
Serrana X R.128.6	67.5	453	14.9	nu	Poor	2	FR
Atzimba X 7 XY.1	67.5	463	14.5	u	Medium	3	FR
Atzimba X 4.1D1	67.5	460	14.6	nu	Poor	3	FR
4x(4x X 2x)							
CFK 69.1 X DTO 33	49.7	396	12.5	nu	Good	1	SR
CEX 69.1 X DTO 28	54.8	403	13.6	nu	Good	1	SR
Serrana X DTO 33	57.5	378	15.2	nu	Medium	3	VS
Local OP families							
260/39	52.5	430	9.8	u	Medium	5	SR
27/40	50.0	389	12.8	nu	Medium	5	SR
16/17	56.0	425	13.1	u	Medium	5	SR
110/26	39.0	315	12.3	u	Medium	5	SR
LSD (0.05)	10.8						
CI (0.95)		$\bar{X} \pm 28.3$	$\bar{X} \pm 0.4$				

* u = uniform; nu = non-uniform; ** 1 = very early; 5 = very late; *** FR = fairly resistant; SR = slightly resistant; S = susceptible; VS = very susceptible; CI = confidence interval

The seedling tuber yields of the three 4x (4x X 2x) progenies, CFK 69.1 X DTO 33, CEX 69.1 X DTO 28 and Serrana X DTO 33 were not significantly different from that of the three locally identified OP progenies, 16/17, 260/39 and 27/40. Also the seedling tubers of the three, 3-way hybrid progenies were non-uniform in appearance, segregating for tuber colour, shape and depth of eyes. Quinn and Peloquin (1973), and Macaso-Khwaja and Peloquin (1983) made similar observations and attributed this to the diploid (primitive) origin of the male parents DTO 28 and DTO 33, while those of OP parents, 16/17 and 260/39 were uniformly white, round and shallow-eyed, and hence can be considered superior to the three, 3-way hybrid progenies. The OP, 27/40 due to its inherent red tuber colour and deep eyes produced seedling tubers that segregated for colour and depth of eyes. In general, the hybrid progenies were found to mature earlier than the OPs.

The mean tuber number/m² of the treatments was very significantly correlated ($r=0.95$) with tuber yields. The 95% confidence interval of the population correlation coefficient (0.95 Clr) was 0.92-0.97 (Freund, 1974). This shows that it was the higher tuber number resulting from the high plant population (75/m²) that contributed to the yield rather than the mean tuber weight, which in this experiment was not correlated with the yield.

Yala 1988: Table 3 gives the performance in 1988, of 22 hybrid 4x X 4x and four OP progenies developed at Sita Eliya along with OP progenies of Tollocan and Desiree. Thirteen of the hybrid progenies significantly ($P = 0.05$) outyielded the highest yielding OP progeny of 27/40. The progenies of 27/40, 260/39 and 12.10/85B gave comparable yields. However, the population mean yield (23.8 t/ha) in 1988 was 43% lower than that of 1987 (55.3 t/ha). Out of the 13 high yielding hybrid progenies, the five that were tested during the two seasons were, Sita X 260/39, 25/40 X 260/39, Atzimba X 260/39, SE14 X 260/39 and Sita X 16/17. These progenies produced uniformly white, round and shallow-eyed tubers and their yields ranged from 30.3 to 37.1 t/ha, showing a consistent trend for high yield as in the previous year (59.7 to 68.2 t/ha). Out of the remaining eight hybrid progenies, CFK 69.1 X 260/39 and CFK 69.1 X 27/40, though very high yielding, produced tubers that segregated for colour, shape and depth of eyes. The progeny, Atzimba X 12.10/85B, produced tubers with acceptable uniformity, while the other five were found to be unsuitable for seed potato production, either due to non-uniform tubers or late blight susceptibility or comparatively low yields.

The correlation of tuber number with the tuber yield was found to be low ($r=0.69$) in the season, which was due to the low plant population adopted (22/m²) and the mean tuber number/m² was only 191 as compared with the mean of 410 tubers per m² in 1987. The mean tuber weight which had no correlation with tuber yield in the previous season was found to be very significant during this season ($r=0.81$) with a 0.95 Clr of 0.63 - 0.91. This is probably due to the increased

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

Table 3. Performance of local hybrid and OP, TPS progenies during yala 1988 - ARS, Sita Eliya

TPS progenies	Tuber yield (t/ha)	Mean tuber		Late blight resistance *	Tuber uniformity**
		no/m ²	wt (g)		
4x X 4x crosses					
Tollocan x 260/39	26.3	180	14.6	VS	u
CFK 69.1 x 260/39	52.2	270	19.3	FR	nu
Desiree x 260/39	25.4	140	18.5	VS	nu
SE 14 x 260/39	31.2	189	16.5	FR	u
Atzimba x 260/39	32.0	203	15.6	FR	u
25/40 x 260/39	34.3	228	15.0	FR	u
27/40 x 260/39	29.4	217	13.5	FR	nu
Sita x 260/39	37.1	218	17.0	SR	u
SE 1 x 27/40	22.0	160	13.7	SR	nu
CFK 69.1 x 27/40	41.0	244	16.7	FR	nu
SE 8 x 27/40	31.0	191	16.1	FR	nu
Desiree x 27/40	20.0	171	11.7	VS	nu
260/39 x 16/17	20.0	204	9.8	SR	u
Sita x 16/17	30.3	251	12.0	SR	u
Atzimba x 16/17	21.0	256	8.2	SR	u
12/34 x 16/17	10.5	165	6.3	S	nu
Isna x Desiree	26.3	183	12.0	VS	nu
27/40 x Desiree	10.2	151	6.7	VS	nu
SE 1 x 12.10/85	26.4	207	12.7	S	u
17/13 x 12.10/85	25.3	247	18.5	S	nu
110/26 x 12.10/85	17.2	215	7.9	S	u
Atzimba x 12.10/85	33.8	247	13.6	SR	u
OP lines					
Tollocan	16.6	165	10.0	VS	u
260/39	21.1	143	14.6	S	u
27/40	22.0	173	12.6	FR	nu
16/17	10.6	155	6.8	S	u
Desiree	11.0	124	8.9	VS	nu
12.10/85	20.2	184	10.9	S	u
LSD (0.05)	3.7	56.7	3.4		

* FR = fairly resistant; SR = slightly resistant; S = susceptible; VS = very susceptible

** u = uniform; nu = non-uniform

per tuber weight brought on by the wider spacing used. Spacing studies carried out earlier (Seasonal Research Reports 1986, ARS, Sita Eliya. Unpubl.) with transplanted seedlings at populations of 10, 25, 50 and 100/m² have not shown significant differences in tuber yields. However, there were significant differences in tuber numbers according to the different plant spacing treatments. Based on these studies the yield differences observed in 1987 and 1988, can be attributed to the seasonal differences and not to the different plant populations (75 and 22 seedlings/m² respectively) used in the two experiments.

The high rainfall during March and April 1988 (Table 4) which coincided with seedling and tuber development stages, contributed to high late blight incidence. This resulted in low yields as compared with the favourable season in 1987. The important phenological stages of the crop in 1987 received well-distributed rainfall comparable to the long term monthly means. The higher mean monthly bright sunshine hours/day during 1987, as compared with 1988, also was conducive to high yields. These results indicate that the strength of correlation between yield, tuber number, and the mean tuber weight depended on the seasonal differences and the different plant

Table 4. Monthly rainfall and mean monthly bright sunshine hours/day at Sita Eliya during yala 1987, 1988 and 1989

Month	Rainfall (mm)				Sunshine (h/d)			
	1987	1988	1989	30 yr average	1987	1988	1989	10 yr average
February	11	44	9	76	9.2	7.1	9.0	5.8
March	63	154	68	97	7.8	6.9	7.9	6.4
April	185	377	108	154	6.4	5.4	6.7	5.2
May	350	94	238	237	5.9	5.2	5.3	3.3
June	128	98	190	266	5.1	4.7	4.7	2.8

populations of the two experiments. Therefore, the calculation of GCA effects with respect to yield components, and the seed tuber size categories, as done by some authors (Rowell *et al.*, 1986) was not followed in the present study. Tuber yield was the only parameter used in the calculation.

GCA is defined as the mean performance of a parent line in a series of crosses with other lines (Falconer, 1960). The performance of the progenies from such crosses can be predicted only if the GCA effects of the parents are significant. Therefore, the GCA effects of the promising parents in the two seasons were determined to identify the desirable parental combinations that can produce high yielding progenies.

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

The results showed that none of the male parents had significant positive GCA effects when compared with the population mean (Table 5). Atzimba was the only female parent that gave a very significant GCA effect at $P=0.025$. Atzimba and Sita when used as female parents have given consistently high yields (>60 t/ha) in all the combinations as compared with the other two female parents, 25/40 and Isna (Table 2). Due to the well-distributed rainfall and low incidence of late blight, and higher daily sunshine hours during the season (Table 4), all the treatments performed well in general ($\mu=55.3$ t/ha). This may be the reason why the GCA effects did not come out clearly.

Table 5. Sample means ($\bar{x}$) of seedling tuber yields of selected parents and their GCA effects - yala 1987

Parent	Sample size	$\bar{x}$ (t/ha)	$\bar{x}-\mu$	GCA effects
Male				
16/17	20	46.8	-8.4	NS
260/39	20	56.4	+1.1	NS
27/40	8	59.9	+4.6	NS
Female				
Atzimba	12	69.2	+13.9	*($P=0.025$)
Sita	6	64.5	+9.2	NS
25/40	4	52.4	-2.9	NS
Isna	6	60.7	+5.4	NS

Population mean (μ) = 55.3 t/ha; NS = not significant

In yala 1988 the GCA effects were distinct (Table 6). Of the male parents, OPs 260/39 and 27/40 have shown significant positive GCA effects. The sample means being 33.4 t/ha and 28.4 t/ha. The male parents, 16/17 and Desiree were not found to be suitable due to negative GCA effects. The male parent 12.10/85 gave a positive GCA effect but was not significant. All the female parents, CFK69.1, 24/40, Sita and Atzimba have shown significantly high GCA effects. The female parent 25/40, though had a negative GCA effect during 1987, has revealed a significant positive GCA effect during 1988.

Yala 1989: All the 14 hybrid progenies tested during yala 1989 (Table 7) out yielded significantly the CIP progeny, OP 104.12 LB. This progeny also showed poor plant cover, due to low seedling vigour and susceptibility to late blight. In general, the $4x \times 4x$ progenies performed better than the $4x(4x \times 2x)$ progeny of CEX 69.1 X DTO 33, with respect to tuber yield, percent plant cover and

Table 6. Sample means ($\bar{x}$) of seedling tuber yields of selected parents and their GCA effects - yala 1988

Parent	Sample size	$\bar{x}$ (t/ha)	$\bar{x}-\mu$	GCA effects
Male				
16/17	12	20.5	-3.3	NS
260/39	24	33.4	+9.7	* (P=0.005)
27/40	12	28.4	+4.7	* (P=0.05)
12.10/85B	12	25.7	+1.9	NS
Desiree	6	15.9	-7.9	* (P=0.01)
Female				
Atzimba	9	28.8	+5.1	* (P=0.05)
Sita	6	33.7	+9.9	* (P=0.005)
25/40	3	34.3	+10.5	* (P=0.025)
CFK 69.1	6	46.5	+22.8	* (P=0.005)

Population mean (μ) = 23.8 t/ha; NS = not significant

late blight resistance. When comparing the yields of the 4x X 4x progenies, the locally developed progeny of Sita X 260/39 gave yields of 46.4 t/ha, outyielding significantly the high yielding progenies, CEX 69.1 X R 128,6 from CIP, and HPS 7/111 and HPS 1/PPL-67 from India. The yield of the local progeny, Atzimba X 260/39 was 36.7 t/ha and was at par with the high yielding progenies from CIP and India, while the yields of the two local progenies CFK 69.1 X 260/39 and 25/40 X 260/39 were very high and comparable to Sita X 260/39. In the high yielding progenies, the percent plant cover was above 90 and they were fairly resistant to late blight. However, the tuber uniformity was acceptable only in the three progenies, Sita X 260/39, Atzimba X 260/39 and 25/40 X 260/39. The superior performance of these three progenies was consistent with the results obtained in the previous two experiments. This also agrees with the findings of Kidane-Mariam *et al.* (1985) that 4x X 4x crossing method with locally adapted cultivars gives high progeny yields similar to standard cultivars and also allows more flexibility than the other breeding approaches.

Correlation analysis of the relationships of yield components showed that the total tuber number was strongly correlated with yield ($r=0.91$ and 0.95 C.I.r = $0.83 - 0.95$). This season, characterized by well-distributed rainfall and higher number of sunshine hours/d, as in 1987 (Table 4), may have brought about a greater extent of tuber initiation than in the previous unfavourable season (1988). The correlation coefficient of yield with the mean tuber weight was also significant

Table 7. Performance of local and introduced TPS progenies during yala 1989 - ARS, Sita Eliya

TPS progenies	Total yield (t/ha)	Total tuber (no/m ²)	Marketable yield of tubers of different sizes (t/ha)			Mean tuber wt (g)	Tuber uniformity *	Plant cover (%)	Late blight resistance **
			≥45 mm	45 - 25 mm	≤25 mm				
Local crosses									
(4x X 4x)									
Sita x 260/39	46.4	134	11.9	30.4	1.8	34.3	u	100	FR
Atzimba x 260/39	36.7	118	6.8	26.3	1.6	30.9	u	100	FR
CKF69.1 x 260/39	43.0	149	8.7	31.2	2.2	28.8	nu	100	FR
25/40 x 260/39	44.1	165	8.8	31.6	2.3	26.8	u	100	FR
Tollocan X 260/39	20.0	90	3.4	14.2	2.2	22.2	u	60	S
CIP crosses									
(4x X 4x)									
CEX69.1 X R128.6	31.4	103	7.4	20.1	1.6	30.5	nu	90	FR
Atzimba X 7XY.1	27.1	101	4.9	15.5	1.8	27.1	u	75	FR
Atzimba X R128.6	22.4	64	5.6	12.8	0.9	33.8	nu	80	S
Atlantic X LT-7	13.5	62	1.1	10.3	1.5	20.9	u	50	VS
4x (4x X 2x)									
CEX69.1 X DTO 33	15.1	69	3.1	9.9	1.1	21.8	nu	50	VS

Table 7. (Continued)

TPS progenies	Total yield (t/ha)	Total tuber (no/m ²)	Marketable yield of tubers of different sizes (t/ha)			Mean tuber wt (g)	Tuber uniformity *	Plant cover (%)	Late blight resistance **
			≥45 mm	45 - 25 mm	≤25 mm				
CIP, OP family									
104.12LB	7.7	32	1.6	5.1	0.6	23.8	nu	50	VS
Indian crosses									
(4x X 4x)									
HPS2/30	19.3	103	1.6	15.1	2.4	19.1	u	50	VS
HPS1/30	16.4	72	2.0	12.1	1.5	22.5	u	60	S
HPS7/111	36.1	114	9.3	24.1	1.5	31.4	nu	90	FR
HPS1/PPL-67	38.8	119	10.2	24.7	2.4	32.5	nu	100	FR
LSD (0.05)	7.0	22	3.2	4.9	1.0	5.6			

* u = uniform; nu = non-uniform; ** FR = fairly resistant; S = susceptible; VS = very susceptible

OPEN POLLINATED AND HYBRID TRUE POTATO SEED PROGENIES

($r=0.69$ and 0.95 CI $r = 0.50 - 0.82$) as in 1988 due to the same wide spacing adopted. The tuber number in the size category of 45 - 25 mm had the highest correlation with the yield ($r=0.93$ and 0.95 CI $r = 0.87 - 0.96$), indicating that most of the seedling tubers produced were of the suitable size for use as seed tubers. The results of the three seasons show that at high density planting it is the tuber number that predominantly determine the yield, while at low density both tuber number and mean tuber weight contribute to the final yield. At the same time the climatic factors also have an influence on the yield components in affecting the final yield.

CONCLUSIONS

Suitable tetraploid parents were identified for hybrid TPS production at high altitudes of Sri Lanka, by evaluating their GCA effects based on progeny yields. They are the male parents 260/39 and 27/40, and the female parents Sita, Atzimba, 25/40 and CFK 69.1. A consistent trend was observed during all three seasons for high yields in the $4x \times 4x$ group of progenies than in the OP and the $4x (4x \times 2x)$ groups of progenies. Comparison of tuber yield together with tuber uniformity among the above progenies enabled the identification of the three inter-tetraploid crosses Sita $\times$ 260/39, Atzimba $\times$ 260/39 and 25/40 $\times$ 260/39 as being superior; producing high yields with high tuber uniformity. This shows that a successful TPS technology can be developed with promising $4x \times 4x$ crosses, which produce progenies that combine yield with other useful traits.

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TROPICAL AGRICULTURIST, VOL. 148, 1992

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