

OPEN POLLINATED LINES FOR TRUE POTATO SEED PRODUCTION

SELECTION OF OPEN POLLINATED LINES FOR TRUE POTATO SEED PRODUCTION

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ABSTRACT

The degree of flowering and berry setting under field conditions at the Agricultural Research Station, Sita Eliya, were studied in 583 potato lines derived from several crosses, with the objective of selecting suitable open pollinated (OP) lines for true potato seed (TPS) production. From studies conducted over four seasons, four promising lines 27/40, 12/34, 16/17 and 260/39 were identified. In general, a seasonal difference was observed for flowering and berry setting among the lines. A high degree of flowering and berry production was observed during the yala season. A planting date experiment conducted with 8 selected OP lines, showed that plantings during mid-February were the best for maximum berry production. TPS quality studies with 19 entries showed a positive correlation between average berry weight and seed number/berry; and a negative correlation between seed number/berry and 100 TPS weight.

KEY WORDS: Berry set, Flowering, Open pollinated lines, Potato, True potato seed

INTRODUCTION

The annual extent under potato cultivation in Sri Lanka is about 7500 ha and is concentrated in the Nuwara Eliya district (upcountry wet zone), Badulla district (upcountry intermediate zone), and the Jaffna and Kalpitiya regions (low country dry zone). The annual seed potato requirement is around 18000-19000 t, of which about 2000 t are locally multiplied in government seed farms and other private seed producing organizations. About 2000 t are imported at very high costs. Apart from its high cost, there is a risk of introducing tuber-borne diseases and pests through imported seed tubers. The balance seed requirement is produced by farmers. Seed potatoes produced by farmers are often of poor quality due to repeated and indiscriminate multiplication.

The non-availability and high costs of good quality planting material is identified as a major constraint to potato cultivation in Sri Lanka. The goal of the Department of Agriculture (DOA) is to reduce seed potato imports by producing good quality seed potatoes in sufficient quantities within the country. True potato seed (TPS) technology is one of the alternatives available for the production of cheap and disease-free planting material. TPS is an efficient barrier against most of the tuber-transmitted diseases (Jones, 1982). Reduced costs of transportation, storage and distribution are added advantages.

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TPS research was started by the International Potato Centre (CIP) in many developing countries (Golmirzaie and Mendoza, 1988). By about 1986, the work was in progress in 38 countries and TPS was grown in farmers' fields in 8 countries (Umaerus, 1987). The majority of the countries were in South Asia and the Far East. Most striking achievements have been reported in China in 1979 (Song Bofu *et al.*, 1987), where a total of 25000 ha was cultivated with seedling tubers (from TPS), and second, third and fourth generation tubers (seedling tubers multiplied).

The production of TPS meets with difficulties in warm tropical areas with a short photoperiod. Clarke and Lombard (1939) found that a long photoperiod of 14-18 h is essential for increased flowering and berry set in potato. However, Pushkarnath (1964) has indicated that cooler temperatures in high altitude tropics may have effects similar to the long day effect in enhancing flowering and berry production in certain cultivars.

Most of the potato varieties do not generally flower under Sri Lankan conditions. Certain cultivars exhibit only sparse flowering while some varieties flower profusely, but do not set berries. Poor berry set observed in some varieties grown in the mid elevations of Sri Lanka may be due to reduced pollen fertility resulting from high temperatures (Malagamba, 1988). Therefore, the work reported in this paper was carried out to identify open-pollinated high yielding lines that flower and set berries freely. A time of planting study was conducted to determine the best planting date for successful berry production. The association between some important quality characteristics such as berry weight, seed number per berry and 100 TPS weight of 19 open pollinated lines was also studied.

MATERIALS AND METHODS

Source of materials

Two separate consignments, identified as Series 3793 and Series 3796 consisting of bulked first filial generations (F₁) of a large number of crosses were received from CIP in 1980. Single plant and bulk selections had been done at the Agricultural Research Station (ARS), Sita Eliya for late blight resistance and tuber shape during 1981 to 1983 (Dr.V.Yogarajnam, Unpublished data). This germplasm was used as the source material for this study.

Germplasm screening experiment

Field experiments were conducted for 4 seasons (maha 1984/85, yala 1985, maha 1985/86 and yala 1986) at the ARS, Sita Eliya for the selection of OP lines suitable for TPS production. Sita Eliya (6° 58'N; 80° 46'E) situated at an altitude of 2060 m above mean sea level has a mean annual daily temperature of 15°C.

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In the first season (maha 84/85), a total of 490 lines was planted in October 1984. Two rows of each line were planted with ten tubers per row at a spacing of 60 cm x 30 cm as recommended by the DOA (Anon, 1990). Other agronomic and plant protection procedures were also carried out according to DOA recommendations. The difficulty of working with a large number of lines and the insufficiency of seed potatoes of each line precluded replicated experimentation.

The following observations were made for each entry:

- * Degree of flowering, based on visual observations made at peak flowering (9 to 10 weeks after planting), according to the scale given by Huaman *et al.* (1977).
- * Berry setting ability, by counting the number of berries harvested within each plot.
- * Field resistance to late blight, scored according to the British Mycological Society Key (FAO, 1973), at 5th, 8th and 10th week after planting. Based on the scores, the lines were classified into resistant, moderately resistant, slightly susceptible and susceptible. Fungicidal spraying was done at weekly intervals starting from 3rd to 4th week after planting.
- * Potential tuber yield (t/ha), based on the yield/m² obtained by harvesting the total number of plants surviving at harvest out of twenty planted.
- * Tuber colour, shape and depth of eyes, by visual observations made in the laboratory.

Single plant selections were made wherever there were substantial within - plot differences for degree of flowering and berries per plant. These selected single plants were harvested individually and new reference numbers were given. Lines 260/39, 110/26 and 14/19A are examples. The morphological characters were recorded according to Huaman *et al.* (1977). Non flowering and infertile lines yielding over 0.6 kg/plant were also selected on their yielding ability for testing during the following yala season for their degree of flowering. Lines infested with Potato Leaf Roll Virus (PLRV) or prone to powdery scab or with deep eyes and odd shapes were rejected. A total of 174 lines was selected and carried forward.

* The 92 lines that were not ready for planting during the first season, along with 39 lines selected in the first season (remaining tubers from the planting material used in the first season) were included for evaluation in the second season

(yala 85). The 174 lines selected in the first season were again planted for evaluation in the third season (maha 85/86). Planting method, characterization and selection procedure in the second and third seasons were same as those followed in the first season.

Lines were selected by the following method: The lines were considered to be good performers if the line mean of a particular character was significantly better than the population mean of that character when all lines were pooled together. For this purpose, the 95% confidence interval of the population mean was computed.

Planting date experiment

The eight entries included in this study were 27/40, 12/34, 260/39, 19/54, 10/19, 110/26, 11/7 and 14/19A. Plantings were carried out at bi-weekly intervals from August 1985 through March 1986. However, plantings were not done in January to avoid possible damage due to frost, and not continued beyond March due to the strong wind and rain, which is the usual weather pattern during June and July at Sita Eliya. Eight tubers of each line were planted in single rows spaced at 60 cm x 30 cm. The degree of flowering and number of berries/m² were recorded as before.

Association between berry weight, TPS number per berry and 100 TPS weight

The 19 entries in the study included thirteen OP lines identified in the germplasm experiment, two OP clones, Tollocan (720054) and I-1039(676008) from CIP and four single plant selections, 12.10.85B, 124/85B, 125/85B and 126/85B made from the OP 12/34 progenies in 1985. In yala 1986, twenty tubers of each entry were planted in 3.6 m² plots at the spacing recommended by the DOA. Berries were harvested from each plot at weekly intervals starting from 3 months after planting. Berries were kept in the laboratory for an additional period of 2 weeks after harvest and allowed to ripen. The following characteristics were obtained from the mean values of randomly selected five berries per line (after rejecting the immature berries): berry weight (g), TPS number per berry (the TPS extracted was dried well and kept over silica gel in a desiccator for two days and counted) and seed index (100 seed weight in mg)

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RESULTS AND DISCUSSION

Germplasm screening experiment

Based on the performance during 3 seasons (maha 84/85, yala 85 and maha 85/86), 21 lines were identified for either profuse or moderate flowering. A description of the observed plant characteristics of the selected 21 lines is presented in Table 1. Seasonal differences were observed in the degree of flowering with enhanced flowering during yala. This was generally true for all the flowering lines identified. However, the line 27/40 flowered profusely both in yala and maha and its flowering appeared to be insensitive to seasonal differences. Berry production varied with the season. In general, high berry production was observed during yala season. However, a high degree of flowering was not always associated with high berry production. The degree of fertility differed in different lines and there was considerable genetic variability in traits such as flowering and berry setting. Similar observations have been reported by Malagamba (1988). In the profusely flowering, late blight resistant, white-tubered line 25/40, there was no berry set and the flowers aborted early. This may have been either due to self-incompatibility or pollen sterility. This line was identified as a good female parent for hybrid TPS production.

Eight lines were selected on the basis of their significantly high berry producing capacity. They were 10/19, 12/34, 16/17, 17/13, 14/19A, 27/40, 260/39 and 73/48. Out of these, 27/40 appeared to be the best OP with 167 berries/3m². The tuber yield of 27/40 ranged from 22-42 t/ha and the line showed resistance to late blight. However, its deep eyes and the deep red tuber colour were expected to segregate in the TPS progenies resulting in non-uniform tuber characteristics. Inheritance of tuber colour in potato is associated with the inheritance of anthocyanin pigmentation. In the absence of this pigment, the tuber appears white. The variation of colour from red to pink is due to the varying degree of concentration of the pigment (Salaman, 1926). TPS parents with pink or red colour will produce progenies that segregate for tuber colour and hence will not be uniform in appearance whereas a white parent will produce uniformly white tuber progenies.

The line 16/17 was the second most promising line that produced 127 berries/3m² and its tuber yield ranged from 23-42 t/ha. It showed slight susceptibility to

Table 1. Observed plant characteristics and yield of potato lines tested during 3 seasons at ARS, Sita Eliya

Progeny number (Bulked F ₁)	Line	Degree of flowering +				Berry no/3m ²				Potential yield (t/ha)		Late * blight resistance	Tuber appearance**		
		maha 84/85	yala 85	maha 85/86	maha 84/85	yala 85	maha 84/85	yala 85	maha 85/86	maha 84/85	yala 85		Skin colour	Shape	Eye depth
CIP 379398	5/8	S	M	S	2	18	3	FD	16.8	12.0	Sus	W/P	Oval	M	
CIP 379403	10/19	S	P	M	0	96	30	24.9	13.5	23.0	Sus	W	Round	Sh	
CIP 379404	11/7	P	P	S	6	65	0	27.6	10.1	34.0	Sus	W	Oval	Sh	
CIP 379405	12/34	P	NP	P	28	NP	26	65.7	NP	56.0	Res	W/P	Oval	Sh	
CIP 379407	14/83	M	P	S	0	16	0	77.0	29.3	34.2	Res	W	Round	Sh	
CIP 379409	16/17	M	P	P	22	127	30	38.5	23.6	42.0	Sl.S	B/W	Oval	Sh	
CIP 379410	17/13	Ab	M	S	0	74	0	FD	19.2	28.8	Sus	P	Round	Sh	
CIP 379412	19/54	Ab	M	Ab	0	26	0	30.2	22.9	33.0	Sus	W/P	Oval	D	
CIP 379407	14/19A	M	P	Ab	28	20	0	76.0	35.0	58.0	Sus	R	Round	D	
CIP 379424	31/64	Ab	M	Ab	0	31	0	27.5	22.9	17.5	Sus	W	Oval	D	
CIP 379420	27/40	P	P	P	30	167	39	22.3	31.3	42.0	Res	R	Round	D	
CIP 379420	27/86	S	P	S	0	34	0	44.0	54.0	48.0	Res	W	Oval	M	
CIP 379421	28/75	NP	P	S	NP	4	0	NP	32.4	20.0	Res	W	Oval	Sh	
CIP 379425	32/34	M	M	S	0	14	0	FD	16.2	48.3	Sus	B/W	Ro/Ov	M	
CIP 379428	35/46	Ab	M	Ab	0	16	0	FD	9.8	5.0	Res	P	Oval	Sh	
CIP 359657	55/98	Ab	P	Ab	0	4	0	27.5	26.7	25.6	Res	W/C	Oval	D	
CIP 379419	260/39	P	P	M	14	90	21	25.0	33.4	23.7	M.Res	W	Round	Sh	

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Table 1. (Continued)

Progeny number (Bulked F ₁)	Line	Degree of flowering *				Berry no/3m ²				Potential yield (t/ha)		Late * blight resistance	Tuber appearance**		
		maha 84/85	yala 85	maha 85/86	maha 84/85	yala 85	maha 85/86	yala 85	maha 84/85	maha 85/86	Skin colour		Shape	Eye depth	
CIP 379418	25/40	M	P	S	0	0	0	0	21.3	13.9	31.0	Res	B/W	Round	Sh
CIP 379683	73/48	NP	P	S	NP	82	0	0	NP	19.6	3.0	Sus	P	Round	Sh
CIP 379404	110/26	M	P	S	6	28	0	0	34.6	20.4	19.7	Sus	W	Oval	Sh
CIP 377258.2	92/2	S	M	S	0	4	0	0	33.0	44.5	33.0	M.Res	W/C	Oval	Sh
$\bar{X}$					7.1	45.8	7.4		38.3	24.8	30.4				
SE.					2.5	10.3	2.9		4.9	2.5	3.3				
CI(0.95)					1.7	24.1	1.2		27.8	19.5	23.5				
					to	to	to		to	to	to				
					12.5	67.5	13.6		48.8	30.1	37.3				
* Degree of flowering		*Late blight resistance						**Tuber appearance				NP = Not planted			
Ab = Absent		Sus	=	Susceptible		W	=	White		FD = Frost damage					
S = Sparse		SI.Sus	=	Slightly Susceptible		C	=	Cream							
M = Moderate		M.Res	=	Moderately Resistant		B	=	Brown							
P = Profuse		R	=	Resistant		P	=	Pink							
						R	=	Red							
						Sh	=	Shallow							
						M	=	Medium							
						D	=	Deep							
CI = Confidence interval															

late blight and its tubers were white, oval and shallow-eyed. Hence, it was expected to produce progenies with a high level of tuber uniformity. Similarly, the line 260/39 was identified for its high berry number (90 berries/3m²), acceptable tuber yield (23-33 t/ha), moderate resistance to late blight and good tuber appearance (white, round and shallow-eyed). The red line 14/19A which did not produce a high berry number (20 - 28 berries/3m²) was selected for its yielding ability (35-76 t/ha) and slight susceptibility to late blight. The lines 17/13 and 73/48 were selected for their berry yielding abilities, but were susceptible to late blight with low tuber yields and pink-coloured tubers. The line, 12/34 which gave a significantly high berry number during both maha seasons, could not be tested during yala 1985, due to unavailability of seed tubers. However, this line was subsequently included in the planting date experiment (Table 2) where its seasonal behaviour of berry production was similar to the other selected OPs justifying its selection for further testing. Although white OP lines are advantageous for TPS production, promising parents with red or pink coloured tubers were also selected for progeny testing because coloured parents may give rise to progenies with acceptable uniformity, a character which can only be ascertained after progeny testing. Hence, considering the overall performance of the lines selected on the basis of berry production, tuber yields and resistance to late blight, the lines 27/40, 16/17, 260/39 and 12/34 appeared more promising than the others.

Planting date experiment

The influence of planting date on the degree of flowering and berry number per m² in the 8 lines tested is shown in Table 2. Out of 16 planting dates from August 16, 1985 through March 17, 1986, data for December 30, January 31 and February 2 are not included in Table 2 as the plants were killed by frost.

The line 27/40 showed profuse flowering throughout, confirming its insensitivity to seasonal differences, but the other lines showed different degrees of flowering at different times of planting. In general, a high degree of flowering was observed in February plantings. The high degree of flowering during this period also corresponded to high berry production. The plantings made on August 16 and September 2, despite having a high degree of flowering, did not give a high berry set. The plantings from September 17 through December 18 showed a comparatively lesser degree of flowering and poor berry set.

Table 2. Influence of planting date on the degree of flowering and berry and berry production in some selected OP potato lines at ARS, Sita Eliya

Line	Planting date													
	Year 1985							Year 1986						
	Aug.	Sep.	Sep.	Oct.	Oct.	Nov.	Nov.	Dec.	Dec.	Feb.	Feb.	Feb.	Mar.	
	16	2	17	1	17	4	18	2	18	7	14	28	17	
	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2
27/40	P 19	P 12	P 9	P 20	P 13	P 12	P 10	P 20	P 22	P 40	P 102	P 60	P 20	
12/34	P 20	P 8	M 4	Ab 0	Ab 0	M 4	M 0	M 0	M 0	M 12	M 51	M 25	M 15	
260/39	P 19	P 20	M 3	M 13	M 7	M 7	M 0	M 0	M 0	P 30	P 73	P 20	M 9	
19/54	S 0	S 0	Ab 0	Ab 0	Ab 0	Ab 0	S 1	S 1	Ab 0	M 8	M 40	M 16	M 2	
10/19	P 16	P 5	M 5	M 9	M 0	M 4	M 4	M 4	M 3	P 15	P 48	P 22	M 8	
110/26	M 14	M 8	M 3	Ab 0	Ab 0	S 7	S 3	M 10	M 17	P 28	P 46	P 30	P 20	
11/7	M 0	M 4	M 0	Ab 0	Ab 0	Ab 0	Ab 0	Ab 0	Ab 0	M 18	M 29	S 1	S 0	
14/19A	M 0	M 13	M 0	Ab 0	Ab 0	Ab 0	Ab 0	Ab 0	Ab 0	M 10	M 27	M 12	S 3	
$\bar{X}$	11.0	8.5	5.2	5.2	3.7	4.2	2.2	4.4	5.2	20.1	52.0	28.2	9.6	
SE	3.3	2.2	2.8	2.8	1.9	1.5	1.2	2.5	3.2	4.0	8.7	6.1	2.8	

1 = Degree of flowering; 2 = Berry production (No. of berries/m²)
 Ab = Absent; S = Separate; M = Moderate; P = Profuse

The mean berry numbers for the plantings from August 16 through December 18 were very low, giving values less than 8.5 berries/m² (Table 2). There was an increasing trend for the February 7 and February 14 plantings, with the highest mean berry production (52 berries/m²) in February 14 planting. Thereafter, there was a progressive decrease in the berry number in all the lines tested.

In Nuwara Eliya, there is only a 45 minute day length difference between the shortest and the longest day of the year. However, the crops planted in February grow during a period of increasing day length whereas the September planted crops grow during a period of decreasing day length. The prevailing cool temperatures in the high altitude together with the progressively increasing day length during the growing period in yala appears to be conducive for increased flowering and berry production. This may account for the enhanced flowering and berry production observed in the February 7 - 14 plantings. However, strong winds and heavy rains prevalent during June-July, caused immature berries to shed in crops planted after February 14. Hence, low numbers of berries were harvested from these late plantings. Therefore, the planting done during February 7 - 14 is the best for maximum berry production. Even though, the difference between the shortest and the longest day of the year in this latitude is small, the influence of increasing day length on the degree of flowering was evident from the observed differences. Hence, it may be possible to increase flowering and berry production in Nuwara Eliya through artificially induced photoperiods.

Association between berry weight, TPS number per berry and 100 TPS weight

Table 3 presents the mean values of berry weight, TPS number per berry and 100 TPS weight of 19 entries. Quality of TPS influences the germination and early growth of seedlings. Dayal *et al.* (1984) have shown a positive correlation between 100 seed weight and tuber yield of the progeny. Seed size and seed weight are influenced by parent, genotype X environment interaction as well as maturity at harvest (Upadhya, 1986). In this study the linear correlation coefficient between the TPS number per berry and berry weight was found to be positive ($r = 0.64$) and significant ($P = 0.05$). The 95% confidence interval of the population correlation coefficient based on the Fisher transformation (Freund, 1974) was between 0.26 and 0.85 showing that it is subject to considerable chance fluctuations. The linear correlation coefficient between

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Table 3. Mean values of berry weight, TPS number per berry and 100 TPS weight of 19 selected entries in yala 1986

Entry	Single berry weight (g)	TPS/berry (number)	100 TPS weight (mg)
OP lines			
27/40	22.64	415	74.2
16/17	15.00	374	82.6
260/39	16.00	410	70.1
17/13	25.36	450	56.1
10/19	14.52	221	86.4
11/7	14.40	273	80.8
14/19A	14.58	395	58.9
12/34	13.60	350	60.2
110/26	20.00	355	83.1
32/34	11.63	265	84.3
27/86	13.86	336	79.8
31/64	14.60	399	65.9
19/54	10.60	253	74.2
Single plant selections			
12.10/85B	18.60	385	80.6
124/85B	17.06	271	90.5
125/85B	16.20	356	74.6
126/85B	17.30	390	70.8
Clones			
Tollocan	14.30	316	59.6
I - 1039	12.32	304	82.2

the 100 TPS weight and TPS number per berry was negative ($r = -0.58$) and significant ($P=0.05$). The 95% confidence interval of the correlation coefficient was between - 0.82 and - 0.17, showing again a high level of chance fluctuations. However, there were lines that combined both high seed number per berry (>400) and fairly high 100 TPS weight (>70 mg). Out of these, 27/40 and 260/39 were noteworthy in that they were also identified for high berry production.

CONCLUSIONS

The experiments reported here were successful in identifying lines suitable for TPS production in the high elevation areas of Nuwara Eliya. The yala season was found to be more favourable for flower and berry production of potato than the maha season, while mid-February plantings were the best for maximum berry production. The four OP parents selected for high berry production were 27/40, 12/34, 16/17 and 260/39. The line 27/40 was found to be insensitive to seasonal differences and thus could be a suitable variety for TPS production in the tropics. The line 25/40 identified as a female parent may be used for hybridization, whereby labour intensive and time consuming emasculating operations can be avoided.

The berry weight showed a positive correlation with TPS number per berry and hence will be an important parameter in the selection of lines for high TPS yield. The lines 27/40 and 260/39 that produced a large number of berries were also found to have a high seed number per berry as well as a desirable 100 TPS weight.

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