Ug. J. Agric. Sci. (1993), 1:29-35 ❖ Printed in Uganda.

Recent Advances in Solanum Potato Improvement in Uganda

L. Sikka and R. Kanzikwera,
Kalengyere Highland Research Station
P.O. Box 6, Kabale, Uganda.

(Accepted for publication in June 1992)

Abstract

The paper reviews the major production constraints for extension of potato production and the role of potato as an important food crop. Breeding techniques to develop tropical potato varieties with higher yield, wider adaptability, and better resistance to late blight and bacterial wilt are discussed. Genotypes, 381381.20, 374080.5-P3, 575049-CEW 69.1 and 381379.9 have been identified in different stages of assessment for high yield, disease resistance and drought tolerance. True Potato Seed (TPS) both as seedling tubers and transplants seems to be a promising alternative to costly tuber seed production. TPS progenies exhibited better resistance to both late blight and bacterial wilt than the conventional seed tubers. Viable, commercial seed schemes and appropriate low cost storage methods are discussed. These technological advances could have far-reaching effects in stabilising potato yields.

Key words: Solanum potato, improvement, constraints, food crop

Introduction

The potato *(Solanum tuberosum)* is one of the New World's greatest contribution to the food supply of mankind. Among the world's food crops, it ranks in the top five in production and as a source of food energy, it provides nearly one-sixth as many calories as rice, wheat and maize. It also contains substantial amounts of high quality protein and essential vitamins, minerals and trace elements. Biological value, which is an index of the portion of absorbed nitrogen, retained in the body for growth or maintenance, or both, is 73, compared to 54 for maize and 53 for wheat flour and compares very well with eggs (Kaldy, 1972). Although originated in the high Andes of South America, its potentialities as an efficient food crop were exploited in Europe. For this reason, it is commonly known as "Irish" potato. Nevertheless, its importance has recently been recognised in the developing countries and its production has more than doubled since 1965 (Horton, 1987).

The potato has also attained a status of one of the most important food crops in Uganda, particularly in the highlands with subsistence agricultural production. Because of its short duration, most farmers cultivate small plots of potatoes in rotation with other crops. Current potato production for 1988 is reported to be 190,158 tonnes on 28,269 hectares giving an average yield of 6.7 tonnes per hectare and estimated per capita consumption of 11.9 kilograms. Most of potatoes are grown on rich volcanic slopes with ideal climatic conditions. These areas have bimodal rainfall pattern that permits two crops each year. From ecological point of view, the yields are extremely low which suggests that major production problems are of scientific and technical nature and need to be solved through research to achieve its production potential consistent with the ideal growing conditions. More recently yields above 25 t/ha were obtained from an area of 6 hectares at Kalengyere and in the experimental plots, particularly with true potato seed technology, yields of the order of 79 to 99.5 t/ha were consistently obtained. It is in this context that systematic research programme was initiated during 1989 under the National Potato Research and Development Project.

Materials and methods

The cultivars, Sangema, Rutuku and Marirahinda introduced during early seventies, still remain the pre-dominant, varieties in Uganda. These varieties being descendants from sub-species tuberosum, have narrow genetic base and are vulnerable to attack of late blight *(Phytophthora infestans)* and bacterial wilt *(Pseudomonas solanacearum)*, the two drastic production constraints. For this reason, variety Cruza (720118) has recently gained importance with farmers.

To overcome this situation, 226 clones and 1593 single tuber progenies pertaining to 31 cross combinations of diverse genetic background, using a population breeding strategy based on recurrent selection (Mendoza and Rowe, 1977) were obtained from the International Potato Center (CIP). The materials include a great deal of variability for important traits such as wider adaptation, high yield, earliness, length of tuber dormancy, storage quality and disease resistance, particularly to late blight, bacterial wilt and virus diseases.

The materials were increased and are tested under different stages of evaluation at Kalengyere highland. A number of lines bred for resistance to bacterial wilt are being increased and the promising genotypes are under study in the mid-elevations and lower elevation.

Studies were undertaken to evaluate yield potential of true potato seed (TPS), dynamics of aphid population and post harvest technology.

Results and discussion

Varietal improvement

The material under study showed a wide range of genetic variability. Better plants and yields were observed from crosses between *S. tuberosum, S. andigerum, S. phureja*, and *Neotuberosum*. A number of promising genotypes with varying characters were identified. Among these, genotypes: 381381.20, 381379.9, 575049 (CEW 69.1), and 374080.5 (P3) were outstanding for their consistent high yield and a useful degree of resistance to late blight (Tables 1 and 2). Another important observation was that all these genotypes confirmed their good yield performance during the short rains characterised by long dry spell of 2-3 months from mid March coupled with warm climate, conducive for high aphid and PTM infestation. These clones are under evaluation in 7 on-station and 13 on-farm trials to study their performance under varying climatic and farming situations.

In the secondary yield trial, genotypes 381378.18, 381382.34, 381388.34 and 381403.1 (BW.3) showed good promises. Besides, 110 genotypes were screened for dual resistance to late blight and bacterial wilt. It is note-worthy that genotypes 800223, 379706.34 (LT.9), and 800938 (AVRDC 1287.19) performed significantly higher than local varieties and were found resistant to *Verticilium* as well as bacterial wilt during two previous crop seasons.

True potato seed (TPS)

Research on TPS initiated during 1989, showed a great promise both for raising first generation tubers in nursery beds *(in situ)* at spacing of 15 x 10 cm and as transplants compared to costly and bulky seed tubers. Mean tuber yield of first generation tubers during first planting (July 1989) ranged from 4.6 to 5.0 kg/m^2 with mean tuber numbers from 263 to 310 per m^2 (Table 3). Mean tuber weight was 17 to 19 g.

Table 1: Performance of promising genotypes in advanced variety trial

Genotype	Mean yield (t/ha)	Mean tuber no. per hill	Mean tuber wgt. (g)	Late blight score (CIP Scale)	
				+ Spray	- Spray
381381.20	60.3	12	91	2	4
381379.9	55.1	14	71	2	6
Maris piper	53.7	11	88	3	6
Monserrata	53.7	10	97	4	7
387711.5	50.3	14	65	3	6.5
575049-CEW 69.1	48.8	12	73	3	5
800945-AL-204	46.6	12	70	7.5	9
374080.5-P3	42.9	9	86	2	7
384298.30	40.3	11	66	4.5	6
800258 (K. Jyoti)	39.6	7	102	7.5	9
Mean	49.1	11	81	-	-
Check varieties					
Cruza	54.0	20	49	5	4
Sangema	35.4	9	74	5	9
Mean	44.7	15	62	-	-

Table 2: Performance of promising genotypes in advanced variety trial during short rains, 1990.

Genotypes	Mean yield (t/ha)	Mean tuber no. per hill	Mean tuber wgt (g)	L.B infection score
575049.CEW-69.1	41.89	13	58	1
381379.9	40.44	13	61	2
381381.20	39.75	9	73	1
374080.5-P3	38.11	8	91	1
800223	37.06	13	48	1
Maris piper	31.53	10	57	1
800945-AL-204	31.08	10	59	1
Monserrata	20.79	9	42	1
Mean	35.08	11	61	-
Check Varieties				
Cruza	42.55	18	43	1
Sangema	27.01	11	44	2
Mean	34.78	15	44	-
LSD (5%)	20.37	-	-	-
CV (%)	11.8	-	-	-

Table 3: Evaluation of TPS progenies for production of seedling tubers

Progeny	Plant height (cm)	Number compound leaves per plant	Mean yield kg/m^2	Mean tuber numbers/ m^2	Mean tuber weight (g)	Specific Gravity/ Density
			Highland			
HPS - 1/13	33	15.6	5.5	310	17.9	1.0797
HPS - 2/13	22	13.6	5.0	263	19.1	1.0930
HPS - 7/13	28	13.0	4.6	271	16.8	1.0797
HPS - 25/13	32	15.1	5.2	287	19.1	1.0914
Mean	28.7	14.4	5.2	283	18.2	1.0859
LSD (5%)	6.10	2.17	NS	NS	NS	-
CV (%)	11.5	8.2	18	19	18.4	-

In the second sowing (28.12.89) 23 TPS progenies were tested. Yields were spectacular ranging from 3.7 to 9.4 kg/m^2 in 12 TPS progenies (Table 4). It is significant that two open-pollinated progenies yielded equally well as hybrid progenies. Similarly, yields from transplants were very encouraging. Mean yield ranged from 18.2 to 99.5 t/ha during two crop seasons as compared to 35.4 to 54.7 t/ha in two improved check varieties raised conventionally (Tables 5 and 6).

Late blight infection score was 1 with 6 fungicidal sprays in TPS progenies as against 5 in check varieties with 14 fungicidal sprays. Genetic heterozygosity of TPS populations has vital biological advantage resulting in overall performance. These and other results suggested the potential of TPS as a viable technology (Macaso-Khwaja and Peloquin, 1983; Kidane-Mariam *et al.*, 1985; Golmirza, 1988). In the developing countries, especially in mid elevation and warm climate, where accumulation of tuber borne diseases in successive generation of seed stocks is a common phenomenon, adoption of TPS would be of great utility.

Dynamics of aphid population

Studies in the highlands (2500 m. above sea level) on dynamics of aphid population showed that aphids appeared towards end of April. This was at the end of the rains and the rise of temperatures. Aphids attained critical numbers during the months of June and July. Potato tuber moth (PTM) was also recorded in menacing number during this period. Preliminary results suggested that if nuclear seed stocks are planted during aphid free period (September to end of April) in a phased program, their health could be maintained for indefinite number of clonal generations.

Results of ELISA test revealed that the stocks developed in this way were practically free from potato virus Y (PVY) and potato leaf roll virus (PLRV). To confirm these findings, an experiment "effect of planting dates on the development of aphid and PTM infestation" has been laid out. A three-stage program starting with initial pathogen-tested stocks is implemented at Kalengyere with the target of producing 300 tonnes of basic seed annually. The following steps comprised the technology. From seed crop of high standards of a given variety, apparently

Table 3: Evaluation of TPS progenies for production of seedling tubers

Progeny	Plant height (cm)	Number compound leaves per plant	Mean yield kg/m²	Mean tuber numbers/ m²	Mean tuber weight (g)	Specific Gravity/ Density
			Highland			
HPS - 1/13	33	15.6	5.5	310	17.9	1.0797
HPS - 2/13	22	13.6	5.0	263	19.1	1.0930
HPS - 7/13	28	13.0	4.6	271	16.8	1.0797
HPS - 25/13	32	15.1	5.2	287	19.1	1.0914
Mean	28.7	14.4	5.2	283	18.2	1.0859
LSD (5%)	6.10	2.17	NS	NS	NS	-
CV (%)	11.5	8.2	18	19	18.4	-

Table 4: Production of seedling tubers from TPS progenies (1989 - 1990)

Progeny	Area harvested (m²)	Mean yield (kg/m²)	Mean tuber No (No/m²)	Mean tuber wt. (g)
HPS -7/13	2.4	9.4	357	26
HPS -2/13	2.4	9.2	345	27
Serrana x LT7	1.6	8.6	300	29
Atzimba x LT-7	1.6	8.5	438	19
HPS -7/69	2.4	8.2	337	24
CEW-69.1 x DTO 33	4.8	7.2	299	24
104.12LB (OP)	3.2	7.5	332	23
4.1 DI (OP)	4.8	7.4	236	31
Atzimba x 104.12 (DTO)	4.8	5.3	348	15
HPS -1/67	2.4	5.2	196	27
Atzimba x R 128.6	9.6	4.9	438	11
Atzimba x DTO 28	14.4	3.7	289	13
Mean	-	7.1	326	22

Table 5: Field performance of TPS progenies as transplants under highlands conditions at highland, Kalengyere.

Group	Plant height (cm)	Vigor rating (LAI)	Yield (t/ha)	Tuber/ Hill (No)	Mean tuber wgt. (g)	Mkt yield (%)	L.B. infe-ction score
Improved varieties							
Sangema	73	2.0	35.4	9	74	99	5
Cruza	94	2.0	54.0	20	49	97	5
Mean	84	2	44.7	15	62	98	5
TPS Hybrid Progenies							
HPS- 2/13	68	4	77.9	16	49	79	1
HPS- 7/13	58	4	86.1	24	35	86	1
HPS- 25/13	71	4	99.5	21	47	93	1
Mean	65.7	4	87.8	20	44	'87	1
CV (%)	12	-	9	27	-	-	-
LSD (P = 0.05)	NS	-	NS	NS	-	-	-

Table 6: Field performance of TPS progenies as transplants under mid-elevation (ml)

Progeny	Mean yield (t/ha)	Number tubers/ hill	Mean tuber weight (g)	Mkt. weight (t/ha)	Marketable yield %
HPS 1/13	49.9	12	43	40.2	81
HPS 2/13	36.8	9	43	27.3	74
HPS 7/13	46.0	11	43	32.1	78
HPS 25/13	42.1	8	51	33.8	76
Mean	43.7	10	45	33.4	77
LSD (5%)	NS	2.61	-	-	-
CV	19.5	23.4	-	-	-

Table 7: Evaluation of seedling tuber of TPS progenies (F^1 C^2) against farmer's seed during short rains (1990) at Kalengyere village.

Progeny	Mean yield (t/ha)	Percent increase over farmer's seed	Mean tuber number per plant	Mean tuber wgt. (g)
HPS 7/13	20.7	51	40	50.4
HPS 1/13	19.3	41	43	40.7
HPS 25/13	17.2	26	38	25.3
Mean	20.2	47	40	38.8
Rosita (Farmer's Seed)	13.7	-	17	-

Recent research has been initiated in designing low cost cool stores for short term storage of ware and seed potatoes. Comparison of variability of storage behaviour of 10 TPS progenies in the diffused light store (DLS) indicated that seed tubers of all the progenies with one exception were in perfect physiological condition during the storage period of 110 days since the start of the experiment. Skin of tubers was firm. Sprout development was balanced. Tuber rottage was negligible. Light is a natural sprout suppressant. Further, glycoalkaloids developed in seed tubers due to greening in DLS impart protection against most of the fungal diseases.

It would be safely concluded that seed tubers can be stored with advantage in DLS at least for a period of 6-7 months. Quality potato tuber seed produced during aphid-free conditions during September to April could be preserved in its right physiological condition for planting seed crop in the following season. The present system of production of seed crop during short rains is faulty. For storage of ware potatoes, the existing stores were modified and provided with ventilation from the windward directions.

Potatoes are stored in the baskets made of bamboo on the pattern of box storage that are kept in potato stores on raised platform and covered on the top with dried grass to prevent greening. Observations indicated that freshly harvested tubers could be stored for 120 days without significant losses by adoption of suitable varieties with long dormancy. For extended storage, research will be soon initiated to study use of sprout suppressants.

References

Golmirza, A.M. (1988). Comparison of different open pollinated generations for agronomical characters. p.77-79 in *Asian Potato Assoc. Proc.*

Horton, D. (1987). *Potatoes: Production, Marketing and Programs for Developing countries.* West View Press. IT. Publication London: 1-243.

Kaldy, M.S. (1972). Protein yield of various crops as related to protein value. *Economic Botany* 26: 142-144.

Kidane-Mariam, H.M., Arndt, G.C., Macaso-Khwaja, A.C. and Peloquin, S.J. (1985). Hybrid vs Open-pollinated TPS families. (En) In: International Potato Centre (CIP), Lima, (Peru). *Innovative methods for propagating potatoes.* Report of the 28th Planning Conference, Lima (Peru): 25-37 Tabs. AP (CIP. 54.9).

Macaso-Khwaja, A.C. and Peloquin, S.J. (1983). Tuber yields of families from Open-pollinated and hybrid true potato seed. *Am. Potato J.* 60: 645-651.

Mendoza, H.A. and Rowe, P.R. (1977). Strategy for potato population breeding for adaptation to the lowland tropics. *Am. Potato J.* (Abstract) 54: 488.

Swaminathan, M.S. and Sawyer, R.L. (1982). The potential of the Potato as a world food. (En). In: International Potato Centre (CIP), Lima, (Peru). *Innovative methods for propagating potatoes.* Report of the 28th Planning Conference, Lima, (Peru): 3-4.