Pak. J. Bot., 45(6): 2013-2018, 2013.

INFLUENCE OF SOWING TIME AND POTATO PROPAGULES ON THE YIELD AND TUBER QUALITY

ABDUR RAB[1*], GHULAM NABI[1], NOOR UL AMIN[1], IHSANUL HAQ[3], MUHAMMAD SAJID[1], KHALID NAWAB[4] AND NEELAM ARA[1]

[1]*Department of Horticulture, KPK Agricultural University, Peshawar, Pakistan*
[2]*Hazara Agriculture Research Institute, Abbottabad, Pakistan*
[3]*Department of Agricultural Extension Education, KPK Agricultural University, Peshawar, Pakistan.*
[*]*Corresponding author e-mail: abdurrubaup@gmail.com*

Abstract

The influence of sowing time and potato propagules on yield and quality of potato was carried out at Agricultural Research Institute, Tarnab, Peshawar during the year 2005-06. Potato tuberlets were developed from Hybrid TPS, OP-TPS and Tissue culture and evaluated against seed tubers for plant growth, yield and tuber quality. The tuberlets from hybrid TPS had significantly higher percent sprouting (92.767%), plant height (65.783 cm), soil cover (91.250 cm^2), number of leaves per hill (35.67) and yield (39.126 ton ha^{-1}) with the minimum disease incidence (0.15%), followed by mini-tubers and OP-TPS. The seed tubers had significantly high disease incidence (23.17%) and lower yield (11.414 ton ha^{-1}) but had high tuber quality high TDS (6.242%), dry matter (23.176%) and specific gravity (1.393). Most of the parameters were none significantly affected by sowing on September 15th or September 22nd but plant height, soil cover, leaves per hill and yield declined with delaying sowing to October 8th.

Introduction

Potato (*Solanum tuberosum* L.) belongs to family *Solanaceae* originated from Peruvian Andes (Rios *et al*., 2007) and has emerged as one of the leading food crop of the world (Khan *et al*., 2010). In Pakistan, the potato is grown over an area of 134300 ha with production of 2.54 million tons (Anon., 2008). The potato is a good source of food and antioxidants (Vanaei *et al*., 2008). Potato can be propagated vegetatively from seed tubers or from botanical seed called the true potato seed (TPS) (Malik, 1995). Traditionally, the potato is grown from seed tubers. But the cost of seed potato is about 40% of total cost of production and the transmittance of diseases through the seed tubers are the major problems limiting crop productivity (Rahman, 2002). The tuber quality is influenced by seed source (Chaudhary *et al*., 1990) and fertilizers application (Naz *et al*., 2013). The availability of quality seed tubers is a serious problem in Pakistan, which satisfy about 2% of its domestic seed demand from seed tubers produced in the high altitudes areas (Chaudhary *et al.,* 1984). The use of tuber potato as seed material has various problems such as seed quality (Chilver *et al.,* 1999), the presence of seed born diseases and its transfer from one generation to the other (Almekinders *et al.,* 1996; Aslam & Iqbal, 2010) and the cost of seed tubers and expanses involved in handling and transportation and degradation of seed potatoes during storage (Malik, 1995). The seed tubers of the same cultivar from different source may also vary in quality and subsequent performance (Chaudhary *et al*., 1990).

An alternative to the use of seed potatoes is the botanical or true potato seed (TPS) (Abrera, 1997). The TPS technology overcome serious constraints associated with the use of conventional seed tubers (Renia & Peter, 1998) and give better yield (Khalid, 2007) and economic returns (Roy *et al*., 2008). Thus according to Rahman (2002) adopting TPS technology minimize the problems associated with tuber seed. The TPS can be used for direct sowing or seed sowing followed by transplanting and production of tuberlets production for subsequent sowing as propagule (Rahman, 2002). The present experiment was initiated to evaluate the influence sowing time and tuberlets produced from open pollinated (OP-TPS) and hybrid TPS, tissue culture against seed tubers for yield and tuber quality attributes in Peshawar conditions.

Materials and Methods

The performance of potato propagules for growth and yield components was investigated in Peshawar conditions during the autumn season of year 2005-2006. The experiment was laid out in 2 factorial randomized complete block design (RCBD), with four potato propagules e.g., tuberlets of hybrid TPS (Line No. 9802), tuberlets of OP-TPS, mini-tubers produced through tissue culture and seed tubers as major factors and sowing time e.g., September 15th, September 22nd, October. 1st and October 8th as sub factors. Each treatment was replicated three times.

The tuberlets of hybrid TPS and OPS were procured from Agricultural Research Institute, Tarnab while mini-tubers (tissue culture seed tubers) were procured from Tissue Culture Laboratory at Agricultural Research Institute, Tarnab. Seed tubers were obtained from seed lot for the autumn to autumn cycle.

Data was recorded on various growth and yield related parameters such as plant height, number of stems per plant, number of leaves per plant, soil coverage percentage, plant height, disease incidence, yield per plant, yield per hectare, number and weight of large (more than 50 mm), medium (20-50mm) and small (less than 20mm) size tubers, specific gravity, moisture content and dry weigh was recorded. Soil coverage was estimated with the help of square counter and then counting the number of square covered by the potato plants.

Specific gravity of the tubers was determine with the help of a hook balance by the following formula:

Specific gravity = Weight in air/ (weight in air - Weight in water)

Dry weight was approximated by exposure of potato tubers to 50°C for 48 hours in an oven and measuring with an electronic balance to the 3rd decimal point in mg.

The data were statistically analyzed using analysis of variance for 2 factorial Randomized Complete Block Design (RCBD). The means were separated for significance using LSD test at 5% level of probability (Steel & Torrie, 1984).

Results

Sprouting percentage: The sprouting percentage of potato was significantly affected by the propagules. The maximum sprouting percentage (92.77%) was recorded for tuberlets from hybrid TPS followed by mini-tubers from tissue culture (89.46%), with the difference being not significant. The sprouting percentage was significantly lower (77.78 and 82.50%) in OP-TPS and seed tubers respectively (Table 1). The influence of sowing time and its interaction with propagules source was not significant.

Table 1. Effect of tuberlets sources and sowing time on the growth of potato crop.

Tuberlets sources	Sprouting (%)	Number of stems/ hill	Hill height (Cm)	Soil coverage (Cm^2)	Leaves per hill
Hybrid TPS	92.77 a	2.24 b	65.78 a	91.25 a	35.67 a
OP TPS	77.78 c	1.91 c	48.33 b	72.42 b	29.02 b
Seed Tubers	82.50 bc	2.04 bc	36.11 c	36.00 c	14.40 c
Mini-tubers	89.46 ab	2.38 a	51.86 b	74.08 b	29.63 b
LSD at α 0.05	9.19	0.396	3.814	5.104	1.477
Sowing time					
September 15th	82.49	1.67 b	55.07 a	69.81 b	27.92 ab
September 22nd	81.13	2.65 a	55.11 a	72.66 b	29.12 a
October 1st	89.44	2.42 a	52.03 a	78.58 a	26.60 b
October 8th	89.45	2.73 a	41.84 b	62.69 c	25.08 c
LSD at α 0.05	Ns	0.328	4.7.53	3.756	1.397
Interaction	Ns	*	*		

Number of stems per hill: The number of stem per hill was significantly affected by both propagules and sowing time but not their interaction. The maximum number of stems per hill (2.38) was developed by mini-tubers followed by hybrid TPS (2.24) with the difference being not significant. The lowest number of stems per hill (1.91) was recorded with OP TPS which was not significant with 2.04 stem per hill recorded with seed tubers. Sowing time also has significantly affected the number of stems per hill, where the maximum number of stems per hill (2.72) was observed for October. 8th sowing, while the minimum (1.68) stems per hill was recorded for September 15th sowing time (Table 1). The interaction of propagules and sowing time was, however, not significant.

Hill height (cm): The hill height had significant variation in both sowing time and propagules. The tuberlets from hybrid TPS had the maximum hill height (65.78 cm) followed by mini-tubers and OP TPS with 51.86 cm and 48.33 cm respectively. The difference in hill height of Mini-tubers and seed tubers was, however, nonsignificant. Hill height was the minimum (36.11 cm) with tuberlets from seed tubers. Sowing time also significantly affected the hill height, with the maximum (55.11 cm) with September.22nd sowing, which was nonsignificant with September 15th (55.07) or October 1st (52.03) but October. 8th sowing resulted in the least (41.84 cm) hill height (Table 1). The interaction between sowing time and propagules was non-significant.

Soil coverage: Soil coverage varied significantly with different propagules and sowing time as well as the interaction between propagules and sowing time. Tuberlets from hybrid TPS source attained the maximum soil cover of 91.25 cm^2 followed by mini-tubers from tissue culture and OP-TPS with 74.08 and 72.42 cm^2 respectively. The difference in soil coverage of mini-tubers and OPTPS was, however, non-significant. Soil coverage was the minimum (36.00 cm^2) in seed tubers. Sowing time also has significant effect on the soil coverage of potato crop, with the maximum soil cover (72.675 cm^2) with September, 22nd sowing, while the minimum soil coverage (62.687 cm^2) was observed with October 8th sowing. However, only September 22nd was significantly superior in soil coverage than the rest of the sowing dates (Table 1). The interaction effect of different propagules and sowing times revealed that the maximum soil coverage (95.46 cm^2) was recorded when tuberlets from hybrid TPS were sown on September 22nd followed by tuberlets from hybrid TPS sowing on September 15th. Soil coverage was the minimum (25.00 cm^2) with seed tubers were sown on October 8th (Fig. 1).

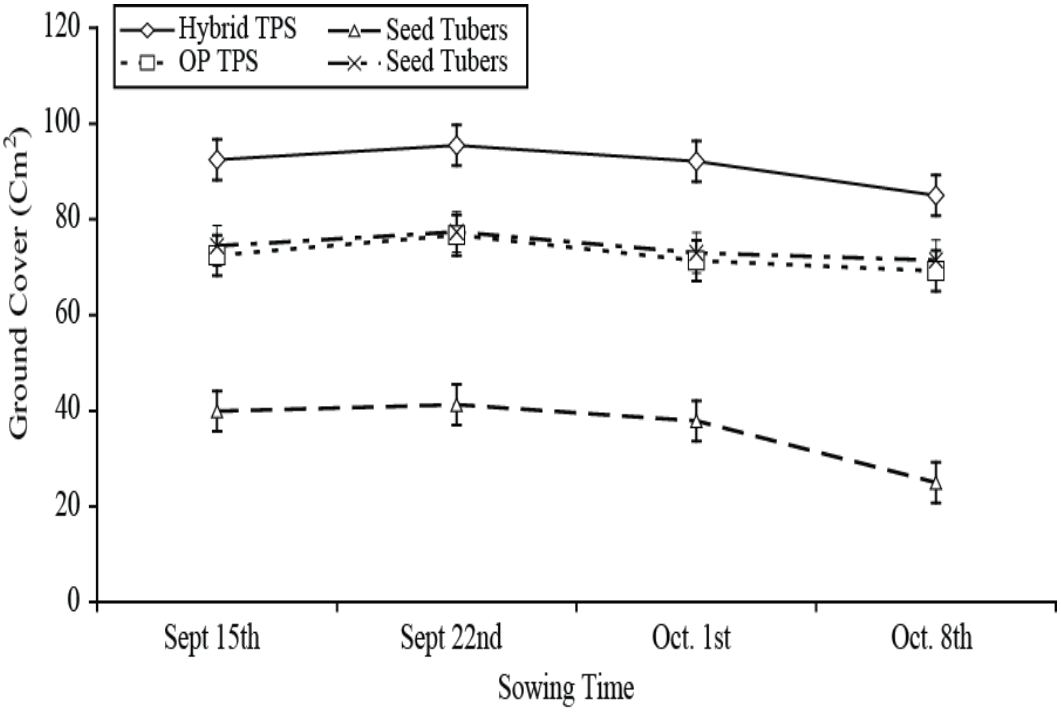

Fig. 1. The interaction of propagules sources and sowing time on soil cover of potato crop. The error bar represents LSD at 5%.

Number of leaves per hill: Significant variation was observed in number of leaves per hill with different sources of potato propagules as well as sowing time. The maximum number of leaves per hill (35.67) was recorded with hybrid TPS followed by mini-tubers and OP-TPS sources with 29.633 and 29.017 leaves per hill respectively (Table 1). Sowing time also had significant effect on the number of leaves per hill with the maximum number of leaves per hill (29.12) recorded with September 22nd sowing which was non-significant with 27.92 leaves per hill of September 15th sowing. October 8th sowing resulted in the minimum number of leaves (25.08) per hill (Table 1). The interaction between sowing time and propagules was not significant.

Disease incidence (%): Disease incidence was significantly affected by different propagules as well as sowing time. Tuberlets from hybrid TPS had the minimum diseases incidence (0.25%) followed by mini-tubers with 1.92%. The differences in disease incidence between hybrid TPS and mini-tubers was, however, not significant. The maximum disease incidence of (15.63%) was recorded in seed tubers. Sowing time significantly affected the incidence of early and late blight diseases on potato crop. Among the sowing times, the maximum disease incidence (11.07%) was recorded with September 15th sowing followed 4.15% with September 22nd sowing. The difference in disease incidence from September 22nd onward was, however, not significant (Table 2).

Yield (T.ha^{-1}): Significant variations in yield per hectare were observed among different propagules as well as sowing time. Tuberlets from hybrid TPS source gave the maximum yield of 39.26 tons t ha^{-1} followed by Mini-tubers from tissue culture source with 25.56 t ha^{-1}. The lowest yield (11.41 t ha^{-1}) was recorded with seed tubers used as propagule as compared to 19.85 t ha^{-1} with tuberlets from OP TPS (Table 2). The yield of potato was also significantly affected by sowing time with the maximum yield (30.21 t ha^{-1}) recorded with September 15th sowing, which was significantly higher than 24.74 and 22.37 t ha^{-1} observed with September 22nd and October 1st sowing respectively. The yield for October 8th sowing (18.63 t ha^{-1}) was the least among different sowing times (Table 2). The interaction between sowing time and propagules was not significant.

Total dissolved solids (%): Different propagules showed significant variations in total dissolved solids but sowing time and the interaction of sowing time and propagules has no significant effect. The tubers from seed tubers had the maximum total dissolved solids (6.24%) followed by tuberlets from OP and hybrid TPS with 5.38 and 5.06% respectively (Table 2). The influence of sowing time or its interaction with propagule was not significant.

Dry matter (%): The percentage of dry matter was significantly affected by propagules and sowing time but not their interaction. The maximum dry matter (23.18%) was recorded in seed tubers followed by hybrid TPS and OP TPS with 21.85 and 21.42% respectively. The difference between hybrid TPS and OP TPS was, however, not significant. The influence of sowing time on dry matter was also significant. The maximum dry matter (22.71%) was observed when sowing was done on October 8th followed by (21.81%) recorded with October 1st sowing, while the minimum (21.03%) was observed when propagules were sown on September 15th (Table 2).

Table 2. Effect of tuberlets sources and sowing time on disease incidence, Yield, TDS, Dry Matter and specific gravity of potato.

Tuberlets sources	Disease incidence (%)	Yield (t ha^{-1})	TDS (%)	Dry matter (%)	specific gravity
Hybrid TPS	0.15 bc	39.13 a	5.06 b	21.85 b	1.193 b
OP TPS	4.61 b	19.85 c	5.38 b	21.42 b	1.257 b
Seed Tubers	15.63 a	11.41 d	6.24 a	23.18 a	1.393 a
Minitubers	1.92 b	25.56 b	4.51 c	20.56 c	1.228 b
LSD at α 0.05	3.408	3.537	0.537	0.7647	0.1179
Sowing time					
September 15th	11.07 a	30.21 a	5.63	21.03 c	1.253
September 22nd	4.15 b	24.74 b	4.90	21.81 b	1.285
October 1st	3.19 b	22.37 bc	5.24	21.44 bc	1.247
October 8th	3.94 b	18.63 c	5.43	22.71 a	1.287
LSD at α 0.05	6.508	4.279	Ns	0.957	ns

Specific gravity: The specific gravity of the tubers was significantly affected by different propagule while the difference due to sowing dates was not significant. The maximum specific gravity (1.393) was recorded in seed tubers, which was significantly higher than the other three propagules. The specific gravity of OP TPS (1.257), mini-tubers (1.228) and hybrid TPS (1.193) were not significantly different in specific gravity. The specific gravity of the tubers was not significantly affected by sowing time and the interaction of propagules and sowing time (Table 2).

Discussion

The growth and yield attributes of potato were significantly affected by various propagules and sowing times. The tuberlets from hybrid-TPS resulted in the highest sprouting percentage, plant height, soil cover, leaves per plant and tubers yield. The hybrid-TPS have been found superior in sprouting (Nizamuddin *et al*., 2010) and the plants may have more axillary branches per stem, thus have higher yield (Rahman, 2002). The superior yield performance of Hybrid-TPS has also been reported by (Khalid, 2007). The tuberlets from OP-TPS resulted in poor growth (Table 1) and yield (Table 2) as compared to hybrid–TPS. (Manrique, 1994). However, it is interesting to observe that the OP-TPS had comparable sprouting percentage and number of stems per hill and even higher yield than seed tubers. It indicates that the OP-TPS offers a potentials indigenous resource for TPS production. While the seed tubers had higher disease incidence Aslam & Iqbal, 2010), it produced tubers having higher TDS, dry matter and specific gravity than both TPS sources as well as mini-tuber from tissue culture (Table 2) despite greater disease incidence on the plants. Since, viral and bacterial diseases can be transmitted through tubers to succeeding generation, it is likely to observe high disease incidence in seed tubers as compared to TPS (Sadik, 1983; Rahman, 2002).

The sowing time significantly influenced the growth, yield and tuber quality of potato (Tables 1 & 2) (Bandara *et al*., 1998). There was a mixed tendency in growth and yield parameters in relation to sowing time (Tables 1 & 2). Whereas the plant height, number of stems per hill and yield were superior with September 15th sowing, the dry matter content was the highest with October 8th sowing (Tables 1& 2). Generally both early and late sowing could be detrimental to the tuber yield (Darabi, 2002; Iwama *et al*., 2005). Lafta & Lorenzen, (1995) reported that high temperatures reduced growth of tubers more than of shoots. The poor performance with early sowing may due to the relatively higher temperature, prevailing in the month of September that resulted in a decreased plant height and number branches per plant as well as poor yield (Darabi, 2002; Iwama *et al*., 2005). By contrast, the decrease in vegetative growth and tuber yield with October, 8th sowing date could be attributed to the short growing season due to frost incidence (Grewal & Singh 1980; Iqbal & Khan, 2003), which terminates the growth of potato crop. Disease incidence was the highest with September 15th sowing which decline significantly when sowing was done September 22nd or later (Table 2). The interaction of different propagules and sowing time resulted in significant variations in soil coverage with the maximum soil coverage recorded with tuberlets from hybrid TPS and September 2nd sowing followed by the same propagules sowing on September 15th. The minimum Soil coverage was recorded when seed tubers were sown on October 8th (Fig. 1).

Crop sown September 15th also had significantly higher disease incidence as compared to later sowing dates (Table 2). Since disease incidence is generally higher at warmer than cooler temperatures (Roshani *et al.,* 2009), it is likely to observe greater disease incidence with early sowing. It is interesting to observe that September 1st sowing, despite high disease incidence had the highest yield (Table 2). The Potato crop is highly sensitive to changes in climate (Abdrabbo *et al*., 2010), In

Peshawar conditions, the frost occur in December-January, which coincides with the bulking phase and may cause yield losses up to 40 per cent (Rahman, 2002) According to Garba *et al*., (2005), late planting of potato delays canopy development and reduce the time available for tuber bulking. Thus, October 8th seems to be too late for optimum growth of potato plants, resulting in low yield (Kawakami *et al*., 2004, Roshani *et al*., 2009).

The dry matter content of the tuber contribute to the tuber quality of potato (Abbas *et al*., 2012). The dry matter content was significantly influenced by the sowing time (Table 2). High dry matter percentage of tubers is a desirable quality attribute for better processing quality of potato (Robert *et al*., 2007) and can be influenced by the cultivation technology and harvest date with more mature tubers having high dry matter (Sawicka & Pszczółkowski, 2005). It is likely that the high dry matter content with late sown plants could be greater allocation to relatively small number of tubers in such plants.

Conclusions

Among the various propagules under study tuberlets from hybrid TPS showed superior performance percent sprouting, plant height, soil cover, number of leaves /hill, disease incidence and yield followed by mini-tubers and OP-TPS. It indicates that OP TPS has the potentials to equate mini-tubers produced through tissue culture. The seed tubers despite high disease incidence and poor yield had produced tubers with high TDS, dry matter and specific gravity may indicate greater ability of seed tubers to exploit available resources through their root system. While most of the parameters were non-significantly affected by sowing on September 15th or September 22nd but the yield was higher with September 15th sowing and declined with delay in sowing.

References

Abbas, G., L.A. Hafiz, N.A. Abbasi and A. Hussain. 2012. Determination of processing and nutritional quality attributes of potato genotypes in Pakistan. *Pak. J. Bot*., 44:201-208.

Abdrabbo, M.A.A., A.A. Khalil, M.K.K. Hassanien and A.F. Abou-Hadid. 2010. Sensitivity of potato yield to climate change. *J. Applied Sci. Res*., 6: 751-755.

Abrera, G. 1997. True potato seed: a low cost alternative technology for potato production in Baka Region. IAR *News letter of Agr. Res*., 12: 1-10.

Almekinders, C.J.M., A.S. Chilver and H.M. Renia. 1996. Current status of the TPS technology in the world. *Potato Res.,* 39: 289-303.

Anonymous. 2008. Agricultural Statistics of Pakistan, Ministry of Food and Agriculture, Islamabad, Pakistan (MINFAL).

Aslam, A and J. Iqbal. 2010. Combined effects of cytokinin and sucrose on *In vitro* tuberization parameters of two cultivars i.e., Diamant and Red Norland of potato (*Solanum tuberosum*). *Pak. J. Bot*., 42: 1093-1102

Bandara, P.M.S., K.K. Tanino and D.R. Waterer. 1998. Effect of pot size and timing of plant growth regulator treatments on growth and tuber yield in greenhouse-grown norland and russet burbank potatoes. *J. Plant Growth Regul*., 17: 75-79.

Chaudhary, J.A., S.M.A. Shah, K.I.Hussain, C.A.H. Tariq and R.E. Web. 1984. Evaluation of potato seed tubers from different sources in the Punjab plians of Pakistan. *Am. Pot. J*., 61: 703-709.

Chaudhary, J.A., S. M. Mughal and N.A. Khan. 1990. Impact of improved seed source on growth characteristics and yield of potato. Sarhad J. Agri., 6: 249-253.

Chilver, A., T. Walker., V. Khatana., H. Fano., R. Suherman and A. Rizk. 1999. On-farm profitability of true potato seed (TPS) utilization technologies. Working Paper Series International Potato Center, Social Science Department. No. 99-3, pp. 41.

Darabi, A. 2002. Effect of planting date on the yield of potato cultivars in autumn cultivation. *Seed Plant*. 18: 252-254.

Garba, A., G.N.Udim, M.A. Ikeasomba and A. Hasuruna. 2005. Influence of seed size and planting sate on the growth, development and yield of potato (*Solanum tuberosum* L.) varieties in Bauchi. *Global J. Agric. Sci*., 4: 19-22.

Grewal, J.S. and S.N. Singh. 1980. Effect of K nutrition on frost damage and yield of potato on alluvial soils of Punjab. *Plant and Soil*, 57: 105-110.

Iqbal, M.Z. and S.A. Khan. 2003. Line x tester in true seed of potato (*Solanum tuberosum* spp. *tubersum*). *Online J. Biol. Sci*., 3: 674-680.

Iwama, K., Y. Jitsuyama and J. Kawakami. 2005. Effects of planting date on the growth and yield of two potato cultivars grown from microtubers and conventional seed tubers. *Plant Prod. Sci*., 8: 74-78.

Kawakami, J., K. Iwama, Y. Jitsuyama and X. Zheng. 2004. Effect of cultivar maturity period on the growth and yield of potato plants grown from microtubers and conventional seed tubers. *Am. J. Potato Res.*, 81: 327-333.

Khalid, F. 2005. Use of true potato seed for better yields. Ph.D. thesis, University of Arid Agriculture, Rawalpindi, Pakistan

Khan, M.Z., M. E. Akhtar, M. N. Safdar, M.M. Mahmood, S. Ahmad and N. Ahmad. 2010. Effect of source and level of potash on yield and quality of potato tubers. *Pak. J. Bot*., 42: 3137-3145.

Lafta, A.M. and J.H. Lorenzen. 1995. Effect of high temperature on plant growth and carbohydrate metabolism in potato, *Plant Physiol*., 109: 2 637-643.

Malik, N.J. 1995. Potato in Pakistan. A hand book . Pak Swiss Potato Development Project . PARC Islamabad, Pakistan.

Manrique, L.A. 1994. Use of true potato seeds in the tropics: Potentials and realities. *J. Plant Nut*., 17: 1569-1586

Naz, F., A. Ali, Z. Iqbal, N. Akhtar, S. Asghar and B. Ahmad. 2011. Effect of different levels of NPK fertilizers on the proximate composition of potato crop at Abbotabad. *Sarhad J. Agr*., 27: 353-356.

Nizamuddin, M. Qamar, B. Mirza, Shakirullah, M. Asghar, S. Ahmad, M. Din, I. Hussain and D. Baig. 2010. Yield performance of true potato seeds (tps) hybrids under climatic conditions of northern areas. *Sarhad J. Agric*., 26: 241-244.

Rahman, A. 2002. Evaluation of TPS varieties. Annual Research Program of potato Section for the year 2001-2002.

Renia, H. and V.H. Peter. 1998. Opportunities and challenges for the commercial use of botanical potato hybrid seed. Paper presented at the FIS/ASSINSEL Congress, Monte Carlo, 30 May-5 June.

Rios, D., M. Ghislain, F. Rodriguez and D.M. Spooner. 2007. What is the origin of the European potato? Evidence from Canary Island landraces. *Crop Sci*., 47: 1271-1280.

Robert, S.P., B.J. Alvin, M.A. Bruce, H. Robert, D.J. Michael and G. Marty. 2007. Effect of planting and vine-kill timing on sugars, specific gravity and skin set in processing potato cultivars. *Am. J. potato Res*., 84: 205-215.

Roshani, S., K.B. Kelarastaghi, E. Amiri and K.S. Noferest. 2009. Effect of planting date on potato varieties in Iran; a case study from Mashhad. *Ecol. Environ.* and *Conservation*, 15: 705-710.

Roy, T.S., T. Nishizawa and M.H. Ali. 2008. True potato seed production and its economic analysis as influenced by supplemental nitrogen and planting density. *Asian J. Plant Sci*., 7: 73-78.

Sadik, S. 1983. Potato production from true seed - present and future. In: *Proceedings International Congress* "Research for the potato in the year 2000" (WS Hooker, ed). International Potato Center, Lima-Peru. Pp. 19.

Sawicka, B. and P. Pszczółkowski. 2005. Dry matter and carbohydrates content in the tubers of very early potato cultivars cultivated under coverage. *Acta Sci. Pol*., 4: 111-122.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics. McGraw Hill book Co. Inc., London.

Vanaei, H., D. Kahrizi, M. Chaichi, G. Shabani and K. Zarafshani. 2008. Effect of genotype, substrate combination and pot size on minituber yield in potato (*Solanum tuberosum* L.). *Am. Eurasian J. Agric. & Environ. Sci*., 3: 818-821.

(Received for publication 15 December 2011)