An improved method to produce rooted seedlings from TPS (True Potato Seed) tested in the highlands of Uzbekistan

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Abstract

In Uzbekistan, farmers struggle to obtain high quality seed potatoes at affordable prices. Price of imported seed has in fact risen sharply in recent years obliging farmers to utilize their own saved seed more frequently with declining potato yields due to seed-borne diseases. In an effort to develop research on seed systems, CIP has focused the development of new techniques and practices that should be prerogative of the informal seed system. Different techniques for seed potato production have been tested, including an original variant to produce rooted seedlings from TPS materials under nursery conditions. This technique has the advantage of producing stronger rooted seedlings with substrate intimately attached to the rooting system, thus improving survival rates and reducing considerably transplanting shocks and root damages. Such method of producing rooted seedlings from TPS is extremely simple, cheap, and offers an alternative activity to smallholders who are familiar with vegetable growing and who live in marginal areas. The only obstacle to the adoption of this alternative material may be represented by the duration of the growing cycle of the tested TPS families that would need to be shortened, requiring, therefore, the supply of new TPS materials.

Keywords: potato, seed production, rooted seedlings, growing cycle, day length.

Introduction

Uzbekistan was part of the Former Soviet Union until it became independent in 1991. The country has a total area of 44.8 million hectares with only 4.5 million hectares arable, out of which 4 million are irrigated (FAO-ICARDA, 2006). Potato is traditionally grown from seed tubers, which account for as much as 47% of the total production cost. Seed importation from Holland is the main source of Elite category seed tubers that are locally multiplied for two to three generations by a State company. Potato is mainly produced in the lowlands where about 70% of total production is concentrated, while the rest is cultivated in the highlands and foothills. Potato is cultivated during three growing seasons, which is typical of other countries of the Central Asia and Caucasus region: a double-cropping system in the lowlands, with the first growing season from February-March till May-June, and the second from mid-July till the end of October, while a single-cropping pattern is practiced in the highlands with planting in May and harvest from mid-September till mid-October. Being Uzbekistan situated in the temperate zone of the northern hemisphere, these growing seasons correspond to different photoperiodic regimes, from short to long and viceversa in the double-cropping system of the lowlands and from long to short in the single-cropping system of the highlands. The country does not have an efficient potato seed production system to provide clean seed sold at an affordable price to potato farmers. Further, the cost of seed is high because the cost of transport of Elite seed categories from Europe to destination adds to the production cost and bears on the cost of further seed categories.

True Potato Seed (TPS) was therefore considered as an alternative source of planting material because of its low cost and easy transport. In an effort to assist NARS of Uzbekistan, CIP supplied some TPS families for evaluation of their potential under long day conditions as a means to support local farm-based seed systems. TPS technology is everywhere recognized (Pandey, 2005) as highly cost effective and the most appropriate seed production technique for the resource poor farmers of the less developed countries. Moreover, TPS are a source of healthy planting materials. In fact, except for potato virus T (PVT) and potato spindle tuber viroid (PSTVd) no other major pathogens are transmitted through TPS as they are filtered out as a consequence of sexual propagation (Salazar, 1996). Research was also axed on the evaluation of different planting methods to standardize the technique under local conditions, among them the direct seeding technique and transplanting of rooted seedlings. The latter technique although mostly appreciated by farmers because it would allow the production of commercial-sized tubers already in the first year of production, has been, however, criticized for

the fragility of the transplanted seedlings. Upadhya (1999) thought that more research focusing on selecting parents providing hardier seedlings was needed. Since we thought that this character was also depending on the way nurseries are managed and rooted seedlings handled, we tested a simple and low-cost technique to produce strong rooted seedlings able to stand transplanting shocks. As in Uzbekistan the objective is to create a seed system to produce high quality planting materials at affordable prices, this improved technique for the production of strong TPS rooted seedlings has been tested in the highlands of the country during the period May-October, 2006-2007, and compared with the traditional TPS rooted seedling production technique described by several authors (Accatino and Malagamba, 1982; Malagamba, 1988; Singh et al., 1990; Upadhya et al., 1990; Cabello, 1996; Upadhya and Cabello, 2001; Pande, 2005). The objectives researched included: (**i**) the assessment of survival rates of TPS transplanted rooted seedlings issued from two nursery methods described below, and (**ii**) the analysis of yield of TPS rooted seedlings issued from the two methods, once transplanted in the field.

Materials and methods

The experiment was conducted at the experimental site of Pskem, a locality situated about 180 km from Tashkent, close to the Kazakh border, at an altitude of about 1 300 m asl and at 42° N, 70° E . Soil is a typical eroded sierozem with a pH approaching 6.2. Three TPS families were used for the experiment: two hybrid TPS families LT-8 x TS-15 and HPS-I/13, supplied by CIP and CPRI (Central Potato Research Institute), Modipuram, India, respectively, and CH-8, an open pollinated (OP) family supplied by the Research Institute of Vegetables, Melon and Potato, Tashkent. In order to implement such experiment, we set up two nurseries for the production of rooted seedlings to be further transplanted in the open field. They were prepared by digging a trench, 30 cm deep, about 1.2 m wide and 20 m long. Sowing occurred on May 22, 2006, and May 16, 2007, at 0.5 cm depth and different spacing distances. The two nurseries were prepared for the production of rooted seedlings according to two methods: the classic method, called "traditional", with sowing of TPS at 15.0 x 4.0 cm (166 seedlings/m^2), and a second method, herewith called "improved", with a seed density equivalent to 204 seedlings/m^2 (7.0 x 7.0 cm). In both methods, after sowing, each hole was covered with a small amount of well-sifted manure. Immediately after, water was carefully applied with a watering-can by providing a fine mist.

In the so-called "traditional" method, the substrate was composed of well-sifted subsoil and well-decomposed organic manure, thoroughly mixed in a 1:1 proportion. The differences between the two methods were in the seed density (166 vs. 204 seedlings/m^2), the substrate composition and the methodology used, which in the "improved" method ensures operational ease in taking out rooted seedlings from the nursery for further transplant in the field. In fact, in the "improved" method, one layer of perforated transparent polythene sheet was laid down between the substrate composed by well-sifted subsoil and the soil bed, at about 10 cm depth. This was done to ensure water percolation and gaseous exchanges within the substrate and between the substrate and the above soil bed. The soil bed, which was not mixed, consisted of two separated layers of about 5 cm each, with organic manure placed above well-sifted subsoil. A specially-manufactured wooden seed marker was prepared for the occasion. At transplanting time, it was extremely easy to extract with a carpentry slice firm blocks having one rooted seedling each with substrate intimately attached to the rooting system. Other cultural practices comprised thinning, to keep one seedling/hill, spraying against Potato Colorado Beetle (*Leptinotarsa decemlineata*, Say) and watering when needed. About two weeks after emergence, a 0.1% (1 g in 1 liter of water) solution of urea was sprayed every two days until transplanting. Seedlings were ready for transplanting 40 to 42 days after seed sowing, at the 4 to 5 leaf stage.

To compare the efficiency and the feasibility of the two methods above described, an experiment was set up with rooted seedlings of three TPS families (LT-8 x TS-15, HPS-I/13, and CH-8), which were transplanted in the field at the distance of 70 x 15 cm in plots measuring 2.1 x 2.7 m (5.67 m^2), with four rows distant 0.7 m and having 18 transplanted rooted seedlings each, for a total of 72 rooted seedlings/plot. Data, i.e. plant survival rates (%) at 20 days after transplanting, number of tubers, average tuber weight (g) and yield (t/ha), were taken on the two inner rows, and precisely on 14 plants of each row, neglecting the two plants at each extremity so that the yield was measured on the effective area of 1.4 x 2.1 m (2.94 m^2). Each plot was replicated three times, so that there were 18 plots distributed at random. The following fertilizers were applied along the furrows: 26 g ammonium sulfate and 27 g monoammonium phosphate per linear meter, corresponding to 120 N and 176 P_2O_5 per hectare. While monoammonium phosphate was integrally applied prior to transplanting, ammonium sulfate was split in two applications, before first and second hilling-up, that is about thirty and fifty days after transplanting, respectively. At the beginning and until plants were 30-40 cm high, furrow irrigation was provided every 5-6 days, but afterwards it was reduced to an application every 10 days. At about ninety days after

transplanting irrigation was stopped and ten days later haulm killing was practiced followed by harvesting about two weeks later. Harvest occurred on October 22 and 14, in 2006 and 2007, respectively, approximately 111 days after transplanting.

The obtained data were statistically processed using MSTAT-C program (1993). The statistical analysis covers the following indicators: mean value (x), and Coefficient of Variation (CV). The experimental design adopted consisted of a 3 (TPS families) x 2 (rooted seedling methods) factorial experiment in a randomized complete block design with three replications for a total of 3 x 2 x 3 = 18 plots. LSD test for the levels of significance of α=0.01 and α=0.05 was then computed.

Results

(i) Study of survival rates of TPS transplanted rooted seedlings

Statistical analysis of the results indicates that there are significant differences among the two rooted seedling production methods and the interaction production method x TPS family. The "improved" method applied for the production of rooted seedlings gave better results than the "traditional" method in terms of plant survival at 20 days after transplanting, at 1% and 5% level (Table 1). Survival rates of LT-8 x TS-15 rooted seedlings produced according to the "traditional" method were significantly higher than those of CH-8 (86.7 vs. 80.6%). Only in the case of the OP TPS family CH-8, there was a significant interaction TPS family x year.

Table 1. Survival rates (%) of TPS rooted seedlings 20 days after transplanting, adopting two different methods of rooted seedling production in nursery. Pskem, Uzbekistan, 2006-2007. Means of three replications

Method (A)	TPS family (B)	Year (C)		Average (AB)	Average (A)
		2006	2007		
**Traditional Method (%)	LT-8 x TS-15	86.9	86.6	86.7**	84.2
	HPS-I/13	84.6	86.3	85.4	
	CH-8	83.4**	77.8	80.6	
	Average (AC)	85.0 ns	83.6		
Improved Method (%)	LT-8 x TS-15	97.2	97.2	97.2**	96.0**
	HPS-I/13	95.0	93.8	94.4**	
	CH-8	97.5*	95.2	96.3**	
	Average (AC)	96.6 ns	95.4	**Average (B)**	
TPS family x Year (BC)	LT-8 x TS-15	92.0	91.9		91.9
	HPS-I/13	89.8	90.0		89.9
	CH-8	90.4 *	86.5		88.4
Average year ©		90.7 ns	89.5		**A x B x C** ns

Factor		A	B	C	AB	AC	BC	ABC
LSD	**1%**	2.73	3.35	2.73	4.73	3.86	4.73	6.68
	5%	2.01	2.47	2.01	3.48	2.84	3.48	4.91

** = significant at 1% level; * = significant at 5% level; ns = not significant

(ii) Performance of TPS rooted seedlings issued from the two methods once transplanted in the field

Results are shown in Table 2.

Table 2. Field performance of transplanted TPS rooted seedlings, adopting two different methods of rooted seedling production in nursery. Pskem, Uzbekistan, June-October 2006*-2007. Means of three replications

Method (A)	TPS family (B)	Yield (t/ha)				No. of tubers				Mean tuber weight (g)			
		Year ©		Mean (AB)	Mean (A)	Year ©		Mean (AB)	Mean (A)	Year ©		Mean (AB)	Mean (A)
		2006	2007			2006	2007			2006	2007		
Traditional Method (%)	LT-8 x TS-15	20.7	23.1	21.9	19.1	309.3	333.3	321.3**	243.5	23.8	26.7	25.2	25.5
	HPS-I/13	12.1	15.7	13.9		170.0	192.3	181.1		21.3	24.5	22.9	
	CH-8	22.3	20.9	21.6		229.3	227.0	228.1		29.4	27.4	28.4*	
	Mean (AC)	18.4	19.9 ns			236.2	250.9 ns			24.8	26.2 ns		
Improved Method (%)	LT-8 x TS-15	28.3	29.4	28.8**	24.0**	192.3	209.0	200.6	252.6 ns	46.2	41.5	43.8**	30.3**
	HPS-I/13	21.0	22.1	21.6**		243.7	260.3	252.0**		24.9	25.4	25.1	
	CH-8	24.0	19.5	21.7 ns		298.7	312.0	305.3**		24.3	19.6	21.9	
	Mean (AC)	17.2	23.7**	**Mean (B)**		244.9	260.4 ns	**Mean (B)**		31.8 ns	28.8	**Mean (B)**	
TPS family x Year (BC)	LT-8 x TS-15	24.5	26.2		25.3*	250.8	271.1		260.9*	35.0	34.1		34.6**
	HPS-I/13	16.6	18.9		17.7	206.8	226.3		216.6	23.1	24.9		24.0
	CH-8	23.1	20.2		21.6	264.0	269.5		266.7*	26.8	23.5		25.1
Mean year ©		21.4	21.8 ns		**A x B x C**	240.5	255.6 ns		**A x B x C**	28.3 ns	27.5		**A x B x C**

Factor		Yield (t/ha)							No. of tubers							Mean tuber weight (g)						
		A	B	C	AB	AC	BC	ABC	A	B	C	AB	AC	BC	ABC	A	B	C	AB	AC	BC	ABC
LSD	1%	3.5	4.2	3.5	6.0	4.9	6.0	8.5	40.3	49.3	40.3	69.8	57.0	69.8	40.3	4.4	5.4	4.4	7.6	6.2	7.6	10.8
	5%	2.6	3.1	2.6	4.4	3.6	4.4	6.2	29.6	36.3	29.6	51.3	41.9	51.3	29.6	3.2	4.0	3.2	5.6	4.6	5.6	7.9

** = significant at 1% level; * = significant at 5% level; ns = not significant

In general, there were no significant differences between the two methods with regard to number of tubers produced by the rooted seedlings. There was on the contrary a highly significant interaction production method x TPS family with regard to tuber number, with LT-8 x TS-15 rooted seedlings produced with the "traditional" method yielding more than those produced with the "improved" method (321.3 vs. 200.6), while the opposite occurred for the other two TPS families.

Yield (t/ha) of rooted seedlings produced with the "improved" method was higher than that of seedlings produced with the "traditional" method (24.0 vs. 19.1 t/ha). Only LT-8 x TS-15 and HPS-I/13 rooted seedlings produced with the "improved" method yielded more than those produced with the "traditional" method. The average weight of tubers issued from rooted seedlings produced with the "improved" method was higher than that of tubers produced with the "traditional" method (30.3 vs. 25.5 g), at 1% level of significance. Tuber weight of LT-8 x TS-15 rooted seedlings produced with the "improved" method was significantly higher than that of seedlings of the same TPS family produced with the "traditional" method (43.8 vs. 25.2 g) and of the other TPS families.

Conclusions and discussion

The technique above described represents an original variant to produce rooted seedlings from TPS materials under nursery conditions. In fact, further to some experiences conducted in Uzbekistan we came to the conclusion that rooted seedlings produced in the traditional way are more prone to losses once transplanted in the field because of transplanting shocks due to two main causes: (i) the rooted seedlings produced traditionally have almost bared roots once they have been transplanted in the open field, thus resulting in weaker and slower plant establishment, and (ii) the traditionally produced rooted seedlings appear particularly weak and more sensitive to intense solar radiation and high temperatures recorded in the highlands of Central Asia during the single-cropping season. The new method explained in the present paper has the advantage of producing stronger seedlings with substrate intimately attached to the rooting system, thus reducing considerably transplanting shocks and root damages, which can open the way to diseases (i.e. *Rhizoctonia solani*), finally ensuring prompt recovery of the rooted seedlings. The so-called "improved" method of producing rooted seedlings from three different TPS families, two hybrids and one Open Pollinated, gave better results in terms of plant survival at 20 days after transplanting. Mean tuber weight and yield of rooted seedlings produced according to the "improved" method were also significantly higher than those of seedlings produced according to the "traditional method". Interaction planting method x TPS family was highly significant for LT-8 x TS-15 in terms of yield and mean tuber weight, while in the case of HPS-I/13 only yield and number of tubers produced were highly significant.

Based on this study, it can be concluded that:

- It is possible to use rooted seedlings produced with the "improved" method, which will ensure better survival after transplanting and better yield although a certain percentage of segregation should be always considered in the progeny;
- The TPS technology herewith described is extremely simple and can be adopted by those smallholders who are familiar with vegetable growing and, especially, by those living in marginal areas. It is probably more labour-consuming, compared with conventional seed potato techniques and the direct TPS seeding technique, but this does not represent an issue in CAC countries because family laborers and unemployed people are numerous in the countryside;
- The major problem to solve, but not the least, refers to the duration of the growing cycle of the tested TPS families: while 120-130 days (Carli and Khalikov, 2006) are necessary for seedling tubers produced according to the direct seeding technique under long day conditions of Central Asia (from sowing till harvesting), about 151 days are needed for rooted seedlings to produce seedling tubers of commercial size (from sowing till harvesting). This could represent a serious obstacle to the diffusion of such alternative planting materials among Uzbek potato growers.

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