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EFFECT OF CROPPING SYSTEM, PLANTING DENSITY AND SIZE OF POTATO SEED-MINITUBERS ON THEIR YIELDING CAPACITY

Andreea Nistor[1], Gheorghe Câmpeanu[2], Nicolae Atanasiu[2], Nicoleta Chiru[1], Sorin Rusu[1], Maria Ianoşi[1]

[1]National Institute of Research and Development for Potato and Sugar Beet Braşov, Fundăturii Street, no. 2, Braşov County, Romania. E-mail: tican_andreea@yahoo.com

[2]University of Agronomic Science and Veterinary Medicine, Bucharest, Mărăşti Bd., no. 59, District l, Romania

ABSTRACT

Our goals were to increase the coefficient of potato propagation by optimizing planting density, using different calibration classes of minitubers in early, mid early and semi-late cultivars (Ostara, Christian, Roclas and Desirée) and planting them in open field and "insect proof" tunnels. All tested cultivars had lower production in the tunnels compared with the culture in the open field (yield differences of 0.74 to 10.29 t ha^{-1}), but tubers were superior in phytosanitary terms, being 100% free of viruses. The 25-35 mm size fraction gave higher production compared with the fraction 15-25 mm, and planting densities of 8 and 6 minitubers per linear meter determined higher yields than the density of 5 minitubers per linear meter, for both cropping systems and all cultivars.

Key words: minitubers, „insect proof" tunnels, planting density, planting size, potato cultivars.

INTRODUCTION

Potato is the most widely cultivated food crop after wheat, rice and maize. In the common environment conditions, potato is infected with 25 viruses and 1 viroid (Salazar, 1996). Most severe viruses, which produce disease and strongly affect potato plants, eventually lead to important production losses (Boţoman and Ianosi, 2005). Producing minitubers from healthy *in vitro* plantlets allows a faster multiplication rate in seed tuber production programs and reduces the number of required field generations (Imma and Mingo-Castel, 2006). These minitubers are the beginning stage of seed potato production. The application of healthy potato tubers can lead to at least 30% yield increase (Zarghami, 2001).

The main problem in the program of conventional seed potato production is the low rate of multiplication in field conditions and the susceptibility of potato to diseases, which can be transmitted through potato tubers.

With each multiplication of potato in the field, the risk of infection with viruses, bacteria or other pathogens increases (Ranalli et al., 1994).

Healthy potato seed can be improved by reducing the number of multiplications in the field required for seed production. This technique requires the use of propagation of original material, in large quantities, in „insect proof" tunnels.

Increasing the density of minitubers over certain limits had negative influence on the number of tubers from fraction 30-50 mm and on their quality (Bărdaş, 2004).

The size of minitubers may range from 5 to 25 mm, although in current systems larger mini-tubers also have become common. This size range coincides with a weight range of 0.1-10 g or more (Struik, 2007).

Planting density variations could influence above and below ground biomass accumulation and, subsequently, tuber number and weight. Karafyllidis et al. (1997) determined that more minitubers and yield per area are expected in high planting densities in contrast with low densities.

Another study showed that increasing planting densities reduces the proportion of

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large minitubers in favor of smaller minitubers (Georgakis et al., 1997).

In this study, minitubers were planted at high altitudes, as these represent natural barriers created on natural conditions for isolating crops and therefore reduce virotic disease propagation (Bozeşan, 2003).

MATERIAL AND METHODS

In 2009, a study on the production of potato obtained from minitubers (both in open field and in "insect proof" tunnels) was done at Lazarea, District Harghita.

In the experimental field at Lazarea, a factorial trial was placed, using a split-plot design of the type 2 x 4 x 3 x 2, with a total of 48 treatments in three replications.

The experimental factors were:

- factor a – cropping system, with two graduations:
  a_1 – in open field (Figure 1);
  a_2 – in „insect proof" tunnels (Figure 2).
- factor b – cultivars with 4 graduations:
  b_1 – Ostara;
  b_2 – Christian;
  b_3 – Roclas ;
  b_4 – Desirée.
- factor c – planting density, with three graduations:
  c_1 – 114285 minitubers ha^{-1} (70 x 12.5) = 11.4 pl m^{-2} (8 minitubers/linear meter);
  c_2 – 86058 minitubers ha^{-1} (70 x 16.6) = 8.6 pl. m^{-2} (6 minitubers/linear meter);
  c_3 – 71428 minitubers ha^{-1} (70 x 20.0) = 7.1 pl. m^{-2} (5 minitubers/linear meter).
- factor d – minituber size used in planting, with two graduations:
  d_1 – <25 mm;
  d_2 – 25 - 45 mm.

The climate on closed areas is wet and cool, the largest amount of precipitation falling in June, July, August, with a high frequency of rainy days in June and July.

The average annual temperature is between 5.6 and 7.5-7.8 degrees Celsius.

Figure 1. Open field (Lazarea, Harghita County)

Figure 2. „Insect proof" tunnel (Lazarea, Harghita County)

RESULTS AND DISCUSSION

ANOVA shows that, when tested against the pooled variance of high order interactions, all 4 studied factors had significant effects on tuber yield, but among the two factors interactions only the interaction between cropping systems and cultivars was significant (Table 1).

Cultivars Roclas and Christian signi-ficantly overyielded the control, the cultivar Ostara in both cropping systems.

The yield increase over Ostara ranged from 2.80 t ha-1 for Roclas, in tunnels and 10.23 t ha-1 for the same cultivar, in open field (Table 2).

Cultivars Roclas and Christian significantly overyielded the control, the cultivar Ostara in both cropping systems.

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Table 1. ANOVA for potato yield (Lăzarea, Harghita County, 2009**)**

Source of variation	SS	df	MS	F	F crit
System	326.87	1	326.87	**118.86**	4.28
Cultivars	379.17	3	126.39	**45.961**	3.03
Size	205.84	1	205.84	**74.852**	4.28
Dens	191.98	2	95.994	**34.907**	3.42
Sys*Cult	163.21	3	54.40	**19.784**	3.03
Sys*Size	4.2008	1	4.2008	1.5276	4.28
Sys*Dens	3.0253	2	1.5126	0.550	3.42
Cult*Size	0.3628	3	0.1209	0.0439	3.03
Cult*Dens	15.358	6	2.5598	0.9308	2.53
Size*Dens	0.0027	2	0.0013	0.0004	3.42
Rest	63.248	23	2.7499	1	
Total	1353.29	47			

F values in bold are significant at P<0.05.

The cultivar Desirée cultivar gave a significant yield increase of 2.37 t ha^{-1} over Ostara in „insect proof" tunnel, but was not significantly different from the control in open field.

The results confirm the productivity of the mid early cultivars Christian and Roclas, both in protected space „insect proof", and in open field.

The yield difference between open field and insect proof tunnels ranged from 0.74 in Ostara to 10.29 t ha^{-1} in Roclas. Higher yields were obtained for all cultivars tested in the open field compared with the tunnels, with very significant positive differences ranging between 6.99 and 10.29 t ha^{-1}, for Christian and Roclas cultivars and a positive significant difference of 2.86 t ha^{-1} for cultivar Ostara, while the cultivar Desirée behaved similarly in both cropping systems.

Table 2. Combined influence of cultivar and cropping system on tuber yield (t ha^{-1}) (Lăzarea, Harghita County, 2009)

Cropping system / Cultivar	Tunnels „insect proof", a_1			Open field, a_2			Differences (t ha^{-1})
	Yield (t ha^{-1})	Dif. (t ha^{-1})	Signif.	Yield (t ha^{-1})	Dif. (t ha^{-1})	Signif.	a_2-a_1
Ostara, b_1 (Check)	20.98	-	-	23.84	-	-	+2.86*
Christian, b_2	24.76	+3.78	***	31.75	+7.91	***	+6.99***
Roclas, b_3	23.78	+2.80	***	34.07	+10.23	***	+10.29***
Desiree, b_4	23.35	+2.37	**	24.09	+0.25	n.s.	+0.74 n.s.
	DL 5% = 0.93 (t ha^{-1})			DL 5% = 1.81 (t ha^{-1})			

Despite the fact that yields in the tunnels were lower than those obtained in open field, tubers obtained in tunnels are qualitatively superior, being 100% free of virus; implementation of the tunnel „insect-proof" system should be regarded as an effective solution to obtaining quality pre-basic plant material and an economically efficient solution, competitive nationally and internationally (Table 3).

For cultivars Christian and Desirée, the highest yield was obtained with the density of 8 tubers per linear meter and size fraction 25-35 mm (33.39 t ha^{-1} in open field and 31.79 t ha^{-1} in the tunnels for Christian and 28.41 and 30.68 t ha^{-1} respectively for Desirée).

In Roclas highest yield in open field was also obtained with the density of 8 tubers per linear meter and size fraction 25-35 mm, while in tunnels highest yield was obtained with the density of 6 tubers of the same size per linear meter.

The 25-35 mm size fraction gave higher yields, as compared with the fraction 15-25 mm, and planting densities of 8 and 6 meter linear minitubers determined higher yields than the density of 5 minitubers linear meter for both cropping systems and all cultivars.

Table 3. Combined influence of cropping system, planting density, size fraction and variety on production (t ha^{-1}) of tubers obtained (Lăzarea, Harghita County, 2009)

Culture technology	Size fraction (mm)	Density (tubers/ linear meter)	Production (t ha^{-1}) / Cultivars			
			Ostara	Christian	Roclas	Desirée
Open fields	15 - 25	8 tubers/m	**23.98** -	**31.90** **+7.92** ***	**34.51** **+10.53** ***	**25.13** **1.15** n.s.
		6 tubers/m	22.51 -	30.14 +7.63 ***	32.50 9.99 ***	24.12 1.61 n.s.
		5 tubers/m	17.86 -	29.32 +11.46 ***	30.55 12.69 ***	17.43 -0.43 n.s.
	25 - 35	8 tubers/m	**30.76** -	**33.39** **+2.63** n. s.	**35.91** **5.15** **	**28.41** **-2.35** n.s.
		6 tubers/m	26.01 -	33.33 +7.32 ***	35.65 9.64 ***	25.31 -0.7 n.s.
		5 tubers/m	21.94 -	32.41 +10.47 ***	35.29 13.35 ***	24.14 2.2 n.s.
Tunnels „insect proof”	15 - 25	8 tubers/m	**21.41** -	**23.84** **2.43** n. s.	**24.18** **2.77** *	**24.35** **2.94** *
		6 tubers/m	18.30 -	20.66 +2.36 n. s.	21.00 2.70 n.s.	21.38 3.08 *
		5 tubers/m	17.47 -	20.73 +3.26 *	19.04 1.57 n.s.	17.86 0.39 n.s.
	25 - 35	8 tubers/m	**24.42** -	**31.79** **+7.37** ***	27.24 2.82 *	**30.68** **6.26** ***
		6 tubers/m	22.75 -	28.54 +5.79 ***	**28.02** **5.27** **	24.08 1.33 n.s.
		5 tubers/m	21.53 -	23.00 +1.47 n.s.	23.22 1.69 n.s.	21.75 0.22 n.s.

LSD 5% =2.72 t ha^{-1} LSD 1%= 4.11 t ha^{-1} LSD 0.1%=5.34 t ha^{-1} n.s. = not significant

CONCLUSIONS

Cropping systems, cultivars, planting densities and tuber size significantly influenced the potato tuber yield, but only the interaction between cropping systems and cultivars was significant.

Cultivars Roclas and Christian yielded significantly more than the control cultivar Ostara both in open field and in tunnels.

Despite lower yields, implementation of the tunnel "insect-proof" should be regarded as an effective solution to keeping quality of plant material and is an economically efficient solution.

The 25-35 mm size fraction gave higher yield than the fraction 15-25 mm, and planting densities of 8 and 6 meter linear minitubers determined higher yields than the density of 5 minitubers linear meter for both cropping systems and all cultivars.

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