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Experimental results on the tuber yield of some potato isogenic lines under "insect-proof" tunnels and open field conditions

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Abstract In true potato seed (TPS) technology the main barrier, but also a challenge to science is the production of seeds which produce uniform tubers despite the great genetic variability of potato. Sexual reproduction on potato involves more elements, compared to other plants, because the potato has four chromosome sets (tetraploid). Therefore, plants obtained from true potato seed have completely different genetic characteristics of their parents regarding phenotype, the group of earliness and the characteristics of the tuber. Today, however, due to the amazing progress, potato hybrid seed is available in sufficient quantities at a reasonable price, and the obtained product is characterized by uniformity and quality.
In the period 2006 - 2009 has been studied the tuber yield of four potato isogenic lines: Mindy, Zolushka, Gilroy and Catalina (creations of Bejo Zaden company, Netherlands), compared with two control varieties (Santé and Rustic) both in fields and "insect-proof "tunnels.

Key words

potato isogenic lines, productivity, „insect-proof" tunnel

The main problem in the conventional production program of potato seed tubers is the low rate of multiplication and their susceptibility to diseases. With each multiplication of potato in field conditions the risk of infection with viruses, bacteria or other pathogens increases [4]. In the seed potato production, crop location in closed areas with favorable climatic conditions is required. Also, the occurrence of the main virus vectors (aphids) is necessary to achieve later and with low intensity.

To improve the quality of planting material, both biological and phytosanitary aspects, it must find new technological solutions, efficient and economically profitable, aiming to achieve constant yields and quality. Taking into account scientific results both in our country and worldwide, in the production of starting material the use of tunnels "insect-proof" made of materials that prevent virus transmission by aphids, was successfully tested.

Research Methods and Materials

In this study are presented experimental results regarding tuber yield of four potato isogenic lines obtained in the period 2006-2009 at the Clonal Seed Potato Production Centre, from Lazarea, Harghita County, affiliated to the National Institute of Research and Development for Potato and Sugar Beet (NIRDPSB) Brasov, Romania. The biological material is represented by the four potato isogenic lines: Mindy, Zolushka, Gilroy and Catalina (creations of Bejo Zaden company, Netherlands) and two potato varieties: Santé (Dutch) and Rustic (Romanian), used as a control.

After minitubers obtaining in greenhouse, starting from true potato seed (F1), they were grown for two consecutive years (2006 and 2007) in tunnels "insect-proof" (Fig. 1) and the next two years (2008 and 2009) in open field conditions, at Lazarea (Fig. 2). This area is located in a very favorable area of potato cultivation, geographically well defined, being a natural ecological factor limiting the development and spread of aphids, as the main vectors of potato virus diseases.

The region is characterized by short spring, cool and frequent rain, more fog and dew. Strong air circulation, reduced opportunities for the spread of virus diseases and vectors a longer interval from the first flight of aphids until early summer maximum flight.

Fig. 1. Tunnels „insect-proof" in the experimental fields of Lazarea, Harghita County

From a climate perspective, during the growing season, in 2006, 2008 and 2009 the average monthly temperatures close to MAA, while in 2007, temperatures were higher than MAA (Table 1). Regarding rainfall during the growing season (Table 2), both in 2006 (433 mm) and 2007 (461 mm) shows a total amount exceeding MAA. The years 2008 and 2009 rainfall, in their evolution, were interesting because noted variations from month to month during the growing season. In 2008, it received a total amount of 651.4 mm rainfall, with a surplus of +62.4 mm from the MAA (589 mm) and in 2009 total rainfall (541.6 mm) is characterized by a deficit to -47.4 mm from the MAA.

Table 1

Average monthly temperatures (^{o}C) during the growing season in 2006-2009 and MAA, (Weather station Joseni, Harghita County)

Average	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
MAA	-7.2	-4.8	-0.9	6.5	10.4	14.3	16.1	15.5	10.7	5.7	0.1	-5.3
Monthly average 2006	-11.6	-6.8	-1.0	7.1	11.0	14.6	16.5	15.9	12.4	6.9	1.4	-2.3
Monthly average 2007	0.8	-0.4	3.6	6.0	14.4	16.6	18.7	17.4	10.5	6.2	-1.5	-6.2
Monthly average 2008	-7.0	-1.5	2.5	7.2	11.8	15.4	16.2	17.2	10.7	7.0	0.2	4.4
Monthly average 2009	-6.7	-2.9	1.9	7.8	12.1	15.9	17.6	16.4	12.4	6.6	3.2	-2.9

Table 2

Average monthly rainfall (mm) during the growing season in 2006-2009 and MAA, (Weather station Joseni, Harghita County)

Average	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
MAA	23.5	38	31.6	59.4	74.9	113.9	75.6	59.6	23.7	16.2	26.2	46.4
Monthly average 2006	17.2	8.7	43.9	41.0	57.5	119.1	73.1	110.6	17.0	14.8	4.6	5.7
Monthly average 2007	16.3	20.1	37.9	22.7	56.7	24.7	63.8	119.1	90.4	84.0	35.1	20.2
Monthly average 2008	12.3	5.9	51.9	62.1	66.3	101.6	167.2	19.2	42.3	40.2	33.3	49.1
Monthly average 2009	13.6	27.7	22.8	24.1	74.3	131.3	47.1	68.6	18.9	69.3	13.9	30.0

Agricultural work performed

Autumn plowing was done with worn plow at a depth of 20 cm. In spring, was done the necessary work to prepare the ground: harrowing and two passes with combiner. Application of chemical fertilizers (NPK complex 15:15:15) was performed a few days before planting.

Table 3

Calendar of activities performed in Lazarea, from 2006 to 2009

Activity	2006	2007	2008	2009
	Tunnel „insect-proof"		Open field	
Autumn plowing (20 cm deep)	11.10.2005	19.10.2006	09.11.2007	29.10.2008
Harrowing (spring)	22.05.2006	31.05.2007	16.05.2008	30.04.2009
NPK Fertilization (15:15:15)	23.05.2006	31.05.2007	21.05.2008	30.04.2009
Planting distances (m)	0.15x0.15x0.05	0.15x0.15x0.06	0.21x0.70x0.1	0.21x0.70x0.2
Planting	Manually, June 6	Manually, June 1	Mechanically, May 26	Mechanically, May 5
Hilling	-	-	June 10	June 8
Weed control	Dancor (July 5)	Dancor (June 20)	Hurricane (June 27)	Hurricane (June 16)
Disease control	Rover (July 11) Electis (July 19) Acrobat (August 2)	Rover (July 2) Rover (July 12) Electis (August 16)	Rover (July 11) Cupertin (July 31) Cupertin (August 11)	Dithane (July 8) Curzate (July 15) Acrobat (August 4)
Pest control	Mospilan (July 11) Mospilan (July 19) Mospilan (August 2)	Mospilan (July 2) Calypso (July 12) Calypso (July 24) Calypso (August 16)	Calypso (July 11) Calypso (July 31) Calypso (August 11)	Calypso (July 8) Calypso (July 15) Calypso (August 4)
Haulm killing (Reglone: 4,5 l/ha)	August 28	Sept. 4	August 26	August 21
Harvesting	Manually, Sept. 14	Manually, Sept. 28	Mechanically, Sept. 22	Mechanically, Sept. 18
Storing (0 – 13 °C)	Bags	Bags	In containers	In containers

As can be seen in Table 3, land preparation and fertilizer applications are activities that are carried out in a similar way both in tunnels "insect-proof" and the open field. Regarding planting distances, they are lower in the tunnels "insect-proof" (15 cm between plants/row, 15 cm between rows and 5-6 cm deep) than the field (21 cm between plants/row, 70 cm between rows and 10-20 cm deep). Planting and harvesting were performed manually in tunnel experiences and mechanically in the field.

Figure 2 shows the images of the potato plants belonging to the four studied isogenic lines (F1C3 generation) during the growing season and tubers harvested in autumn 2008.

Fig. 2. Aspects of experimental field from Lazarea, 2008

The hilling work was performed only for the experimental variants located in the field. For those that are inside the tunnels "insect-proof" was not been carried out the hilling operation and visual removing of virus infected potato plants in order to reduce the spreading possibility of transmitted by contact viruses (PVM, PVS, PVX).

The chemical treatments for weeds, aphids (prevention), the Colorado potato beetle and late blight control were performed through the "insect-proof" canvas, without removing it. After harvesting, the

potato tubers were stored and kept in appropriate conditions of temperature, humidity and light.

Results and Discussions

Growing experimental variants in protected areas such as "insect-proof" tunnels, aims to increase the efficiency of applied fertilizers, improved plant nutrition especially in the early stages of vegetation and thus increase the propagation coefficient. The plants resulting from small tubers (such as minitubers obtained from botanical seed) are more fragile than potato plants obtained from tubers because of limited nutrient resources. Protected areas such as "insect-proof" tunnels provide a favorable microclimate for plant development, protecting them at the same time against viral infections transmitted through aphids. Also, its contribute to an easier acclimatization of planting material, making the transition from a protected space (greenhouse) in a natural environment like an open field crop.

For the experiments located in tunnels "insect-proof" vegetation period (from emergence to end of potato plants vegetation) was 60 days in 2006 and 70 days in 2007. Table 4 presents the results regarding tuber yield of the studied isogenic potato lines compared with two control varieties.

Table 4

Tuber yield of studied potato genotypes in tunnels "insect-proof" in 2006 and 2007 (Lazarea, Harghita County)

Line/Variety	2006			2007		
	Area (m^2)	Cantity (kg)	Yield (kg/m^2)	Area (m^2)	Cantity (kg)	Yield (kg/m^2)
Mindy	10.9	3.6	0.33	10.1	40.0	3.95
Zolushka	9.2	10.3	1.12	23.2	90.0	3.88
Gilroy	6.9	6.9	1.00	15.6	55.0	3.52
Catalina	7.9	3.7	0.47	13.7	45.0	3.28
Santé	220.0	320.0	1.45	110.0	240.0	2.18
Rustic	165.0	230.0	1.39	165.0	340.0	2.06

It may be noted that in 2006, the control varieties obtained a higher yield compared to isogenic lines, but in 2007 isogenic lines exceeded the production of control varieties.

In 2006, the highest tuber yield was obtained by Santé variety (1.45 kg/m^2), followed by Rustic variety (1.39 kg/m^2). Zolushka and Gilroy lines achieved a production of about 1 kg/m^2 and lowest results were recorded on Mindy (0.33 kg/m^2) and Catalina (0.47 kg/m^2).

In 2007, the tuber yield of isogenic lines exceeded that of the control varieties. The highest yield was achieved by Mindy (3.95 kg/m^2), followed by Zolushka (3.88 kg/m^2), Gilroy (3.52 kg/m^2) and Catalina (3.28 kg/m^2). The lowest yields were recorded to control variety Rustic (2.06 kg/m^2) and Santé (2.18 kg/m^2). Potato isogenic lines yield was almost double than those of control varieties, in 2007.

Table 5

Tuber yield of studied potato genotypes in open field during 2008 and 2009 (Lazarea, Harghita County)

Line/Variety	2008			2009		
	Area (ha)	Cantity (kg)	Yield (t/ha)	Area (ha)	Cantity (kg)	Yield (t/ha)
Mindy	0.010	124.00	12.40	0.035	366.00	10.50
Zolushka	0.023	317.00	13.80	0.077	920.00	11.90
Gilroy	0.010	158.00	15.80	0.047	503.00	10.70
Catalina	0.010	179.00	17.90	0.041	553.00	13.50
Santé	0.260	4700.00	18.10	0.060	850.00	14.20
Rustic	1.210	21500.00	17.80	0.380	4900.00	12.90

During 2008 - 2009, the biological material obtained in tunnels "insect-proof" was grown in the open field, at the Clonal Seed Potato Production Centre, from Lazarea, Harghita County. The length of vegetation (from emergence of potato plants to haulm killing) was about 70 days. Table 5 presents data on tuber yield obtained in these conditions by the six studied potato genotypes.

Under the ecological and climatic conditions of Lazarea (Harghita County), in the experiments carried out both in tunnels "insect-proof" and in open field, the vegetation period of potato plants was shorter (60-73 days), compared with the experiences placed in

the same period at the National Institute of Research and Development for Potato and Sugar Beet (NIRDPSB) Brasov, for example (more than 120 days). For the experimental field crop placed at Lazarea, the period in which plants receive sunlight was longer and therefore, the processes of growth and development occur more intensely. Moreover, the technology of seed potatoes production aim to get small and medium-sized tubers and not too large. As a result, the haulms of potato plants are killed before they reach the maximum storage capacity of the biological production. Also, by earliest vegetation stopping, secondary viral infections can be avoided.

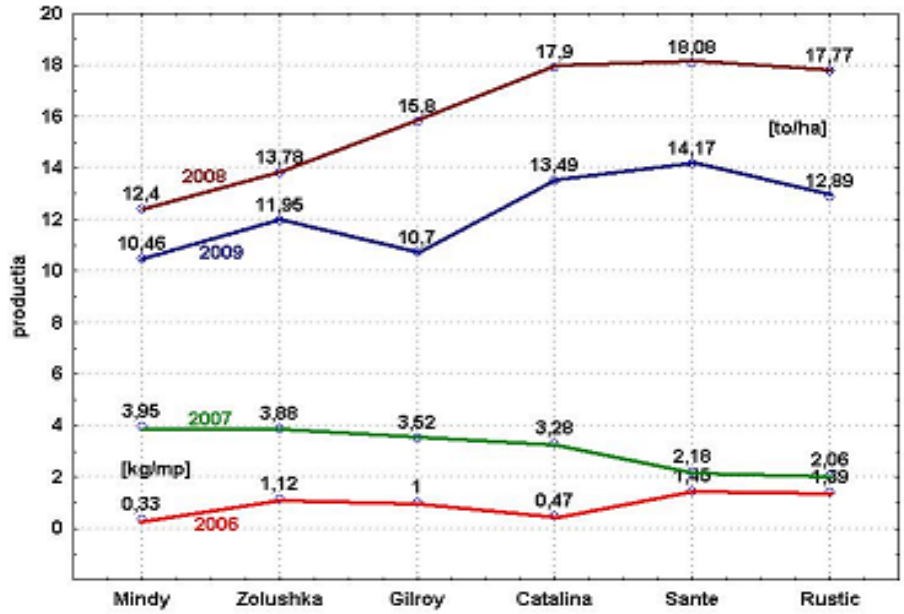

Fig. 3. Evolution of tuber yields of the six potato genotypes in 2006-2009 (Lazarea, Harghita County)

Under the conditions of 2008, the tubers yields obtained by Catalina (17.9 t/ha) was higher than Rustic variety (17.8 t/ha) and similar to Santé variety (18.1 t/ha). To the other three isogenic lines, production level was low in particular for Mindy (12.4 t/ha).

In 2009, the highest yield of tubers was obtained from Santé variety (14.2 t/ha). Of the studied lines Catalina was noted as most productive (13.5 t/ha), the difference from Santé variety being insignificant. Gilroy (10.7 t/ha) and Mindy (10.5 t/ha) achieved the lowest yield.

Conclusions

During the four years of study, the production of tubers obtained from isogenic lines was different depending on the location (tunnel "insect-proof" or open field) and specific climatic conditions of the years (Fig. 3).

The experimental results obtained during the four years at the Clonal Seed Potato Production Centre, from Lazarea, Harghita County on tuber yield capacity of the studied potato isogenic lines are nevertheless encouraging. In 2007 potato isogenic lines yield was almost double than those of control varieties.

In terms of yield capacity, both in 2008 and in 2009, of the four studied isogenic lines, Catalina was the best performants exceeding the control variety Rustic and making similar productions with Santé variety (most productive from the studied potato genotypes). Catalina was noticed both by good production capacity, compact and restricted houlm growth, with significance for mechanized agriculture practices and uniformity of obtained tubers.

High temperatures, difficult to access lands, involvement of great expense in procuring and transporting of a high quality starting material are just some of the factors that lead researchers and small farmers to be interested in testing of the potato genotypes derived from true seed.

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