LETOPIS NAUČNIH RADOVA / ANNALS OF AGRONOMY
Vol. 43, No 2, 101-108
UDK: 633.15

Poljoprivredni fakultet
Univerzitet u Novom Sadu

Effectiveness in the production of seed maize per different way of detasseling

Vladimir Sabljak[a], Radivoj Prodanović[a*], Lazar Ožegović[a], Katarina Đurić[b], Dragan Ivanišević[a]

[a]University Business Academy in Novi Sad, Faculty of Economics and Engineering Management in Novi Sad, Department of Agribusiness, Novi Sad, Serbia
[b]University of Novi Sad, Faculty of Agriculture, Department of Agricultural Economics, Novi Sad, Serbia
*Contact author: rprodanovic@fimek.edu.rs

ABSTRACT
The aim of the research is to determine what method of detasseling in the production of hybrid seed maize is more effective, manual or mechanical. In the study, method of observation, measurement, comparative method, logic, induction and deduction, analysis and synthesis are applied. The yield of hybrid maize seed in both hybrids ("MAS 26 K" and "Suanito") was higher in the variant of manual detasseling. The number of engaged workers was bigger in the manual detasseling in both hybrids, at "MAS 26 K" on average by 4.6 workers per hectare, while in the hybrid "Suanito" the number of workers engaged during all three controls was higher by 4.2 workers per hectare, compared to the variant of machine detasseling. The higher number of workers per hectare in hybrid "MAS 26 K" in the variant of manual detasseling justifies a difference in yield that amounts 0.97 t/ha, which is not the case with hybrid "Suanito", where the difference in yield of 0.18 can not compensate the higher labor consumption.

KEY WORDS: Effectiveness, maize seed production, hibrid, yield, detasseling

Introduction

Maize (*Zea mais L.*) is, besides wheat and rice, one of the most important cereal. Maize is used in human nutrition mainly in the form of products, as well as for feeding livestock in the form of grains, silage or as a component in concentrated mixtures. There is a great importance of maize in our country, because 38 % of the area is cultivated (on average about 1 120 000 ha, total production 6,03 million tonst) (Pejić et al., 2018).

Since that world demands for maize grow year after year, science has a task to respond to this challenge. One of the ways is introduction of seed material into production, which will be more productive i.e. it will contribute to the achievement of high and stable yields. Hybrids are produced, which have advantages over varieties, and in the first place is the possibility of achieving higher yields (Jockovic et al., 2010).

Commercial maize is predominantly grown from hybrid seed produced from the cross-pollination between two genetically distinct inbred parent lines. One inbred line is selected as the pollen donor (male parent) and the other as the pollen recipient (female parent). For commercial production of maize hybrid seed, male and female inbred parent lines are planted alternately, in adjacent rows, in isolated fields. To produce pure hybrid seed, the male inbred parent must cross-pollinate the female inbred parent, and the female inbred parent must be prevented from self-pollinating (Wu et al., 2016).

Self-pollination is prevented by physical removal of the male-bearing floral structure at the top of the plant. Mechanical detasseling can remove significant amounts of vegetative material resulting in reductions of as much as 40 % of the potential inbredseed yield (Wych, 1988). Mechanical detasseling using rubber discs resulted in a lower yield of seeds by 5% in relation to manual methods (Marković and Branković, 2006). Also, Huanuqueño and Tobaru (2016) have found that for each stripped leaf, the yield is reduced by 4, 3%.

In the process of production of mercantile maize, the key factor is quality (hybrid) seed. The transition to the hybrid concept of breeding and maize production has enabled amazing progress in the field of breeding and seed production, thus seed production of maize has become a high/tech industry (Secanski et al., 2015).

The production of hybrid seed maize is significant also from the aspect of achieving the profit for companies that are engaged in it, thus, there is a high demand in terms of quality, yield and benefits for production areas, in order to maintain and increase competitiveness on the world market. Quality and profitability of hybrid maize seed production will be ensured by good production management. Seed must meet high genetic, physical and phytosanitary standards (Mac Robert et al., 2014).

The process of detasseling, in addition to soil preparation, sowing and removing atypical plants,

present one of the key phases in total production process of seed maize and has significant impact on the end result. If the process of detasseling is not conducted well and on time, desired result will be absent, which is a quality and genetically uniform hybrid seed of maize (Knezevic, 2005).

Material and methods of research

In the research, the method of observation, measurement, comparative method and other general scientific methods are applied. The research was conducted on parcels of "Poljoprivreda" Inc. from Senta in 2014. On the location Bogaras, a hybrid "Suanito" was planted, with total area of 97 ha, and the location Gornji Breg, the hybrid "MAS 26 K" was planted on area of 28 ha.

The type of soil where the research is carried out is the blackness of the wood terrace, mild alkaline reaction, with approximately 2.5 % humus in the arable land, medium provided with easily accessible phosphorus and well potassium. The preconditions are winter cereals – wheat and barley.

Table 1 lists all phases and sub-phases in the production process of the Suanito hybrid seed maize. Both hybrids were planted in the sowing scheme 4:3. The "Mother" was sown at a spacing of 70 cm with a space of 16 cm, while the first "father" was sown at a distance of 55 cm from the "mother" with a space of 21 cm. Sowing depth was 5 cm.

Table 1.
Phase and sub-phase preparation for hybrid "Suanito"
Tabela 1.
Faze i podfaze kod hibrida „Suanito"

Phase	Sub-phase	Time
Sowing	♀	18.04.2014. – 21.04.2014.
	$♂_1$	18.04.2014. – 21.04.2014.
	$♂_2$	26.04.2014. – 27.04.2014.
	$♂_3$	06.05.2014. – 07.05.2014.
Protection	herbicides	23.04.2014. 11.05.2014. – 12.05.2014. 22.05.2014. – 23.05.2014.
	fungicides	18.07.2014
	insecticides	05.08.2014. – 07.08.2014.
Cultivation among the ranks	I	30.05.2014. – 02.06.2014.
	II	
Detasseling (general)	Machine detasseling	30.06.2014. – 01.07.2014.
	Manual detasseling	01.07.2014. – 02.07.2014.
	Machine detasseling	02.07.2014. – 03.07.2014.
Detasseling (control)	I	04.07.2014. – 06.07.2014.
	II	09.07.2014. 11.07.2014. 13.07.2014. 14.07.2014.
	III	15.07.2014.
Removal of "fathers"	–	01.08.2014. – 03.08.2014.
Harvest	–	23.08.2014. – 27.08.2014.

The sowing of the second "father" was conducted from 26-27 April 2014 at the time when "mother" had a 2 cm long coleoptile. Second "father" was planted at a 70 cm spacing in relation to the "mother" and 15 cm in relation to the first "father" with a spacing of 25 cm and a depth of sowing of 4.5 cm.

The third "father" sowing was carried out from 6-7 May 2014 at the time when the second "father" had a 3-5 cm long coleoptile. The third "father" was planted at an interval of 55 cm in relation to the "mother" and 15 cm to the second "father", with a space of 30.5 cm and a depth of sowing of 4.5 cm.

The use of herbicides during vegetation was performed in three treatments. The first treatment with

Glifol preparation (a.m. glyphosate 480g/l) at a dose of 4 l/ha was done before the crop on April 23, 2014. The second treatment with the preparations Motivel (Ammonosulfuron 40g/l) at a dose of 0.4 l/ha and Laudis (a.m. tembotrion 44 g/l and isoxadifen-ethyl 22 g/l) at a dose of 1 l/ha, performed when the "mother" and the first "father" were in phase of 2-3 leaves, in period from May 11 to May 12, 2014. The third treatment with preparation Motivel (a.m. nicosulfuron 40 g/l) at a dose of 0.45 l/ha and laudis (a.m. tembotrione 44 g/l and isoxadifen-ethyl 22 g/l) at a dose of 1 l/ha, was performed when "mother" and the first "father" were in phase of 5-6 leaves, in the period from May 22 to May 23, 2014.

Fungicidal treatment was performed with Quilt preparation (a.m. 141.4 g/l azoxystrobin and 122.4 g/l propiconazole) at a dose of 1 l/ha, at the fertilization stage, July 18, 2014.

The treatment with insecticide for controlling the larvae of maize flame (lat. *Ostrinia nubilalis* was performed with Coragen (a.m. chlorantraniliprol 200 g/l) at a dose of 0.15 l/ha and Vantex (a.m. gamma-cyhalothrin 60 g/l) at a dose of 0.06 l/ha, in the phase of filling the grain, in the period from 5 to 7 August, 2014.

Intermittent cultivation for the purpose of aeration and weed destruction was performed in the period from May 30 to June 2, 2014.

The stage of general detasseling was conducted in three sub-phases. Machine cutting was carried out on a total area of 97 ha, in the period from June 30, 2014 to July, 1 2014. After that, the detasseling was performed manually, on the part of the plot of 36 ha in the period of July 1-2, 2014, while machine detasseling was carried out on the other part of plot on the surface of 61 ha, in the period from July 2 to 3, 2014. The sub-phase of machine detasseling was conducted by the high-clearance machine "Frema" type Aiglon, and the following sub-phase was conducted using the high-clearance machine "Frema" type Condor.

Table 2.
Phase and sub-phase preparation for "MAS 26K" hybrid
Tabela 2.
Faze i podfaze kod hibrida MAS 26K

Phase	Sub-phase	Time
Sowing	♀	29.04.2014.
	$♂_1$	13.05.2014.
	$♂_2$	22.05.2014.
	$♂_3$	22.05.2014.
Protection	herbicides	01.05.2014.
		24.05.2014.
	save through leaf	24.05.2014.
	insecticides	10.08.2014.
Cultivation among the ranks	I	27.05.2014.
	II	05.06.2014.
Detasseling (general)	Machine detasseling	10.07.2014.
	Manual detasseling	12.07.2014.
	Machine detasseling	12.07.2014.
Detasseling (control)	I	15.07.2014. – 16.07.2014.
	II	18.07.2014. – 19.07.2014.
	III	21.07.2014.
Removal of "fathers"	–	08.08.2014.
Harvest	–	24.09.2014. – 25.09.2014.

After the phase of general detasseling, three controls are conducted in which the detasseling were manually. The first control was carried out in the period of July 4 to 6, 2014. The second control was done in three times: July 9, July 11 and July 13, 2014. The third control was done on two occasions on July 14 and 15, 2014. The next phase was the removal of "fathers" and it was carried out between August 1 and 3 of 2014.

The harvest started when grain moisture was 35 % and was carried out from August 23-27 of 2014. Table 2 lists all phases and sub-phases in the process of production of seed maize hybrid "MAS 26 K". The sowing of the "mother" component was carried out in optimal weather and soil conditions

on area of 28 ha on April 29 2014. “Mothers” were sown at a spacing of 70 cm with a space of 17 cm. The sow depth was 5 cm.

The sowing of the first “father” (code line LSH 369) was carried out on May 13, 2014 at the time when “mother” had 1 to 1.5 leaves. The first “father” was sown at intermittent space of 105 cm in relation to the “mother”, with space of 20 cm and a depth of sowing of 4.5 cm. The sowing of the second and the third “father” was carried out on May 22, 2014 at the time when the fist “father” was sprouting. The second and third “father” were sown at a 70 cm spacing from the “mother” and 35 cm in relation to the first “father”, with space of 23 cm and a sow depth of 4.5 cm.

The application of herbicides during vegetation was performed in two treatments. The first treatment was performed with Glifol preparation (a.m. glyphosate 480 g/l) at a dose of 5 l/ha before germination of crop on May 1, 2014. Another treatment with preparation Callisto (a.m. mesotrion 500 g/kg) in a dose of 0.2 l/ha and liquid fertilizer Fertileader Axis at a dose of 3 l/ha, performed when the “mother” had two leaves and when the “first” father was sprouted on May 24, 2014. The treatment with insectide for controlling the larvae of maize flame (lat. *Ostrinia nubilalis*) was conducted with Coragen preparation (a.m. chlorantraniliprol 200 g/l) at a dose of 0.15 l/ha and Vantex (a.m. gamma-cyhalothrin 60g/l) at a dose of 0.06 l/ha, in the phase of filling the grain on August 10 2014.

Intermittent cultivation was done for the first time on May 27, 2014, and the second time on June 5, 2014. The stage of general detasseling was conducted in three sub-phases. Machine detasseling was carried out on a total area of 28 ha on July 10, 2014. After that, the detasseling was performed manually, on the part of the plot of 10 ha on July 12 2014, while machine detasseling was carried out on the other part of plot on the surface of 18 ha, on the same day The sub-phase of machine detasseling was conducted by the high-clearance machine “Frema” type Condor.

After the phase of general detasseling, three controls are conducted in which the detasseling was manually. The first control was carried out in the period of July 15 to 16 2014. The second control was done in three times: July 18 – 19, 2014. The third control was done on July 21, 2014.

The next phase was the removal of “fathers” and it was carried out on August 8, 2014. The harvest started when grain moisture was 28 % and was carried out in the period from September 24-25, 2014.

Results of research and discussion

Seed Yield

One of the important parameters is the amount of raw ear of maize, which presents a moist, picked up ear of maize with all impurities and admixtures, which is placed in the transport medium. The second parameter is the amount of natural seed, which presents unfinished and undeclared seed that is dried, crowned and cleaned from rough impurities (Knezevic, 2005).

Table 3.
Suanito hybrid yield parameters
Tabela 3.
Parametri prinosa kod hibrida „Suanito”

Hybrid „Suanito”	Area (ha)	The quantity of ear of maize (t)	The quantity of natural seed (t)	Yield of natural seed (t/ha)
Manual detasseling	36	217.000	101.880	2.83
Machine detasseling	61	344.180	161.650	2.65
TOTAL	97	561.180	263.530	2.72

Table 3 shows the yield parameters of hybrid “Suanito”. In the case of manual detasseling, higher yield was achieved compared to the mechanical detasseling method by 0.18 t/ha. Table 4 shows the yield parameters of seed maize “MAS 26K”. In the case of manual detasseling, higher yield was achieved compared to the mechanical detasseling by 0.97 t/ha.

Table 4.
Yield parameters of hybrid “MAS 26K”
Tabela 4.
Parametri prinosa kod hibrida „MAS 26K”

Hybrid „MAS 26K”	Area (ha)	The quantity of ear of maize (t)	The quantity of natural seed (t)	Yield of natural seed (t/ha)
Manual detasseling	10	73.130	46.800	4.68
Machine detasseling	18	104.410	66.780	3.71
TOTAL	28	177.540	113.580	4.06

Consumption of Labor in the Process of Detasseling
General detasseling includes the first sub-phase in the process of detasseling, when workers enter for the first time in the field of seed crops of maize and manually detasseling. This sub-phase was done after the machine detasseling was completed (Marinkovic et al., 2008). Then, three controls were conducted in which the rest detasseling was by the use of human labor.

Table 5.
Employment of labor force per hectare in the process of detasseling of hybrid “Suanito”
Tabela 5.
Angažovanost radne snage po ha u procesu uklanjanja metlica kod hibrida „Suanito”

Hybrid „Suanito”	Area (ha)	Average number of working days per ha – general detasseling	Average number of working days per ha – contorols I, II, III	Average number of working days per ha – entire phase of detasseling
Manual detasseling	36	10.6	1.3	11.9
Machine detasseling	61	6.3	1.4	7.7
TOTAL	97	8.8	6	14.8

Table 5 shows parameters of labor consumption in the process of detasseling in the “Suanito” hybrid seed maize. On the surface of 36 ha, manual detasseling was done, while on the remaining part of the parcel area of 61 ha, the detasseling was done mechanically. On part of the parcel where the manual detasseling was made, 10.6 workers were engaged per hectare in the sub-phase of the general detasseling, while on the other part of the parcel, where the machine detasseling was, 6.3 workers per hectare were engaged for the mentioned sub-phase. In the case of manual detasseling in the sub-phase of general detasseling, more workers were employed in relation to the mechanical method, for 4.3 workers/ha. During all three controls in the process of manual detasseling, 1.3 workers per ha were engaged on average, while in the machine method of detasseling during all controls, on average 1.4 workers were engaged per ha. The number of engaged workers is higher by 0.1 workers/ha during machine detasseling.

The total labor force consumption on the entire parcel during sub-phase of the general detasseling is 8.8 workers/ha on average, while during all controls during the mentioned sub-phase, 6 workers were engaged on average. The total consumption of human labor on the entire parcel with the seed crop of hybrid “Santo” is 14.8 workers per ha for the entire phase of detasseling.

Table 6.
Employment of labor force per hectare in the process of detasseling in hybrid "MAS 26K"
Tabela 6.
Angažovanost radne snage po ha u procesu uklanjanja metlica kod hibrida „MAS 26K"

Hybrid „MAS 26K"	Area (ha)	Average number of working days per ha – general detasseling	Average number of working days per ha – contorols I,II,III	Average number of working days per ha – entire phase of detasseling
Manual detasseling	10	7.9	2.7	10.6
Machine detasseling	18	4.0	2.0	6.0
TOTAL	28	6.2	4.9	11.1

Table 6 shows the consumption parameters of human labor in the process of detasseling in hybrid of seed maize "MAS 26K". On one part of the parcel of area of 10 ha, manual detasseling was done, while on the remaining part of parcel of area 18 ha, detasseling was done by machine. On the part of parcel where the manual detasseling was, 7.9 workers/ha were engaged in the sub-phase of the general detasseling, while on the other part of parcel where the machine detasseling was for the mentioned sub-phase, 4 workers were engaged per ha. In the manual detasseling in the sub-phase of general detasseling, more workers were engaged compared to the mechanical method, by 3.9 workers/ha. During all three controls in the process of manual detasseling, on average, 2.7 workers/ha were engaged, while in the machine method of detasseling during all controls, on average, 2 workers/ha were engaged. The number of engaged workers is higher by 0.7 workers per ha during manual detasseling.

The total consumption of human labor on entire parcel during sub-phase of general detasseling on average was 6.2 workers/ha, while during all controls during mentioned sub-phase on average was engaged 4.9 workers/ha. The total consumption of human labor on entire parcel with seed crop of hybrid "MAS 26K" for entire phase of detasseling was 11.1 workers/ha.

Conclusion

Seed yield in both observed hybrids is higher in the variant of manual detasseling, which coincides with the results of the research Wych (1988). The highest yield was achieved in hybrid "MAS 26K", in the variant of manual detasseling (4.68 t/ha). In the hybrid "Suanito", seed yield during manual detasseling was higher by 0.18 t/ha compared to the machine detasseling. In the hybrid "MAS 26K", even more significant difference was achieved and it amounts to 0.97 t/ha.

With both hybrids, the number of engaged workers was higher in the sub-phase of the general detasseling. In hybrid "Suanito", total number of workers engaged during all three controls was on average less than 0.1 workers/ha, in a variant with manual detasseling. In the hybrid "MAS 26K", the reverse situation was noticed, because during all conducted controls, the number of engaged workers in the variant with manual detasseling was on average higher by 0.7 workers/ha, compared to the machine detasseling. In the entire phase of the detasseling of "Suanito" hybrids, the number of engaged workers was higher by 4.2 workers/ha in the variant with manual detasseling, while in the hybrid "MAS 26K", this difference is 4.6 workers/ha.

The difference in yield in hybrid "MAS 26K" of 0.97 t/ha in the variant of manual detasseling compared to the mechanical method, justifies higher labor consumption per hectare.

In hybrid "Suanito", the difference in yield of 0.18 t/ha in the variant of manual detasseling compared to the mechanical method, can not justify a higher consumption of workers per hectare.

With the hybrid "MAS 26K", the manual way of detasseling is more effective, while in the hybrid "Suanito", more effective is machine mode.

Literature

Huanuqueño, E. H., Tobaru, J. 2016. Efecto de diferentes formas de emasculación en el rendimiento de maíz amarillo (*Zea mays L.).* Anales Científicos, 77 (2): 233-237.

Jocković, Đ., Stojaković, M., Ivanović, M., Bekavac, G., Popov, R., Đalović, I. 2010. NS maize hybrids: Today and tomorrow. Ratarstvo i povrtarstvo, 47 (1): 325-333.

Knežević, I. 2005. Varijabilnost osobina hibridnog semena kukuruza ZP SC434 proizvedenog na dve lokacije. Poljoprivredni fakultet, Zemun.

MacRobert, J., Setimela, P. S., Gethi, J., Regasa, M. W. 2014. Maize hybrid seed production manual. International Maize and Wheat Improvement Center - CIMMYT, Mexico.

Marinković, B., Crnobarac, J., Jaćimović, G., Marinković, D. 2008. Tehnologija gajenja u funkciji optimalnog prinosa, prilagođena godini, njivi i hibridu/sorti. Zbornik radova Instituta za ratarstvo i povrtarstvo, 45 (1): 159-178.

Marković, D., Branković, D. 2006. Razvoj savremene mehanizacije za proizvodnju semenskog kukuruza. Savremena poljoprivredna tehnika, 32 (3-4): 158-166.

Pejić, B., Mačkić, K., Milić, S., Maksimović, L., Bajić, I., Jančić-Tovjanin, M., 2018. Efekat površinskog i potpovršinskog navodnjavanja kapanjem na prinos i evapotranspiraciju kukuruza. Letopis naučnih radova, 42 (2): 1-8.

Sečanski, M., Mirić, M., Radenović, Č., Marković, K., Jovanović, Ž., Popović, A. 2015. Importance of permanent improvement of production and control of basic seed of ZP maize hybrids. Selekcija i semenarstvo, 21 (2): 103-117.

Wu, Y., Fox, T. W., Trimnell, M. R., Wang, L., Xu, R., A. Cigan, M., Huffman, G. A., Garnaat, C. W., Hershey, H., Albertsen, M. C. 2016. Development of a novel recessive genetic male sterility system for hybrid seed production in maize and other cross-pollinating crops. Plant Biotechnology Journal, 14 (3): 1046–1054.

Wych, R.D. 1988. Production of hybrid seed corn. In: Corn and Corn Improvement (Sprague, G.F., ed.), Madison, WI: American Society of Agronomy, Inc., Crop Science Society of America, and Soil Science Society of America, pp. 565–607.

Efektivnost u proizvodnji semenskog kukuruza u zavisnosti od načina uklanjanja metlica

Vladimir Sabljak[a], Radivoj Prodanović[a*], Lazar Ožegović[a], Katarina Đurić[b], Dragan Ivanišević[a]

[a]Univerzitet Privredna akademija u Novom Sadu, Fakultet za ekonomiju i inženjerski menadžment u Novom Sadu, Departman za agrobiznis, Novi Sad, Srbija
[b]Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za ekonomiku poljoprivrede, Novi Sad, Srbija
*Autor za kontakt: rprodanovic@fimek.edu.rs

SAŽETAK

Cilj istraživanja je utvrditi koji način uklanjanja metlica u proizvodnji hibridnog semenskog kukuruza je efektniji, ručni ili mašinski. U istraživanju je primenjen metod ogleda, merenje, komparativni metod, logika, indukcija i dedukcija, analiza i sinteza. Prinos hibridnog semena kukuruza kod oba hibrida („MAS 26 K" i „Suanito") bio je veći u varijanti ručnog uklanjanja metlica. Broj angažovanih radnika bio je veći pri ručnom uklanjanju metlica kod oba hibrida, kod „MAS 26 K" u proseku za 4,6 radnika/ha, dok je kod hibrida „Suanito" broj radnika koji su angažovani tokom sve tri kontrole bio veći za 4,2 radnika/ha, u odnosu na varijantu mašinskog uklanjanja metlica. Veći broj radnika/hektaru kod hibrida „MAS 26K" u varijanti ručnog uklanjanja metlica opravdava razlika u prinosu koja iznosi 0,97 t/ha, što nije slučaj kod hibrida „Suanito", gde razlika u prinosu od 0,18 t/ha ne može nadomestiti veći utrošak radne snage.

KLJUČNE REČI: Efektivnost, proizvodnja semenskog kukuruza, hibrid, prinos, uklanjanje metlica.

Primljen: 25.07.2019.
Prihvaćen: 08.11.2019.