

EFFECTS OF AGROECOLOGICAL FACTORS AND HYBRID COMBINATIONS ON SEED TRAITS OF MAIZE HYBRIDS

UTICAJ AGROEKOLOŠKIH FAKTORA I HIBRIDNE KOMBINACIJE NA OSOBINE SEMENA HIBRIDA KUKURUZA

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ABSTRACT

The present study encompasses the analysis of effects of agroecological conditions (year, location) and hybrid combinations on seed size, relationships between fractions (in %, small vs. large), and germination. The following four hybrids were used in the study: ZP 704, ZP 434, ZP 684, and ZP 666. The analysis covers three years (2010, 2011 and 2013), while 2012 was omitted due to poor production conditions. Furthermore, meteorological factors were also analysed and this analysis shows that years differed in the amount and distribution of precipitation. According to obtained results, the hybrid combination had a crucial effect on observed traits, but effects of agroecological factors over years and locations were also important. The most desirable relationship between small and large seed fractions was detected in the hybrid ZP 704 (88.3% vs. 11.7%). In hybrids ZP 434, ZP 666 and ZP 684, seed quality, i.e. germination was higher in the large fractions, while a quite opposite situation was recorded in the hybrid ZP 704 - small seed fractions had higher germination. Such studies should be continued, because new hybrids are constantly introduced into the production.

Key words: seed maize, seed production, location, production year, germination, seed fraction.

REZIME

U radu je obavljena analiza uticaja agroekoloških uslova (godina, lokacija) i hibridne kombinacije na krupnoću semena, procentualni odnos frakcija (sitne, krupne) i klijavost. Za analizu su uzete četiri hibridne kombinacije i to: hibrid ZP 704, ZP 434, ZP 684 i ZP 666. Analiza obuhvata 3 godine (2010, 2011 i 2013. god.). Godina 2012. je izostavljena zbog izuzetno loših uslova za proizvodnju semenskog kukuruza. Urađena je analiza meteoroloških faktora za navedeni period i može se zaključiti da su se godine vrlo mnogo razlikovale po visini i rasporedu padavina. Na osnovu dobijenih rezultata može se zaključiti da presudan uticaj na posmatrane osobine ima hibridna kombinacija, a da je zapažen i uticaj agroekoloških faktora kroz godine i lokacije. Zaključeno je da najpoželjniji odnos sitnih i krupnih frakcija ima hibrid ZP 704, kod koga je zastupljenost sitnih frakcija 88,3%, dok je krupnih bilo 11,7%. Što se kvaliteta semena tiče kod ZP 434, ZP 666 i ZP 684 krupne frakcije su imale bolju, tj. veću klijavost. Kod hibrida ZP 704 je zabeležena obrnuta situacija - sitne frakcije su imale veću klijavost. Ovakva istraživanja treba nastaviti zbog toga što se u proizvodnju stalno uvode novi hibridi.

Ključne reči: semenski kukuruz, proizvodnja semena, lokacije, godina proizvodnje, klijavost, frakcija semena.

INTRODUCTION

Seed maize growing practices are very specific and greatly affect the production and quality. Vojvodina, with best soils - different types, varieties and forms of chernozem, is the largest producer of maize seed.

The heat unit sum of 1550-1660°C provides the cultivation of the earliest maturing hybrids to full season hybrids. Maize is a plant with great heat demands. However, temperatures above 32°C, especially during a flowering period, are unfavourable for seed production. High temperatures (>35°C) affect a reduction in pollen viability and silk drying, which have unfavourable effects on pollination that is on grain formation (*Tatum and Kehr, 1951*). Moreover, high temperatures can reduce yields significantly just in few days (*Herrero and Johnson, 1980*).

Precipitations, both their amounts and distribution, are also a very important factor in seed production of maize hybrids. The deficit in precipitation in the period prior to tasseling and 2-3 weeks after tasseling can result in the yield reduction. Furthermore, a significant precipitation deficit leads to complete yield failure.

Therefore, wherever possible, seed maize should be grown under irrigation conditions. The present study shows results on seed maize mainly grown under rainfed conditions, while a smaller part of this crop was grown under irrigation conditions.

MATERIAL AND METHOD

The following four maize hybrids were analysed: ZP 704 - the hybrid with the longest production (more than 35 years, and so far the best-selling ZP hybrid both in Serbia and abroad); hybrids ZP 434 and ZP 684 have been the best-selling hybrids for the last ten years; the hybrid ZP 666 of the most recent generation of ZP hybrids whose distribution has been significantly increasing. The analysis included three years - 2010, 2011 and 2013 (2012 was omitted because it was extremely dry and therefore very unfavourable for the seed production). A comparative analysis of meteorological conditions for the stated period was presented (average temperatures and average precipitation for the growing season in Vojvodina, as more than 95% of the seed production is performed in this part of Serbia). Following the primary processing, the seed was divided by using sieves into small and large fractions.

According to gained experience seeds are sufficiently uniform if they are graded only into two fractions (*Pavlov, et al., 2008*). The size of small, i.e. large fraction of seeds amounts to 6.5 mm - 8.5 mm and 8.5 mm - 11 mm, respectively. Germination of seed fractions was determined. The percentage ratio of small to large seed fractions was calculated. The analysis performed in this study was not based on experiments, but on the complete production of stated hybrids over the three observed

years. Furthermore, the analysis encompassed more than five million kilograms of primarily processed seeds and based on it the conclusions were drawn.

Results gained in this study should indicate the direction in which breeders should aim their breeding and selections programmes, and to point out to processors to the seed processing methods in order to produce the largest possible number of seed units per area unit.

Meteorological conditions in 2010, 2011 and 2013

As the most of the seed production of maize hybrids is located in Vojvodina, this paper comparatively presents the average of both, temperatures and precipitation for the observed period (Tables 1 and 2).

Table 1. Average temperatures in 2010, 2011 and 2013 in Vojvodina, ideal temperatures according to Spasojević (1984) and long-term mean (°C) during the growing season

Month	Ideal temp. according to Spasojević (°C)	30 year mean (°C)	Average temperatures (°C)		
			2010	2011	2013
IV	10.0	11.6	12.6	13.2	13.2
V	15.0	17.0	17.2	16.6	18.3
VI	20.0	19.9	20.6	21.1	20.3
VII	23.3	21.9	22.9	22.2	22.4
VIII	22.8	20.9	22.2	22.9	23.5
IX	18.0	16.6	16.7	21.1	15.9

Table 1 shows that the temperature in 2010 was at the level of the long-term mean for May and September. The temperature in April of 2010 was higher by 1°C than the long-term mean. A similar situation was in June, July and August: temperatures were higher by 0.8°C, 1.3°C and 1.3°C, respectively. Such temperatures in June and July had a crucial impact on the formation of record yields in 2010.

An average April temperature in 2011 was higher by 1.7°C than the long-term mean, which favourably affected emergence of seed maize crop. On the other hand, temperatures in May were lower by 0.5°C than the long-term mean, while June temperatures were higher by 1.3°C than the long-term mean. The average temperature in August was higher by 2.2°C than the long-term mean, which vitally affected the formation of lower yields in certain locations. September was warmer than the long-term mean, which accelerated the seed maize maturing process. Full season hybrids had reduced yields because grain filling was faster and due to it maturing was accelerated.

April and May temperatures in 2013 were higher, which provided good sowing and emergence of seed maize. There was a recommended number of plants per hectare, due to which a high yield of seed maize could have been expected. As June and July temperatures were higher by 0.4°C and 0.5°C, respectively, than the long-term mean, they positively affected the formation of high yields of medium early to medium late hybrids. The average temperature in August was higher by 2.6°C than the long-term mean, which adversely affected yield levels of full season hybrids. An average temperature lower by 0.7°C was recorded in September and therefore maturing of late maturity hybrids was slowed.

It can be concluded that observed years (2010, 2011 and 2013) insignificantly differed in average temperatures, except for the August temperatures in 2013 when they were higher by 2.6°C than the long-term mean. Based on the average tempera-

tures, 2010 was the most favourable year, which resulted in the highest grain yields.

Precipitation in Vojvodina in 2010, 2011 and 2013

Seed maize plants consume greater amounts of water than commercial maize plants, but parental hybrid lines are much more susceptible to precipitation deficits because their root system is less developed. Water requirements of seed maize plants differ over stages of growth and development. The highest water needs are in the period starting 7-10 days prior to tasseling and finishing at the end of pollination and grain filling (Bošnjak, 1987). The precipitation deficit is often accompanied by high temperatures and low relative air humidity, which unfavourably affects yields.

Table 2 shows great variations in precipitation sums over years. The highest precipitation sum (574.0 mm) was recorded in 2010, which was higher by 149 mm than the ideal precipitation sums (according to Vučić, 1971) or even higher by 209.8 mm than the long-term mean. Precipitation sums were higher in all months but July than the long-term mean. Such favourable precipitation sums in 2010 alongside with temperatures that were at the level of the long-term mean positively affected the formation of high average yields in the observed period.

In 2011, the average precipitation sum was significantly lower (232.7 mm), which was significantly lower than ideal precipitation sums (according to Vučić, 1971), or the long-term mean. The precipitation distribution was not favourable: there was the precipitation deficit in the period from sowing to the end of the growing season, while the greatest deficit was in August, which negatively affected yields of late maturity hybrids, as well as, the 1000-seed weight.

Table 2. Precipitation in Vojvodina, ideal precipitation according to Vučić (1971) and long-term mean

Month	Ideal precipitation according to Vučić (mm)	30 year mean (mm)	Precipitation (mm)		
			2010	2011	2013
IV	35.0	51.3	47.7	11.2	34.0
V	75.0	57.4	128.8	55.6	101.2
VI	80.0	81.9	150.0	49.4	59.1
VII	100.0	64.8	74.2	88.8	25.8
VIII	95.0	58.4	104.7	3.4	41.3
IX	40.0	50.4	68.6	24.4	66.8
Sum	425.0	364.2	574.0	232.7	328.2

In 2013, the recorded average precipitation sum amounted to 328.2 mm, which was lower than in 2010, but significantly higher than in 2011. The precipitation distribution was unfavourable. The dry spell started at the beginning of June, extended over July and August when precipitation sums were lower by 74.2 mm and 53.7 mm, respectively, than the long-term mean. These unfavourable precipitation sums during summer months accompanied by high temperatures and low relative air humidity adversely affected yields in 2013. The lowest yields of full season hybrids were recorded in this year.

RESULTS AND DISCUSSION

Table 3 presents results gained in 2010, 2011 and 2013. The following seed traits are presented: germination, percentage ratio of small to large seed fractions and 1000-seed weight of obtained fractions.

Table 3. Amount of processed seeds, 1000-seed weight, percentage share of fractions and germination of seed fractions

Year	Amount of processed seeds (kg)	1000-seed weight (g) and percentage share of seed fractions				Germination (%)	
		Small fraction (6.5 – 8.5 mm)		Large fraction (8.5-11 mm)		6.5-8.5	8.5-11
		g	%	g	%		
Hyb.	ZP-434						
2010	485,265	280.5	41.3	354.9	58.7	92.8	96.0
2011	232,605	275.9	40.2	350.4	59.8	91.5	95.9
2013	1,226,598	244.7	58.1	317.4	41.9	95.6	96.6
Aver.		267.0	46.5	340.9	53.5	93.3	96.1
Hyb.	ZP-666						
2010	159,820	299.1	52.8	358.1	47.2	93.0	96.0
2011	570,871	318.0	41.0	372.7	59.0	95.0	97.1
2013	483,311	377.2	46.4	356.3	53.6	94.1	95.6
Aver.		298.1	46.8	362.3	53.2	94.0	96.2
Hyb.	ZP-684						
2010	333,749	253.0	17.1	346.6	82.9	91.0	96.2
2011	519,091	267.9	39.2	339.6	61.4	94.4	97.5
2013	724,383	257.3	36.3	327.0	63.7	93.3	96.2
Aver.		252.4	30.8	337.7	69.2	92.9	96.6
Hyb.	ZP-704						
2010	158,602	258.2	81.5	342.9	18.5	95.3	94.5
2011	102,940	281.3	92.0	393.2	8.0	97.5	98.0
2013	119,710	266.2	91.5	381.5	8.5	95.9	92.0
Aver.		268.5	88.3	372.5	11.7	96.2	94.8

A total of 1,917,468 kg of primarily processed seeds of the hybrid ZP-434 was encompassed by the study (Table 3). The average 1000-seed weight of the small fraction amounted to 267.0 g. This parameter varied over years of investigation. The greatest 1000-seed weight of 280.5 g was recorded in 2010 when conditions for the seed production were the most favourable. In the succeeding year, the value of this parameter was somewhat lower, while the lowest 1000-seed weight of 244.7 g was recorded in 2013. The value of this parameter of the large fraction was 340.9 g. The 1000-seed weight varied from 317.4 g in 2013 (which was unfavourable from the aspects of temperatures and precipitation sums in July and August) to 354.9 g in the most favourable year of 2010. The average percentage ratio of small to large fractions over the three observed years was 46.5% : 53.5%. This parameter varied from 41.9% in 2013 to 59.8% in 2011. These results are in accordance with results previously obtained by Pavlov et al. (2008). In the observed period, average germination of small and large fractions amounted to 93.3% and 96.1%, respectively.

Table 3 shows results obtained for the hybrid ZP-666. It is observable that 1,214,002 kg of processed seeds of this hybrid were included into the study. The average 1000-seed weight for the small, i.e. large fraction amounted to 298.1 g, i.e. 362.3 g, respectively. The value of this parameter for the small fraction varied over years from 277.2 g in 2013 to 318.0 g in 2011. The corresponding values for the large fraction were 356.3 g in 2013 and 372.7 in 2011. The average percentage share of the small fraction was 46.8%, with variations from 41.0% in 2011 to 52.8% in 2010. Furthermore, the average percentage share of the large fraction was 53.2%, with variations from 47.2% in 2010 to 59.0% in 2011. The values of germination were lower in the small fraction (94.0%) than in the large fraction (96.2%). Here it can be concluded that the percentage share of fractions in the hybrid ZP 434 was also similar and that germination of the small fraction was somewhat lower than of the large fraction.

The sample encompassed 1,577,223 kg of processed seeds of the maize hybrid ZP 684 (Table 3). The average 1000-seed weight amounted to 259.4 g, while this parameter did not vary significantly (253.0-267.9 g). The average percentage ratio of small to large fractions amounted to 30.8% : 69.2%. The value of percentage share of the small fraction varied from 17.1% in 2010 to 39.2% in 2011. On the other hand, 1000-seed weight for the large fraction ranged from 61.4% to 82.9%. Germination of the small fraction (92.9%) was lower than of the large fraction (96.6%).

Table 3 shows that 381,252 kg of processed seeds of the maize hybrid ZP 704 were encompassed by the study. The average 1000-seed weight amounted to 268.5 g and 372.5 g in small and large seed fraction, respectively. The smallest variation in this parameter over years was registered in this hybrid. Germination of small, i.e. large seed fractions amounted to 96.2%, i.e. 94.8%, respectively. Furthermore, germination varied insignificantly in small seed fraction (95.3-97.5%), while this parameter varied in large seed fraction from 92% in 2013 to 98.0% in 2011. The percentage share of fractions in this hybrid differed from all other observed hybrids. According to the three-year average, small, i.e. large fraction amounted to 88.3%, i.e. 11.7, respectively. This parameter varied in the small fraction from 81.5% in 2010 to 92.0% in 2011, while the corresponding values in the large fraction amounted to 8% in 2011 and 18.5% in 2010.

CONCLUSION

Based on the three-year studies the following conclusions can be drawn:

- A hybrid combinations, i.e. a hybrid has a decisive effect on the percentage ratio of seed fractions,
- The percentage ratio of seed fractions varied over years of investigation.

Results gained in this study should indicate the direction in which breeders should aim their breeding and selections programmes in order to increase grain yields per area unit as much as possible. Moreover, this study should point out to processors to the seed processing methods in order to produce the largest possible number of seed units per hectare.

Such studies should be continued because new hybrids are all the time introduced into the production.

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