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EFFECT OF SOWING TIME ON YIELD OF ZP MAIZE HYBRIDS

UTICAJ VREMENA SETVE NA PRINOS ZP HIBRIDA KUKURUZA

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ABSTRACT

These experiments were conducted in the period 2003-2008 in Zemun Polje. Five hybrids were investigated in six sowing dates – on April 5th (Sd$_1$), 15th (Sd$_2$) and 25th (Sd$_3$), and on May 5th (Sd$_4$), 15th (Sd$_5$) and 25th (Sd$_6$). Three unfavorable years for the maize production were distinguished in this period: 2003 with 210.0 mm, 2007 with 290.1 mm and 2008 with 224.6 mm of precipitation; 2005 was moderately favorable, with 387.4 mm of precipitation. Two years were favorable for the maize production, both in terms of precipitation amounts and distribution: 2004 with 427.6 mm and 2006 with 417.1 mm. The highest average yield was achieved in Sd$_2$ (11.21 t/ha – 100%). On the other April sowing dates, average yield was lower: on Sd$_1$ - 11.04 t/ha (98.48%), on Sd$_3$ - 10.97 (97.86%). The effects of the May sowing dates were significantly lower comparing with the Sd$_2$: Sd$_4$ - 10.53 t/ha (93.93%), Sd$_5$ - 10.46 t/ha (93.31%) and Sd$_6$ - 9.71 t/ha (86.62%). The highest yielding hybrid was ZP 684 (11.16 t/ha). These results doubtlessly point to the mid April sowing date as an optimum for maize in Serbia.

Key words: *maize, sowing date, precipitation, yield.*

REZIME

Vreme setve spada u faktore koji imaju značajan uticaj na nivo prinosa kukuruza. Optimalan rok setve bi se mogao definisati kao vreme setve kojim se obezbeđuje nicanje kukuruza u najpovoljnijem trenutku kako bi se maksimalno iskoristili uslovi vegetacionog perioda i formirao što veći prinos. Ova ispitivanja obavljena su u periodu od 2003. do 2008. godine u Zemun Polju. Ispitivano je pet hibrida u šest rokova setve: tri u aprilu (5., 15., i 25.) i tri u maju (5., 15. i 25.). U toku ispitivanja, tri godine su bile nepovoljne za proizvodnju kukuruza: 2003. sa 210,0 mm padavina, 2007. sa 290,1 mm i 2008. sa 224,6 mm. Jedna godina (2005) je imala umereno povoljne uslove - 387,4 mm padavina. Dve godine su bile povoljne u smislu količine i rasporeda padavina: 2004 sa 427,6 mm i 2006. sa 417,1 mm. Najviši prinos ostvaren je pri setvi kukuruza 15. aprila (11,21 t/ha), koji je uzet kao referentna vrednost (100,00%). U ostalim rokovima setve u aprilu prinos je bio niži: Sd$_1$ 11,04 t/ha (98,48%), Sd$_3$ 10,97 t/ha (97,86%). Setvom u maju, ostvareni su statistički veoma značajno niži prinosi u odnosu na referentnu vrednost: Sd$_4$ – 10,53 t/ha (93,93%), Sd$_5$ – 10,46 t/ha (93,31%) i Sd$_6$ – 9,71 t/ha (86,62%). Hibrid ZP 684 imao je najviši prosečan prinos (11,16 t/ha), dok su svi ostali prinosi bili niži: ZP 680 za 8,23%, ZP 434 za 7,71%, ZP 580 za 4,75% i ZP 578 za 3,05%. Ove činjenice nedvosmisleno ukazuju da je setva kukuruza u aprilu, a posebno polovinom ovog meseca, najpovoljniji rok setve u Srbiji.

Ključne reči: *kukuruz, vreme setve, padavine, prinos.*

INTRODUCTION

Sowing date significantly impacts the level of maize production. Beginning of the vegetative season significantly influences sowing date and depends on the favorable temperatures and sufficient amount of precipitation. These factors vary from year to year, so the precise date of the sowing is not possible to determine. Thus, usually optimal sowing date is determined as the period of about 10 days. Optimal sowing date could be defined as the sowing date providing that maize seedling emergence occurs in the most favorable moment, and that conditions of the vegetative period are exploited in terms of the maximizing the yield. Besides that, maize in Serbia is sown up to 1000 m altitude, where sowing is even one month later compared to the lowlands. Nevertheless, every year sowing is delayed due to various reasons and mostly floods. One of the reasons could also be found in the small size farms in Serbia that are not equipped with proper mechanization. All those reasons led to the research aiming to find the latest maize sowing date that can provide satisfactory yield.

Among high-quality ZP maize hybrids of different FAO maturity groups, it is possible to choose ones, for later sowing dates that have high yield and less moisture content in the kernel at harvest. Hybrids of the later maturity groups should be sown earlier and those of the earlier maturity groups later. Beside that, increasingly more hybrids of the mid early maturity groups (FAO 400) are produced, because they get through silking and tasseling stages before dry season by the end of July and beginning of August. Due to the smaller habitus, they are produced in densities up to 70,000 plants/ha, and can achieve and overcome yields of the hybrids of FAO 600-700 maturity groups. Such hybrids reach full maturity one month earlier than the later maturity hybrids, which has significant agrotechnical impact on the soil preparation for the following crop. Their lower kernel moisture content by 3-5%, influence the production efficiency. All this points to the significance of the optimal sowing time research.

Videnović (1989), found that kernel moisture content increases in maize sown after April 15th, and that yield is significantly lowered when maize is sown after optimal sowing date. In early sowing dates cold and rainy weather slows down initial crop growth, which enables weeds gain advantage in competition with maize. On the other hand there is a need for the appropriate application of weed control measurements, based on the knowledge of competitive relations between crops and weeds. According to the research conducted in Northern Italy, maize sowing in the late winter period increases the influence of the winter and early spring weeds on the maze production (Otto et al., 2009). Comparing to the traditional sowing dates in mid spring, earlier sowing prolongs precompetitive period, which makes after sowing and pre-emergence weed control with herbicides more difficult. Considering thermophilic weed species that are mostly found in maize, the time of their emergence compared to the developmental faze of the crop and its sowing time, significantly influence the percentage of the yield decrease (Harrison et al., 2001; Travlos et al., 2011). Hybrid properties, foremost fast initial growth and time of weed appearance in the crop, directly determine result of the competition and percentage of yield decrease. When emerging concurrently with maize, individuals of the thermophilic specie *Echinochloa crus-galli* produced 1010–1305 seeds per plant, while individuals that emerged after maize was in 4th leaf stage produced 112–240 seeds per plant (Travlos et al., 2011). Accordingly, maize yield decreased 24-35% when specie *Echinochloa crus-galli* emerged earlier, comparing to the 9% yield decrease when weed emerged after the 4th leaf development in maize. Bača et al. (2003) concluded that, in order to achieve successful decrease of the size and intensity of attacks of the *Diabrotica v. virgifera* population under conditions of applying insecticides or not, it is necessary to use maize hybrids of the earliest possible maturity group and to saw the seed on the earliest date possible in the first year of growing maize, if maize is to be followed by maize in the next year. The aim of this study was to (i) determine the optimal sowing date for ZP maize hybrids, (ii) point to the hybrids that could be sown even after that and (iii) to determine the tendency of the kernel moisture content decrease, when sowing date was optimal or later.

MATERIALS AND METHODS

These experiments were conducted in the period 2003-2008 in Zemun Polje, on the chernozem soil type. The trial was set up according to the split-plot design in four repetitions. The size of the elementary plot was 9.66 m^2. Preceding crop was winter wheat.

The following factors were investigated (Tab.1). According to the sowing plan 10 days delay between every sowing date was established so the period between the first and the last sowing date was 50 days.

Table 1. Investigated factors

Year (A)	Sowing date (B)		Hybrid (C)		FAO	Growing days
2003	Sd_1	April 5th	H_1	ZP 434	400	120-125
2004	Sd_2	April 15th	H_2	ZP 578	500	125-130
2005	Sd_3	April 25th	H_3	ZP 580	600	135-140
2006	Sd_4	May 5th	H_4	ZP 680	650	140-145
2007	Sd_5	May 15th	H_5	ZP 684	700	145-150
2008	Sd_6	May 25th	/	/	/	/

Shallow stubble plowing at the depth of 15 cm was performed after wheat harvest. Autumn plowing was performed to the depth of 25 cm. Soil preparation was done by seed bed tiller, 7-10 days prior to sowing. Sowing density was 62,112 plants/ha. Total amount of fertilizers 150kg/ha N; 100kg/ha P2O5 and 80kg/ha K2O was applied in the autumn by spreading on the soil surface. Pre-emergence application of herbicide Atrazine 500 SC in amount 1 l ha^{-1} (atrazine 500 g a.i.) and Harness 2 l ha^{-1} (acetochlor 900 g a.i.) were carried out on all treatments until 2007, when atrazine was replaced with terbuthylazine. During vegetation, inter-row cultivation was applied to control weeds, so they would not affect growth and development of the plants or depress the maize yields. The measurement of grain moisture content started when it was about 30%, and it was determined from the sample of 2 ears twice a week. Samples were shelled and the moisture content was measured on the Dickey John apparatus. Yield was analyzed by three factorial ANOVA and Fisher's least significant test – LSD ($p<0.01$). Factor A was year (6), the B was sowing date (6) and C hybrid (5).

METEOROLOGICAL CONDITIONS

In the examined period extremely different meteorological conditions during vegetation were present. Three types of years were distinguished according to their favorability for maize production, considering amount and distribution of precipitation from April until October. The amount of precipitation during vegetative period was less than 300 mm in unfavorable years, second group had 300-400 mm and over 400 mm in favorable years (Fig.1).

Three unfavorable years for maize production were: 2003 with 210.0 mm; 2007 with 290.1 mm, and 2008 with 224.6 mm of precipitation. Those amounts were not sufficient for effective production. In those years, there were periods with highly expressed lack of precipitation, especially in critical maize developmental stages in July and August (Fig. 1). Moderately favorable conditions with 387.4 mm of precipitation during vegetative period were recorded in 2005. Both, the amount and distribution were more favorable, inducing higher yields than in previous arid years. Two years were favorable for the maize production both in terms of amounts and distribution of precipitation during vegetative period: 2004 with 427.6 mm and 2006 with 417.1 mm (Fig. 1).

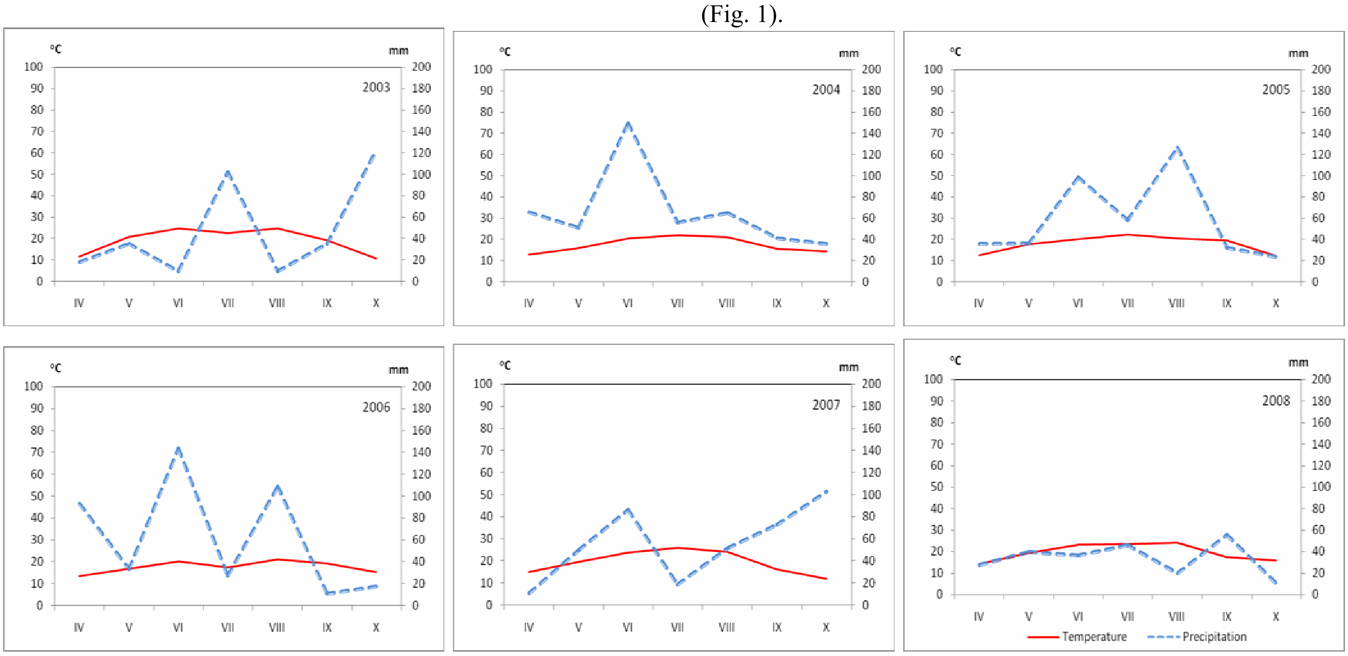

Fig.1. Walter's diagrams of precipitation and average air temperatures from April until October in the 6-year period (2003–2008)

RESULTS AND DISCUSSION

According to the obtained results, maize grain yields greatly varied in the observed period due to the examined factors (Tab. 2 and Tab. 3). Variations were mostly expressed in term of years. The highest average yield was achieved in 2004 (13.60 t/ha, set as 100.00%). In all other years significantly lower yield was recorded - 93.75% in 2005 and only 38.68% in 2003. Sole cause for this are meteorological conditions and mainly amount and distribution of precipitation. This in some years greatly affected maize production of hybrids sown in April terms, and in other years maize production of hybrids sown in May terms. Significant differences among maize yields between hybrids sown at different dates were found (Tab. 3). On average, the highest yield was achieved in Sd_2 sowing date 11.21 t/ha (100%). In other April sowing dates maize yields were lower, although not significantly. May sowing dates produced significantly lower yields than April ones.

Table 2. Average grain yield of five ZP maize hybrids (t/ha)

Year	Hybrid					Average	
	ZP 434	ZP 578	ZP 580	ZP 680	ZP 684	(t/ha)	%
2003	4.48	5.06	5.66	5.04	6.05	5.26	38.68
2004	13.30	13.91	13.91	12.70	14.15	13.60	100.00
2005	12.27	12.99	12.84	12.88	12.77	12.75	93.75
2006	11.37	11.89	12.50	13.39	13.80	12.59	92.57
2007	9.67	10.40	8.55	8.12	9.28	9.21	66.72
2008	10.72	10.64	10.34	10.01	10.89	10.52	77.35
Average	10.30	10.82	10.63	10.36	11.16	10.65	-

$LSD_{0.01}$= 0.485 (Y)

Table 3. Influence of the sowing date on yield (t/ha) of maize ZP hybrids (average2003-2008)

Sowing date		Hybrid					Average	
		ZP 434	ZP 578	ZP 580	ZP 680	ZP 684	(t/ha)	%
Sd_1		10.60	11.28	10.93	10.91	11.48	11.04	98.48
Sd_2		10.91	10.98	11.57	10.67	11.92	11.21	100.00
Sd_3		10.67	10.98	11.02	10.79	11.38	10.97	97.86
Sd_4		9.98	10.77	10.65	10.18	11.08	10.53	93.93
Sd_5		9.92	10.93	10.13	10.17	11.15	10.46	93.31
Sd_6		9.73	9.94	9.50	9.42	9.95	9.71	86.62
Aver.	t/ha	10.30	10.82	10.63	10.36	11.16	10.65	-
	%	92.29	96.95	95.25	92.83	100.00		

$LSD_{0.01}$ 0.485 (S_d) 0.505 (H) 0.765 (S_dxH)

Differences between grain yields of the examined hybrids were significant. The highest average yield achieved ZP 684 – 11.16 t/ha (100%), while the lowest yielding hybrid was ZP 434 with 7.71% yield decrease.

Hybrids of the later maturity had high kernel moisture content at harvest (Table 4), being important as it increasees cost of drying. Due to the significant effect of the sowing date on maize grain yield, we did not wanted to comment on their genetic potential of productivity. The trend of yield decrease in later sowing dates of these hybrids is noticeable on Fig. 2. This is in accordance with previous results of Kolčar and Videnović (1984), where it was found that maize hybrids of FAO maturity groups 500-700 yielded best when sown on April 25th. When sown later, maize plants lack heat units at the beginning of vegetation and that has tremendous impact on the faster performance of the first half of the vegetation and lowering down the yield (Videnović et al., 1993). Beside that the leaf area was largest at sowing date 22nd April (Videnović and Nedić, 1978).

Hybrid x sowing date interactions did not differ significantly in first three sowing dates in all hybrids, while comparing to the May sowing dates differences were significant. These results doubtlessly point that sowing date in the mid of April is the optimal sowing date for the most important maize production areas in Serbia. In case that the sowing must be done in May it is better to use maize hybrids of shorter vegetation such as FAO 400 or earlier. Videnović at al. (2000), found that maize grain yield significantly varied among examined locations and that hybrids of FAO maturity groups 300-400 had the highest adaptability.

Maize grain dry-down during maturation basically depends on two factors: meteorological conditions and genetic characteristics of the hybrid. If temperature is higher, it's windy and relative air humidity is low, grain dry-down is faster and vice versa. On the other hand, if the genotype feature is a cob of small diameter and physiological properties of the grain provide faster dry-down, the process is faster. This process is also influenced by the compactness of the ear, its position during maturation, and it is noticed that the hanging ear retains less moisture when raining. Grain moisture content varied among hybrids and sowing dates, and variations were noticed also among investigated years (Tab. 4). The lowest kernel moisture content was in hybrid ZP 434 (22.20%). It was lowest in Sd_1 (20.91%), and it grow with later sowing dates up to 26.91% in the Sd_6. This is the result of the higher temperatures in maturation when sowing was performed in April compared to the ones in May. Nevertheless, in some years grain moisture in harvest reached 40% in last two sowing dates. Ivanišević (2010) found that drying of 28,700 t of mercantile maize requests 17.43 Nm^3/t of gas, which cost 0.56 din/kg. As in that trial grain drying started at 28% of moisture content and in our study grain moisture content was even much higher, it is clear that it causes significantly higher processing expenses. According to Uhrig and Maier (1992), 40% more energy is required for maize grain drying to 13% than to 17% when drying maize kernel with 30% of moisture content, while 90% more is required when drying starts with 22% of moisture content. Joseph et al. (1999) concluded that grain yield did not change much when maize was planted between 24 April and 8 May in Wisconsin, and the date to switch from full-season to shorter-season hybrids depends on numerous factors, including maize price and draying costs. Videnović and Dumanović (1994) found that in grain moisture content range of 40-30%, dry down rate amounted to 1.11% per day for the hybrid ZP 330 and 0.67% per day for the hybrid ZP 704 when they were planted on April 15, but 0.67% per day and 0.53% per day, when planted June 5.

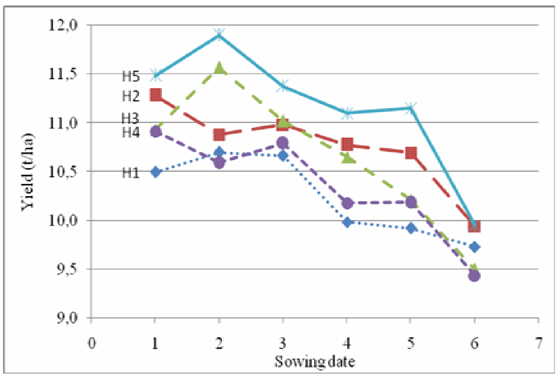

Fig. 2. Effects of sowing dates on yield (t/ha) of ZP maize hybrids (average 2003-2008)

Table 4. Grain moisture content (%) in dependence of sowing dates (average 2003-2008)

	ZP 434	ZP 578	ZP 580	ZP 680	ZP 684	Average
Sd_1	19.80	19.38	22.30	21.40	21.68	20.91
Sd_2	20.02	20.45	24.40	24.12	24.40	22.68
Sd_3	21.92	21.77	25.12	24.13	25.65	23.72
Sd_4	23.67	24.03	25.24	24.84	23.83	24.32
Sd_5	22.73	23.08	24.34	25.98	24.46	24.12
Sd_6	25.08	25.38	28.24	28.86	27.00	26.91
Average	22.20	22.35	24.94	24.89	24.50	23.78

CONCLUSIONS

Based on the results obtained in this research following conclusions were made:

- During the observed period three types of years with different favorability for maize production were distinguished on the basis of amounts and distribution of precipitation: first group with up to 300 mm, the second with 300-400 mm and the third with more than 400 mm of precipitation in vegetative period. Thereafter, three arid years with extreme lack of precipitation were: 2003, 2007 and 2008. In 2005, we recorded moderately favorable conditions. Two favorable years were 2004 and 2006, with sufficient and well distributed precipitation.
- Highest yield (100%) was achieved in Sd_2 sowing date (11.21 t/ha). In other April sowing dates yields were smaller: in Sd_1 (98.48%) and Sd_3 (97.86%). Sowing dates in May produced significantly smaller yields: Sd_4 (93.93%), Sd_5 (93.31%) and Sd_6 (86.62%). Hybrid ZP 684 had highest yield (11.16 t/ha), and all other hybrids had significantly smaller yields. Hybrids of the later maturity groups had high grain moisture content in harvest. These results doubtlessly point that sowing date in the mid of April is the optimal sowing date for the most important maize production areas in Serbia. In case that the sowing must be done in May, shorter vegetation maize hybrids (such as FAO 400 or less) are suggested.
- Grain moisture content differed among hybrids, sowing dates and years. Hybrid ZP 434 had the lowest grain moisture content in average (22.20%). In Sd_1 average grain moisture content was 20.91% and it was higher in later sowing dates up to 26.91% in Sd_6.

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