Biblid: 1821-4487 (2017) 21; 3; p 149-153
UDK: 633.15

Original Scientific Paper
Originalni naučni rad

VARIABILITY OF AGRONOMIC TRAITS OF MAIZE HYBRIDS INFLUENCED BY THE ENVIRONMENTAL FACTORS

VARIJABILNOST AGRONOMSKIH OSOBINA HIBRIDA KUKURUZA POD UTICAJEM FAKTORA SREDINE

Dragana BRANKOVIĆ-RADOJČIĆ, Jelena SRDIĆ*[*], *Marija MILIVOJEVIĆ*[*], *Gordana ŠURLAN-MOMIROVIĆ*[**], *Aleksandar RADOJČIĆ*[***], *Tomislav ŽIVANOVIĆ*[**], *Goran TODOROVIĆ*[*]
[*]*Maize Research Institute Zemun Polje, Slobodana Bajića 1,Belgrade, Serbia*
[**]*Faculty of Agriculture, University of Belgrade, Nemanjina 6, Belgrade, Serbia*
[***]*Chemical Agrosava, Palmira Toljatija 5/IV, Belgrade, Serbia*
e-mail: dbrankovic@mrizp.rs

ABSTRACT

In this study 36 maize hybrids of different FAO maturity groups were observed in three successive years (2011, 2012 and 2013), on 8 locations. The main objective of this experiment was to observe the GxE interaction concerning yield, grain moisture, grain yield per ear and test weight. The experiment was set up according to the RCBD. Based on the obtained results average estimates, CV and overall ranking of hybrids were calculated. ANOVA was applied in order to estimate the effect of factors: genotype, environment and interaction. Thus the significance of all these factors was observed. Results of this research indicate the importance and necessity of performing multilocation and multiyear trials with the aim of observation and understanding the intensity of GxE interaction, as well as its influence on the grain yield and it components.

Key words: *GxE interaction, maize, grain yield, yield stability.*

REZIME

Istraživanje je obuhvatilo 36 hibrida različitih FAO grupa zrenja, u 2011, 2012 i 2013 godini, na 8 lokaliteta. U ogledu je ispitivana interakcija genotip x sredina u pogledu stabilnosti prinosa zrna, vlage zrna, težine zrna po klipu i zapreminske mase kukuruza. Ogled je bio postavljen popotpuno slučajnom blok sistemu (RCBD). Na osnovu dobijenih podataka izračunate su prosečne vrednosti, pokazatelji varijabilnosti posmatranih osobina i ukupan rang hibrida, a analizom varijanse utvrđena je značajnost efekta genotipa, sredina i interakcija. Za sve proučavane agronomske osobine, analizom varijanse su utvrđene statistički visokoznačajne vrednosti genotipa, sredina i interakcije. Najviši prosečan prinos zrna u ogledu ostvaren je u 2011. godini (11,62 t/ha), a najniži u 2012. godini (6,90 t/ha). Najniži prosečan procenat vlage zrna kukuruza u ogledu ostvaren je u veoma sušnoj 2012. godini (14,86%), dok između vrednosti ostvarenih u 2011. godini (19,47%) i 2013. godini (19,52%) nije bilo značajnije razlike. Vrednosti težine zrna po klipu kukuruza bile su direktno srazmerne vrednostima prinosa. Najveća zapreminska masa zrna kukuruza ostvarena je u sušnoj 2012. godini (74,84 kg/hl), dok je najmanje izmrena u kišovitoj 2013. godini (70,47 kg/hl).

Rezultati ovog istraživanja potvrđuju neophodnost izvođenja višelokacijskih i višegodišnjih ogleda u cilju što boljeg sagledavanja intenziteta interakcija genotip x sredina, i njihovog uticaja na prinos i komponente prinosa hibrida kukuruza različitih FAO grupa zrenja na teritoriji Srbije. Da bi proizvodnja kukuruza bila stabilna, farmerima koji nemaju mogućnost navodnjavanja, već kukuruz gaje u suvom ratarenju, treba savetovati da seju hibride različite dužine vegetacije.

Ključne reči: *GxE interakcija, kukuruz, prinos zrna, stabilnost prinosa.*

INTRODUCTION

According to the sowing area of crops, maize is on the third place in the world, and on the first place in Serbia *(Statistički godišnjak, 2016).* That is due to the fact that maize has such a versatile usage from the unprocessed product for livestock feed, to that it is processed in many different industries such as food, pharmaceutical and more and more nowadays maize is row material for production of energy. The main goal in production of this crop is achieving high and stabile yields, and recently more and more, higher biomass. Grain yield beside the genetic potential is highly influenced by many factors such as: applied crop practices, soil fertility, and level of ground water, altitude, amount and distribution of precipitation, i.e. conditions of the environment.

*Filipović et al. (2015),*emphasized that maize breeders are due to the global climatic changes, challenged to create highly adaptable genotypes, which are capable to produce high and stabile grain yields in different environments. Genotype stability in different environments is the consequence of its genetic structure, but there is a few information about genetic components that determine genotype stability, and how the selection and breeding has the influence on them (*Lee et al., 2003).* Factors that influence grain yield and thus the economic aspect of maize production are associated with polygene action, but are also under great influence of the environment. In the research of *Pavlov and Crevar (2014)*, it was confirmed that beside the hybrid combination as the major factor, very important influence expressed environmental factors such as years and locations on the parameters of seed production. Therefore trials in maize breeding process that are focused on grain yield are performed on the larger number of locations and in several successive years. These experiments usually observe the relative success of genotype performances in different environments *(Kandus et al., 2010).*The aspect of the GxE interaction is very important in breeding programs and as well in the commercial introduction of new hybrids. *Deitos et al. (2006)* indicate that GxE interaction is important in breeding process because it influences the genetic gain, as well as the recommendation and choosing the varieties with high adaptability. *Petrović et al. (2009)* concluded that breeding for the targeted environment highly depends on the identification of the major sources of phenotypic variation in that region. In order to develop a variety or a hybrid which possess lower GxE interaction, for the dominant sources of variation, variety should have the balanced proportion between stabile and high yield *(Boakyewaa, 2012)*.

The crucial impact on the maize grain yield has the amount and the distribution of precipitation. This crop responds very stressfully to the drought, especially in certain developmental phases. *Filipović (2012)* emphasized that high and stabile yields under our climatic conditions could be only achieved with the production under irrigation systems. In production years with pronounced drought, yield of certain hybrids could be lowered up to 80 %.

The aim of this research was to estimate GxE interaction for 36 maize hybrids of different FAO maturity groups on 8 locations and in three production years and to establish the intensity of these interactions. Based on these interactions genotypes that express highest stability and yielding potential in different production conditions and years should be selected.

MATERIAL AND METHOD

This research included 36 maize hybrids which were classified according to FAO maturity groups as followed: FAO 300: H1-H4; FAO 400: H5-H12; FAO 500: H13-H22; FAO 600: H23-H32; FAO 700: H33-H36. Trials were performed in the period 2011-2013, according to the RCBD in three replications on 8 locations in Serbia. Locations were selected according to the major regions in which this crop is most intensively produced (Sombor, Kikinda, Senta, Pančevo, Sremska Mitrovica, Svilajnac, Loznica i Šimanovci). Each hybrid was sown in four rows, out of which two inner rows were harvested, while outer rows were border rows. In each replication hybrids were sown according to different randomization so that GxG interaction could be excluded. The same sowing density was applied for all hybrids and the number of plants per ha was 62,643. Inter and intra row distance was adjusted to the mechanical sowing and harvesting. Following agronomic traits were observed: grain yield (JUS standard t/ha); grain moisture (%); grain yield per ear (kg) and test weight (kg/hl).The three factorial ANOVA according to the fixed model (*Steel and Torrie, 1960*), was applied to analyze observed results. Comparisons between average estimates were performed by LSD test. The correlation between traits in this research was analyzed by Spearman's rank coefficient correlation (Zar, 1999).

RESULTS AND DISCUSSION

Grain yield: Significantly high variation of observed traits, especially maize grain yield was expected, considering the three very different production years in terms of the amount and distribution of precipitation during vegetation.

Significant differences were observed in amounts of precipitation, relative air humidity and average daily temperatures in certain critical developmental phases of maize, above all silking, pollination, and grain filling in the period July –August (Figure 1 and 2).The variation in grain yield of maize hybrids was significantly influenced by the difference in yielding potential, as well as the differences in FAO maturity group of hybrids.

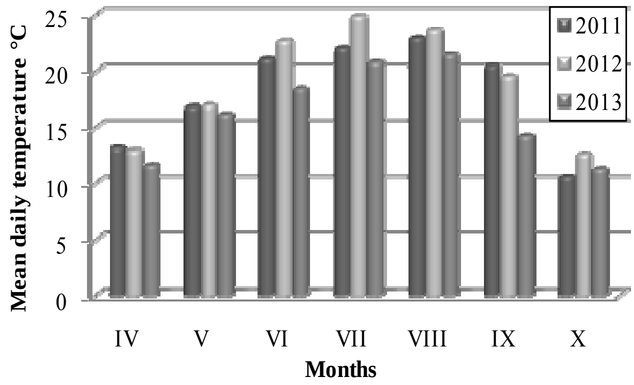

Fig. 1. Average daily air temperatures for all locations (^0C)

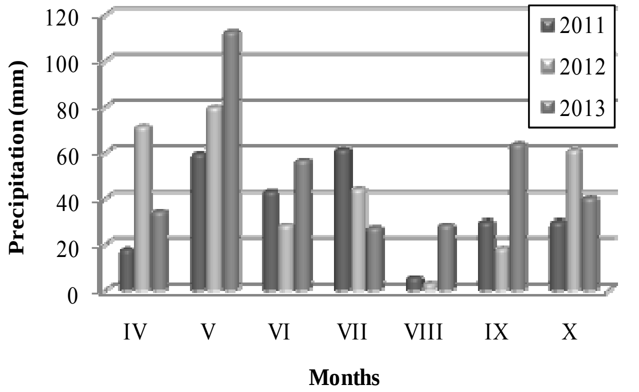

Fig. 2. The amount of precipitation for all locations (mm)

The highest average grain yield was achieved in 2011 (11.62 t/ha), while the lowest was in dry and stressful 2012 (6.90 t/ha). Average grain yields of observed hybrids in the first year of this trial ranged from 10.38 t/ha (H1) to 13.23 t/ha (H36). In the second year average grain yields ranged from 5.75 t/ha (H7) to7.87 t/ha (H3), while in 2013 average grain yields of hybrids ranged from 8.76 t/ha for hybrid H5 up to 12.01 t/ha for hybrid H36 (Table 1). Higher average grain yields were noticed in hybrids of longer vegetation in 2011 and 2013, while in 2012 the highest average grain yield had the hybrid H3 that belongs to the FAO 300. That could be explained by high temperatures and low air humidity during the period of pollination. Hybrids of shorter vegetation went through the silking and pollination phases, before temperature peaks occurred in July, therefore ear pollination was higher and the share of barren plants was lower. The highest average grain yield during three years and on 8 locations produced hybrid H36 (10.88 t/ha), while the lowest was observed in hybrid H14 (8.17 t/ha).Six hybrids had higher average grain yields compared to the trial average which were highly significant, and two hybrids had significantly higher average grain yields than the trial average. The highest coefficient of variation for grain yield in the observed years was established in the stressful 2012 (19.30 %), while the lowest was in 2011 (9.93 %), which was also the most productive year. *Kovačević et al. (2007)* explained that highly significant differences between average estimates between years are expected and justified and that they point to the fact that meteorological factors during vegetation significantly influence yielding productivity, which confirms the significance of the GxE interaction, such was found in this research. That clearly points that the yielding variability is under the influence of the environment.

Table 1. Average estimates and indicators of variability for grain yield (t/ha) and grain moisture (%) of 36 maize hybrids for all locations

Hybrid	FAO	Grain yield (t/ha)					Grain moisture(%)				
		2011	2012	2013	$\bar{x}$	Rank	2011	2012	2013	$\bar{x}$ $\bar{x}$ $\bar{x}$	Rank
H1	300	10.38**	6.89	9.02**	8.76**	33	17.87*	13.60**	17.94**	16.47**	10
H2	300	11.48	6.34	9.72	9.18	27	16.70**	13.50**	17.27**	15.83**	3
H3	300	11.45	7.87*	10.06	9.80	12	15.17**	13.15**	17.68**	15.33**	2
H4	300	11.65	7.29	10.24	9.73	14	14.55**	12.64**	17.00**	14.73**	1
H5	400	10.69**	6.95	8.76**	8.80**	32	17.90*	13.24**	18.43*	16.52**	12
H6	400	10.55**	7.00	9.46*	9.00**	30	17.33**	13.84**	18.43*	16.54**	13
H7	400	11.34	5.75**	9.06**	8.72**	35	17.06**	13.76**	17.30**	16.04**	4
H8	400	10.87*	5.99*	9.97	8.94**	31	17.67*	13.15**	18.01**	16.28**	7
H9	400	12.46*	6.90	10.69	10.01*	8	17.33**	13.46**	17.82**	16.20**	5
H10	400	11.08	7.30	10.15	9.51	21	17.80*	14.00**	17.52**	16.44**	9
H11	400	12.57**	7.32	10.54	10.14**	5	18.34	14.80	18.75	17.30	16
H12	400	11.29	6.61	9.40*	9.10*	29	21.21*	15.25	17.59**	18.02	19
H13	500	11.10	7.22	10.75	9.69	15	21.60**	15.87**	19.61	19.02**	23
H14	500	10.86*	5.70**	9.56	8.71**	36	17.94*	15.29	18.95	17.39	17
H15	500	11.38	6.77	9.80	9.31	26	18.97	14.50	18.39*	17.29	15
H16	500	11.58	6.93	10.01	9.51	22	17.49**	13.17**	18.09**	16.25**	6
H17	500	11.28	6.03*	8.87**	8.73**	34	18.41	13.90**	18.16**	16.83**	14
H18	500	11.49	6.67	10.53	9.56	19	20.41	14.28	19.02	17.90	18
H19	500	11.57	6.55	10.81	9.64	16	18.03	14.04*	16.88**	16.32**	8
H20	500	12.39*	7.25	10.28	9.97	9	18.03	13.44**	18.00**	16.49**	11
H21	500	12.29*	7.54	11.40**	10.41**	3	20.98*	13.62**	19.96	18.19	20
H22	500	12.86**	6.37	10.60	9.95	10	19.97	15.42	19.24	18.21	21
H23	600	11.20	6.51	10.50	9.40	23	21.37**	16.35**	21.60**	19.77**	29
H24	600	11.70	7.13	10.52	9.78	13	21.90**	15.75**	21.29**	19.65**	28
H25	600	11.37	6.90	9.71	9.32	25	19.83	15.32	20.57*	18.57	22
H26	600	11.63	7.17	10.65	9.82	11	21.30*	16.61**	21.48**	19.79**	31
H27	600	12.72**	7.48	10.36	10.19**	4	21.63**	16.16**	21.56**	19.78**	30
H28	600	11.23	6.72	10.05	9.33	24	21.71**	15.87**	20.54**	19.37**	27
H29	600	11.62	7.49	10.93*	10.01*	7	20.90	15.80**	21.00**	19.23**	26
H30	600	11.71	7.22	9.73	9.55	20	19.69	16.31**	21.15**	19.05**	24
H31	600	11.90	6.76	10.08	9.58	18	22.81**	16.72**	21.56**	20.36**	33
H32	600	13.07**	7.13	11.41**	10.54**	2	22.91**	16.02**	23.07**	20.67**	36
H33	700	11.37	7.00	10.43	9.60	17	19.40	15.56*	22.66**	19.21**	25
H34	700	10.93**	6.65	9.74	9.11*	28	22.48**	16.80**	22.24**	20.50**	35
H35	700	11.97	7.49	10.97*	10.14**	6	21.93**	16.87**	22.38**	20.39**	34
H36	700	13.23**	7.38	12.01**	10.88**	1	22.28**	17.00**	21.66**	20.32**	32
$\bar{x}$		11.62	6.90	10.19	9.57		19.47	14.86	19.52	17.95	
LSD	0.05	0.65	0.75	0.72	0.41		1.44	0.63	0.99	0.73	
LSD	0.01	0.86	0.99	0.94	0.54		1.90	0.83	1.31	0.96	
CV	(%)	9.93	19.3	12.4	13.08		13.07	7.51	8.98	12.46	

, - significant at 0.05 and 0.01 probability level, respectively*

Grain moisture: Grain moisture is the relative indicator and it depends on the moment of harvest. The lowest grain moisture was observed in very dry 2012 (14.86 %), while between estimates in 2011(19.47 %) and 2013 (19.52 %) there were no statistical differences. In all three experimental years, harvest begun in mid September and ended by mid October. The order of harvesting certain location was under the influence of meteorological condition but it didn't differ significantly among years. Since the average daily and monthly air temperatures in 2012 were significantly higher than in 2011 and 2013 (Figure 1), hybrids accumulated sums of thermal units for specific developmental phases faster, including the phase of formation of black layer, i.e. the phase of physiological maturity. All this together with the warm and dry autumn of 2012, contributed the lower grain moisture at the moment of harvest. *Videnović et al., (2011),* also concluded that grain moisture is highly dependent on the factors such as genotype, the year and also sowing date. Average grain moisture of examined hybrids in the first year ranged from 14.55 % (H4) up to 22.91 % (H32). In the second year average grain moisture ranged from 12.64 % (H4) to 16.87 % (H35), while in the third year it ranged from 16.88 % for hybrid H19 to 23.07 % for hybrid H32 (Table 1). The hybrid from the FAO 300 H4 had the lowest average grain moisture (14.73 %), while the highest grain moisture was observed for the hybrid of FAO 600 H32 (20.67 %). The highest coefficient of variation in grain moisture was found in 2011 (13.07 %), while the lowest was in 2012 (7.51 %).

Grain yield per ear: Grain yield per ear is directly proportional to the grain yield, and as such it is very important indicator. The highest average grain yield per ear was observed in 2011 (0.171 kg), while such as average grain yield the lowest was in 2012 (0.089 kg).

Table 2.Average estimates and indicators of variability for grain yield per ear (kg), and test weight (kg/hl) of 36 maize hybrids for all locations

Hybrid	FAO	Grain yield per ear (kg)					Test weight (kg/hl)				
		2011	2012	2013	$\bar{x}$	Rank	2011	2012	2013	$\bar{x}$	Rank
H1	300	0.153**	0.092	0.162	0.135*	28	74.47**	78.04**	72.70**	75.07**	1
H2	300	0.164	0.078*	0.152*	0.131**	34	73.13**	76.16	73.85**	74.38**	6
H3	300	0.156*	0.097	0.174	0.142	21	73.68**	76.08	74.14**	74.63**	4
H4	300	0.161	0.100*	0.171	0.144	18	72.72	75.18	72.55**	73.48**	11
H5	400	0.154**	0.089	0.153*	0.132**	32	73.90**	76.57*	72.06**	74.18**	8
H6	400	0.147**	0.086	0.157	0.130**	35	73.17**	76.24	68.71**	72.71	15
H7	400	0.163	0.078**	0.157	0.133**	31	71.48	75.16	70.81	72.49	18
H8	400	0.152**	0.075**	0.158	0.128**	36	73.07**	74.92	71.37	73.12	13
H9	400	0.176	0.084	0.170	0.144	20	72.15	73.25*	72.04*	72.48	19
H10	400	0.159	0.094	0.161	0.138	25	73.53**	76.00	70.40	73.31*	12
H11	400	0.198**	0.094	0.173	0.155**	6	69.88**	74.04	68.37**	70.76**	29
H12	400	0.176	0.087	0.152*	0.138	24	73.82**	76.32	72.04*	74.06**	9
H13	500	0.171	0.093	0.181	0.149	9	74.64**	77.31**	71.55	74.50**	5
H14	500	0.155**	0.078*	0.168	0.134**	30	69.20**	75.03	66.68**	70.31**	32
H15	500	0.169	0.085	0.150**	0.135*	29	71.82	75.36	70.37	72.52	17
H16	500	0.169	0.085	0.155*	0.136*	27	73.50**	76.47*	72.65**	74.21**	7
H17	500	0.165	0.078*	0.153*	0.132**	33	74.48**	76.93**	72.67**	74.69**	3
H18	500	0.168	0.082	0.172	0.141	23	70.81**	74.07	71.91*	72.26	23
H19	500	0.170	0.083	0.182	0.145	14	72.28	74.16	70.02	72.15	24
H20	500	0.179	0.092	0.174	0.148	10	74.50**	76.03	73.59**	74.70**	2
H21	500	0.188**	0.092	0.189**	0.156**	5	71.39	75.66	71.30	72.78	14
H22	500	0.195**	0.082	0.173	0.150	8	69.05**	73.60	68.00**	70.22**	34
H23	600	0.167	0.085	0.180	0.144	17	72.00	74.36	70.59	72.32	21
H24	600	0.177	0.092	0.174	0.148	13	70.30**	72.38**	68.32**	70.33**	31
H25	600	0.169	0.086	0.170	0.141	22	71.07*	73.23*	69.58	71.29**	26
H26	600	0.172	0.095	0.176	0.148	12	71.83**	74.29	69.66	71.92	25
H27	600	0.188**	0.096	0.170	0.152**	7	70.32**	73.61	68.75**	70.89**	28
H28	600	0.173	0.088	0.172	0.144	16	71.75	75.33	70.12	72.40	20
H29	600	0.184	0.102*	0.192**	0.159**	4	72.07	73.61	71.15	72.27	22
H30	600	0.170	0.099	0.165	0.145	15	74.20**	75.12	72.74**	74.02**	10
H31	600	0.181	0.093	0.169	0.148	11	69.87**	71.99**	65.43**	69.10**	36
H32	600	0.189**	0.091	0.200*	0.160**	3	70.07**	74.02	69.16*	71.09**	27
H33	700	0.168	0.091	0.173	0.144	18	71.36	72.79**	67.08**	70.41**	3
H34	700	0.165	0.086	0.159	0.137	26	69.78**	72.93*	67.89**	70.20**	35
H35	700	0.181	0.113**	0.187*	0.160**	2	72.16	76.37	69.04*	72.52	16
H36	700	0.195**	0.100*	0.190**	0.162**	1	69.45**	71.56**	69.76	70.26**	33
$\bar{x}$		0.171	0.089	0.17	0.144		72.03	74.84	70.47	72.45	
LSD	0.05	0.01	0.01	0.01	0.01		0.73	1.55	1.29	0.71	
LSD	0.01	0.02	0.01	0.02	0.01		0.96	2.03	1.70	0.94	
CV	(%)	12.88	20.3	13.93	14.93		1.78	3.64	3.23	3.01	

*,** - *significant at 0.05 and 0.01 probability level, respectively*

Average grain yield per ear of the examined hybrids in the first trial year ranged from 0.152 kg (H8) up to 0.198 kg (H11). In the second year it varied from 0.075 kg per ear (H8) to 0.113 kg per ear (H35). In the third year of the trial, grain yield per ear ranged from 0.150 kg (H15) to 0.200 kg for H32 (Table 2). Higher grain yield per ear was observed in 2011 and 2013, and it was achieved by hybrids of longer vegetation. In 2012 grain yield per ear extremely varied and it was independent from the length of the vegetation and with no regularity. The highest average grain yield per ear had the hybrid H36 (0.162 kg), which also had the highest average grain yield (Table 2). The lowest grain yield was established in hybrid H8 (0.128 kg per ear).Seven hybrids had highly significantly higher grain yield per ear in correspondence to the trial average. The highest coefficient of variation was established in 2012 (20.30 %), while the lowest was in 2011 (12.88 %). *Ilić (2002)* and *Živanović (2005)* concluded in their research that the greatest influence on the grain yield per ear had the meteorological conditions during the phase of grain filling, and beside that sowing date and density.

Test Weight: This trait such as the grain yield depends on many factors: genetic potential of hybrid, grain moisture at harvest, and the environmental factors. If the stress occurs early in the grain filling phase, it has more impact on the yield and test weight reduction *(Bowling, 2014)*. The crucial impact on the test weight has the stress during grain filling such as drought or early frost, because it disrupts the transfer of nutrients to the grain, and such grain is poorly filled and prone to diseases. Early frost during grain filling could cause lowering of test weight due to the forced maturation, because the plant could not reach naturally physiological maturity. Due to stressful factors test weight of one hybrid could vary over years and over locations in one year. This trait is in reverse proportion to the grain yield and grain moisture. Moreover grain moisture at the moment of harvest is the major reason for the variability of test weight. The highest test weight was noticed in dry 2012 (74.84 kg/hl), while the lowest test weight was in the year with the highest precipitation 2013 (70.47 kg/hl). Average test weight of examined hybrids in the first experimental year ranged from 69.05 kg/hl (H22) to 74.64 kg/hl (H13). In 2012 the lowest test weight had H36 (71.56 kg/hl) and H1 had the highest test weight (78.04 kg/hl), while in 2013 test weight ranged from 65.43 kg/hl (H31) to 74.14 kg/hl (H3) (Table 2). Average test weight was highest in 2012, and it was noticed in shorter season hybrids. This could be explained by the lower grain moisture at the moment of harvest, and because those hybrids avoided drought stress. On the other hand precipitation in September of 2013 was very high and with lower average daily temperatures, so the hybrids had higher grain moisture at harvested lower test weight. Similar variation in test weight in relation to the grain moisture at harvest in 2012 and 2013 was found in the research of *Bowling (2014). Rankin (2009)* also explains that it is essential to understand the relationship between grain moisture at harvest and test weight, because the dry grain is naturally smooth and slippery, so it provides better packaging. The highest test weight in this trial achieved H1 (75.07 kg/hl), while the lowest test weight had H31 (69.10 kg/hl). Highly significant differences between trial average and hybrids were found for 22 hybrids and for one significant difference. The highest coefficient of variation was found in 2012 (3.64 %), while the lowest was in 2011 (1.78 %). Test weight could be very interesting and important information to the farmers who are paying dry grain storage in big silos. The better the maize grain could be packed, the more kg could fit per hl, so the storage per ton is cheaper.

The correlation between observed traits: Spearman's rank coefficient correlation showed that in this trial there is significant positive correlation between grain yield and grain moisture (0.42*). Highly significant positive correlation was established between grain yield and grain yield per ear (0.91**). Moreover this correlation was very strong. On the other hand between grain yield and test weight correlation was negative and not significant (-0.33). Test weight was also in negative correlation with grain moisture and grain yield per ear, although these correlations were significant (-0.61**-0.41*, respectively). Highly significant positive correlation was found between grain moisture and grain yield per ear (0.61**).

CONCLUSION

Obtained results showed that the amount and distribution of precipitation, as well as average daily temperatures significantly influenced the variation of the observed traits and the ranking of hybrids. Analysis of variance showed that there were significant differences among genotypes, environments and GxE interactions. In the dry 2012 higher average grain yields produced hybrids of a shorter season, while in the years with average and above average precipitation higher yields were observed in hybrids with longer vegetation. On average for all three years hybrid H36 had the highest grain yield, and it was the most productive hybrid in 2011 and 2013. Similar trend was noticed for grain yield per ear for this hybrid. Grain moisture is a relative indicator and it depends on the speed of grain dry down of selected hybrids and the moment of harvest. Hybrids of longer vegetation had higher grain moisture at the moment of harvest than the shorter season hybrids. Average grain yields per ear were fully consent with the average grain yields of certain hybrid, which was confirmed by the Spearm's rank coefficient correlation. Test weight was in inverse proportion to the grain yield and moisture at harvest. Grain moisture is the most significant factor influencing this trait. Dry maize grain could be better packed, so the storage expenses could be lowered. Farmers lacking irrigation systems should be advised to sow hybrids of different length of vegetation, in order to achieve stabile yields.

ACKNOWLEDGMENT: This paper is a result of the research within project TR 31037, supported by the Ministry Education, Science and Technological Development, Republic of Serbia.

REFERENCES

Boakyewaa, A.G. (2012). Genotype by environment interaction and grain yield stability of extra early maize (Zea mays L.) hybrids evaluated at three locations in Ghana. Ph.D Thesis. Faculty of Agriculture, Kwame Nkrumah University of Science & Technology, Kumasi, Ghana.

Bowling, D. (2014). Test Weight & Yield. http://www.agrigold.com/universal/articles/test-weight-yield(Date of access, 18/1/2017)

Deitos, A., Arnhold, E., Miranda, G.V. (2006). Yield and combining ability of maize cultivars under different eco-geographic conditions. Crop Breeding and Applied Biotechnology, 6, 222-227.

Filipović, M., Jovanović, Ž.,Tolimir, M. (2015). Pravci selekcije novih ZP hibrida. "XX Savetovanje o biotehnologiji", Čačak, 13-14.3.2015. Zbornik radova, 20 (22), 7-13.

Filipović, V. (2012).Voda za navodnjavanje u službi održivog razvoja. Aktuelni savetnik, PDS Institut ″Tamiš″ Pančevo, 1, 4-7, Pančevo.

Ilić, T., Lazović, D., Biberdžić, M., Barać, S. (2002).Uticaj roka i gustine setve na prinos zrna različitih genotipova kukuruza (Zea mays L.). Nauka-poljoprivreda iskustvo, Banja Luka, Agroznanje, II (3), 50-57.

Kandus, M., Almorza, D., Boggio Ronceros, R., Salerno, J.C. (2010). Statistical models for evaluating the genotype-environment interaction in maize (Zea mays L.). Fyton, 79, 39-46.

Kovačević, V., Šimić, D., Šoštarić, J., Josipović, M. (2007). Precipitation and temperature regime impacts on maize yields in Eastren Croatia. Maydica, 52 (3), 301- 305.

Lee, E.A., Doerksen, T.K., Kannenberg, L.W. (2003). Genetics of yield stability in maize breeding populations. Crop Sci., 43, 2018-2027.

Mandić, V. (2011).Genotipski odgovor stay green hibrida kukuruza na povećanu gustinu useva. Doktorska disertacija, Poljoprivredni fakultet, Beograd - Zemun.

Pavlov, M., Crevar, M. (2014). Effects of agroecological factors and hybrid combinations on seed traits of maize hybrids, Journal on Processing and Energy in Agriculture, 18 (1), 11-13.

Petrović, S., Dimitrijević, M., Belić, M., Banjac, B., Vukosavljević, M. (2009). Spike stability parameters in wheat grown on solonetz soil. Genetika, 41(2), 199-205.

Renken, M. (2009). Understanding Corn Test Weight; Extenstion Team Grains. University of Wisconsin. http://fyi.uwex.edu/grain/files/2009/12/CornTW09.pdf

Statistički godišnjak (2016). Republički Zavod za Statistiku, Republika Srbija. http://webrzs.stat.gov.rs/WebSite/

Steel, R.G., Torrie, J. H. (1960). Principes and Procedures of Statistics. McGroow, Hill Book Company, London.

Videnović, Ž., Simić, M., Srdić, J., Dumanović, Z., Pavlov, M. (2011). Effect of sowing time on yield of ZP maize hybrids, Journal on Processing and Energy in Agriculture 15 (1), 23-26.

Zar, J.H. (1999). Biostatistical Analysis, 4^{th} edition. Prenice-Hall, Inc., New Jersey, USA.

Živanović, Lj. (2005). Uticaj vremena setve na ontogenezu i prinos hibrida kukuruza različite dužine vegetacionog perioda. Magistarska teza, Poljoprivredni fakultet, Beograd-Zemun.

Received: 20. 02. 2017. Accepted: 01. 09. 2017.