YIELD AND YIELD COMPONENTS OF MAIZE HYBRIDS (*Zea mays* L.) AS AFFECTED BY IRRIGATION

Monika Marković[1]*, Jasna Šoštarić[1], Marko Josipović[2], Mirta Rastija[1], Maja Matoša Kočar[2], Kristina Andrišić[1]

[1]Faculty of Agrobiotechnical Sciences Osijek, Vladmira Preloga 1, Osijek 31000, Croatia

[2]Agricultural Institute Osijek, Južno predgrađe 17, Osijek 31000, Croatia

Abstract

Maize (Zea mays L.) grain yield largely depends on the amount of plant-available water, nutrients, climatic conditions, soil, and genotype. The grain yield formation is closely related to yield components. The field study was set up near Osijek (2020) on silty clay soil with, loamy texture. The different treatments consisted of two irrigation treatments (a1=irrigated; a2=rainfed), and two maize hybrids (b1=ossk515; b2=po216). Surface irrigation was conducted with the use of furrows, while the soil water content was measured with tensiometers placed at a depth of 30 cm on each irrigation treatment. Net irrigation was 280 mm which completely compensated the crop water requirements on irrigated plots. Significantly ($p<0.05$) higher grain yield (16.44 t ha^{-1}), grain weight/cob (220 g), cob (114.92 cm) and tassel height (181.26 cm) were recorded in irrigated plots. On average across irrigation treatment the significantly ($p<0.05$) higher grain yield (15.12 t ha^{-1}), grain weight/cob (227 g), grain number/cob (556), hectoliter weight (70.87), and cob weight (291.3 g) were recorded for b2 hybrid (po216). The higher tested variables were recorded for b2 hybrid in both, irrigated and dry plots. The correlation analysis showed a strong positive correlation between grain yield and grain number/cob ($r=0.91$; $p<0.00$), grain yield and the position of the cob, i.e. cob height ($r=0.65$; $p<0.05$), grain yield, and cob length ($r=0.78$; $p<0.05$) and between grain yield and grain moisture ($r=0.62$; $p<0.05$). As for yield components, the strong positive correlation was found between cob weight and cob length ($r=0.89$; $p<0.05$), cob weight and grain moisture ($r=0.73$; $p<0.05$), grain number/cob and tassel height ($r=0.82$; $p<0.5$), and between grain weight/cob and grain number/cob ($r=0.72$; $p<0.05$).

Keywords: *irrigation, maize hybrid, grain yield, yield components, crop water requirements*

1. INTRODUCTION

In terms of agri-environmental factors, maize (*Zea mays* L.) yield formation and yield itself are primarily dependent on the available water and nutrients. This statement is of special importance in the conditions of frequent occurrences of weather extremes (floods and droughts), which are the main characteristics of climate change. For crop production, drought is of special importance since it causes significant yield reductions both for rainfed and irrigated crops (Ray et al., 2018). The previous study about the appearance and severity of drought in continental Croatia, conducted by Tadić et al. (2019), reveals that the drought occurrence is influenced more strongly by the increasing trends in air temperature than by the amount of precipitation. The average air temperature over the 30 years (1961-1990) during the maize growing season (April-September) in the Osijek region (continental area of Croatia) was 17.6 ^{o}C. If the 30 years is analyzed for the 1981-2010 period, then the air temperature was 18.1 ^{o}C, which means that the air temperature is gradually increasing. For example, during the last decade, the air temperature for each growing season was above the long-term average (LTA=18.1 ^{o}C), and ranged from 18.3 ^{o}C (2014) to 20.1 ^{o}C (2011). As for precipitation, during the mentioned period, frequent changes in wet, dry, and average years were recorded, which confirms the climate variability and climate change as well. Only in the past decade have frequent changes in the extremely rainy and dry periods been recorded, with precipitation during the maize growing season ranging from 676.6 mm (2010) to 244.9 mm (2011). In the mentioned decade, the drought was somewhat rarer compared to the previous decade (2000-2009), which is perhaps one of the reasons why farmers are struggling to decide on irrigation. However, significant variation in maize yields in Croatia as a consequence of weather conditions should be noted. According to the last available data (CBS, 2019, 2020), maize yield in the 2010-2019 period ranged from 5.3 t ha^{-1} (2012) to 9.1 t ha^{-1} (2018). Given the significant reduction in yield and quality of maize in drought conditions and unfavorable weather conditions in general, it is recommended to compensate for the lack of water by irrigation. The percentage of irrigated areas in the Republic of Croatia is far below the European and world average. According to the last available data, only 1570 ha of agricultural land in Croatia sown with maize is irrigated (FAO, 2021).

It was reported that irrigation in crop production is the biggest consumer of water globally (Simsek et al., 2011, Wang et al., 2021). For that reason, water scarcity during the dry season should be compensated by irrigation water in a way that meets the water needs of plants and saves water resources. Improving crop yield per unit land area is a key to solving the problem of food security (Zhang et al., 2019). This means that it is necessary to strive to increase the irrigation efficiency, i.e. to increase the yield per unit of water used for irrigation. When planning irrigation, water is saved with proper irrigation scheduling, meaning that the time and duration of irrigation should be correctly determined. The most accurate method for determining irrigation time is to measure the soil water content (SWC) and to collect the climatic data, primarily the rainfall and air temperature data collected from a weather station.

In general, maize grain yield (GY) in irrigated agriculture is higher than the in rainfed (Farré and Faci, 2009, Fang and Su, 2019, Kara and Biber, 2008), yet Orfanou et al. (2009) claim that increasing the amount of water does not directly equate to higher yields. It should be noted that the yield increase in irrigated agriculture will depend on agroecological conditions, i.e. fertilization, genotype, and weather conditions. In general, water stress can influence maize developmental and physiological processes resulting in reduced biomass and consequently yield, due to a reduced number of kernels per ear or kernel weight (Payero et al., 2009, Traore et al., 2000). As previously stated, maize yield formation highly depends on yield components, primarily grain number/cob (GN/C) and grain weight (GW). Vazin et al. (2010) stated that maize grain yield is normally highly and positively correlated with GN and that the GN depends on the number of cobs per plant (CN/P) and the number of mature grains per cob. The effects of drought stress on maize yield and yield components have been previously studied by Bancy (2000), Pandey et al. (2000), Cakir (2004), Abbas et al. (2005), Oktem (2008), Marković et al. (2017a) and Marković et al. (2018). In general, authors claim that besides the GY, water deficit reduces GN/C, 1000-grain weight (1000-GW), cob weight (CW), and cob length (CL) as well. Besides the agroecological factors, maize GY is determined by genotype as well as by genotype-environment (GE) interaction (Das et al., 2019, Kang, 1997). Previous studies have shown the significant impact of maize genotype on GY (Mafouasson et al., 2018, Marković et al., 2017b, Shojaei et al., 2021) and yield components (Marković et al., 2017a, Marković et al, 2018).

A large number of existing studies in the broader literature have proved that among various crop phenotypes, plant height is proved to be the key indicator related to drought stress (Chapman et al., 1999, Hussain et al., 2019, Su et al., 2019). The results of Zhou et al. (2020) study indicate the importance of plant height, especially in the conditions of climate change, i.e. the occurrence of intense precipitation and strong winds when the plants are prone to lodging. The author claims that the plant height can be regarded as an important index to characterize the degree of crop lodging, since the more serious the lodging, the lower the plant height. This statement is very important if we take into account the fact that in the area of eastern Croatia in the past decade (2010-2019) two growing seasons were characterized as extremely wet (2010 and 2014), while three growing seasons (2013, 2016 and 2018) as wet (CMHS, 2021). This study was, therefore, conducted to (i) assess the maize water needs, (ii) examine the effect of irrigation water on maize GY and yield components (GN/C, GW/C, grain moisture (GM), CL, CW, cob diameter (CD), CN/P and hectoliter weight (HW)), (iii) examine the effect of irrigation on maize cob height (CH) and tassel height (TH).

2. MATERIALS AND METHODS

2.1. Study site

The field study was conducted during the growing season 2020 in Petrijevci (45°36′36″ N, 18°32′24″ E), located near Osijek in the continental region of Croatia, at an 89 m elevation. The soil type at the study site is sandy clay, loamy in texture (32% of clay, 48% of sand, and 20% of silt). The average particle density is 1.18 g cm^{-3}, with the bulk density (BD) of 1.14 g cm^{-3}. The soil porosity is 2.63%, and the water holding capacity (WHC) 57.11%. The preceding crop was wheat. The region has a temperate, subhumid continental climate (Cfwbx), characterized by a diversity of weather situations with frequent and intense exchanges during the year (Zaninović et al., 2008). The average weather conditions in Osijek region during the study are shown in Table 1. The average air temperature was 18.7 ^{o}C, which is 1.15 ^{o}C higher than the LTA (1981-2010). The average reference evapotranspiration (ETo) was 3.59 mm/day, which is 0.69 mm/day higher than the LTA. The ETo was noticeably higher in the spring and summer months. In April, the ETo was 1.19 mm/day higher than the LTA, while in August, it was 1.07 mm/day higher. This of course indicates an increased irrigation water requirements (IWR).

Month	**T_{max}**		**T_{min}**		**T_a**		**RH (%)**		**WS**		**SR (h/day)**		**ETo (mm/day)**	
	2020	**LTA**	**2020**	**LTA**	**2020**	**LTA**	**2020**	**LTA**	**2020**	**LTA**	**2020**	**LTA**	**2020**	**LTA**
IV	20.3	17.9	4.1	5.9	12.2	11.7	56	69.9	2.1	2.1	9.6	5.6	3.09	1.9
V	21.2	23.2	9.9	10.9	15.3	17.0	69	69.0	1.9	1.9	6.8	6.9	2.94	2.91
VI	26.1	26.0	14.5	13.9	20.2	20.1	72	70.6	1.8	1.8	7.2	7.6	3.41	3.51
VII	28.5	28.5	15.2	15.3	22.3	21.9	67	68.5	1.7	1.7	10.2	8.3	4.21	3.77
VIII	29.9	2.78	17.4	14.9	23.4	21.3	71	70.8	1.6	1.6	9.4	7.5	4.32	3.25
IX	26.0	23.1	12.4	11.0	18.8	16.8	68	75.4	1.6	1.6	8.0	5.8	3.54	2.09

Table 1. Average daily maximum (Tmax), minimum (Tmin) and average air temperature (Ta, ^{o}C), relative humidity (RH, %), wind speed (WS), sunshine hours (SR, h/day) and average reference evapotranspiration (ETo, mm/day)

The average annual LTA rainfall at the study region is 690 mm, and 401.9 mm during the April and September (growing period) period. The amount of rainfall during the growing season 2020 was 325 mm which is 16% less than LTA, yet the distribution of precipitation during the vegetation period was quite favorable. In our study (Figure 1) rainfall was significantly less in April (21 mm; LTA = 52.8 mm) and July (37.4 mm; LTA = 59 mm), while significantly higher in August (83.3 mm; LTA = 70.2 mm).

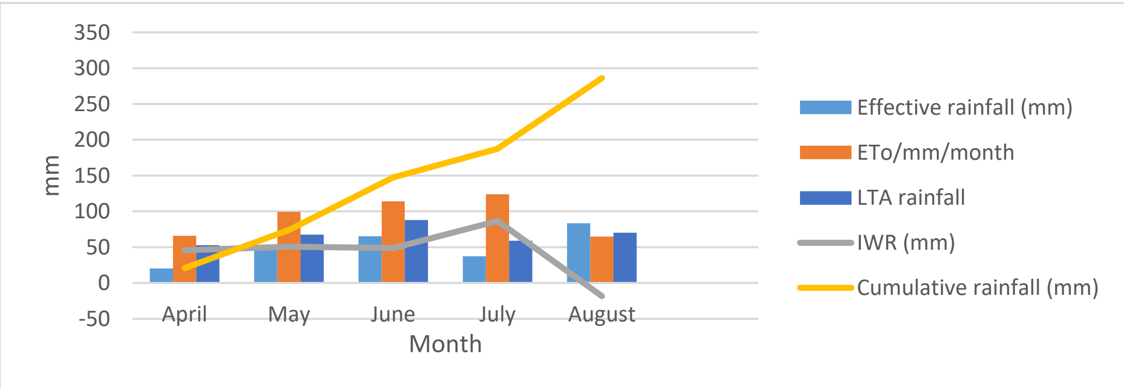

Fig. 1. Rainfall (Long Term Average, and growing season 2020) and ETo (mm/month)

2.2. Study design and treatments

The field study followed a split-plot design with three replications. The total size of the experimental plot was 1344 m^2. Each plot (study treatment) had two maize rows, 0.7 m apart and 40 m long. Between each plot, four maize rows were sown, which served as a protective belt to avoid overlapping irrigation treatments. The effect of irrigation on yield and yield components was observed through two treatments;

a1 = irrigated; a2 = rainfed (control). The full irrigation treatment (a1) was performed in a way that the crop available water (irrigation water + rainfall + soil water content, SWC) was adequate to meet crop water requirements (CWR), estimated according to Penman-Monteith equation (Allen et al., 1998) by use of CROPWAT 8.0 computer model. Surface irrigation was conducted with the use of furrows, where each row of the maize crop was irrigated within each irrigation event. The length of the furrows was the same as the experimental plot (40 m) with a 0.2% slope. The length of the slope was adjusted to soil type so that the excessive percolation losses are avoided and that the irrigation water would reach the downstream end, with stream size up to 0.5 l/sec. Irrigation water was taken from a 17 m deep well, located near the experimental plot. Irrigation scheduling was based on the SWC readings, whereas irrigation water was applied at 70% of field capacity (FC). SWC was measured using a tensiometer (Irrometer Company Inc.), placed at a depth of 30 cm on each irrigation treatment (irrigated and rainfed). Before placement in the soil, the tensiometer was calibrated for the soil on the study site. Calibration results indicate that the SWC at FC is 0 – 15 cbar, and 20 cbar at management allowable depletion (MAD). It should be noted that 35 cbar was the end of the range that the tensiometer can operate at. Irrigation was scheduled so that the CWR would be compensated with irrigation water. Soil water depletion between the irrigation event was within the range of 80 to 98 mm, which represents 70% to 75% of total available water (TAW) in rooting depth.

Two maize hybrids (b1 = ossk515; b2 = po216) with similar biological cycles were sown on 8 April 2020 with a pneumatic planter. The seeds were sown to a depth of 6 cm, with 20 cm inter-row spacing, and 70 cm spacing between rows. The same management in terms of soil tillage, sowing, crop protection, fertilization, and harvesting was applied to both maize hybrids. Maize crop was treated with a nonselective herbicide on 8 May. The maize crop was top-dressed on 25 May with calcium ammonium nitrate (CAN, 130 kg ha^{-1}). The cobs were collected from each subplot by hand-harvesting on 5 October 2020.

2.3. Data collecting and analysis

After the milk stage, the height (cm) of four randomly selected plants was measured from the base of the plant to the tip of the cob (cob height, CH) and the tip of the tassel (tassel height, TH). The height was recorded as the average value of selected plants for each subplot. Before maize harvesting, cob number (CN) per plant was recorded. At harvest, four randomly chosen plants from each plot were taken for measuring the yield components: cob weight (CW), cob length (CL), cob diameter (CD), grain number/cob (GN/C), grain weight/cob (GW/C). Grain yield (GY) was obtained from each experimental plot and adjusted to a 14% wet basis. Irrigation efficiency was analyzed by the following indices: (i) Irrigation Efficiency (IE) according to Takac et al. (2008), IE = Yi / Yd x 100, where Yi is the yield on irrigated plots while Yd is the yield on rainfed plots, (ii) Irrigation Water Use Efficiency (IWUE) according to Boss (1979), IWUE = Yi - Yd / I (mm), where Yi is the yield on irrigated plots, Yd represents yield on rainfed plots, while I represent net irrigation (mm), (iii)of irrigation efficiency is determined according to Han et al. (2017), IEindex = (ETc – Er)/I, where ETc stands for crop evapotranspiration, Er stands for effective rainfall (mm) and I for irrigation water (mm). USDA method (Wane and Nagdeve, 2014) was used for assessment of effective rainfall (Er) where neither the soil intake rate nor rainfall intensities are considered; Re = (R x (125 - 0.2 x 3 x R))/125 if R < 250/3 mm, and Re = 125/3 + 0.1 x R, if R > 250/3 mm, where R stands for rainfall. USDA method estimates effective rainfall by processing long-term climatic and soil moisture data. In this method, neither the soil intake rate nor rainfall intensities are considered (Dastane, 1978). Meaning, the method averages soil type, climatic conditions, and soil-water storage. The statistical analyses of data, which included analysis of variance (ANOVA) and Person's (r) correlation was done in STATISTICA (StatSoft Inc.) computer software.

3. RESULTS

3.1. Crop water needs and irrigation management

During the initial stage (the first and second decade of April) the ETc was 43.1 mm, while the effective rainfall was 6.2 mm. Although it is obvious that the CWR is greater than effective rainfall, the SWC accumulated in the winter/spring period and the fact that the plant is in early vegetative growth should not be neglected here (Figure 2). The situation is very similar in terms of the CWR until the second decade of June, i.e. until the beginning of the mid-season stage.

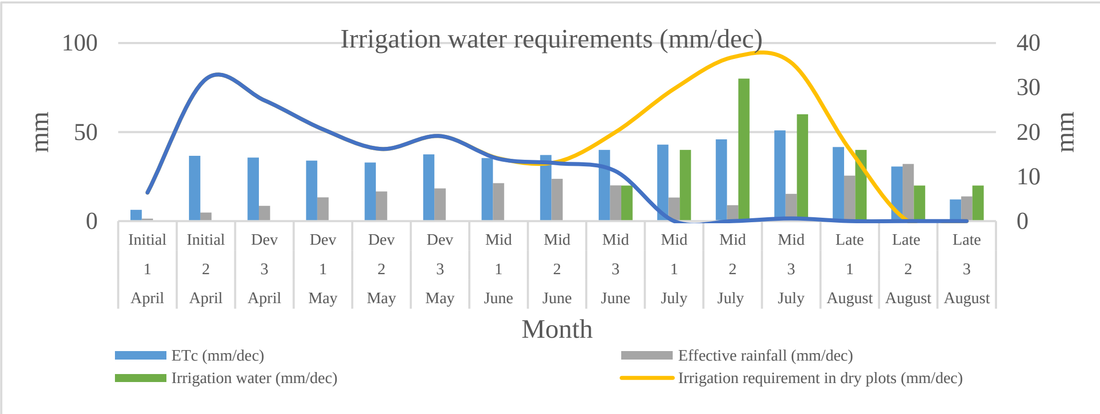

Fig. 2. Crop evapotranspiration (ETc), effective rainfall (mm/dec), and irrigation water requirements (mm/dec) in rainfed and irrigated plots

As presented in Figure 3, the SWC in the last decade of the May (development stage) was in the range of FC. Afterward, the SWC gradually decreases to the value of MAD (18 cbar). The first irrigation event was on 10 July and thereafter continues on average every three to five days until the end of the month of August (late-stage). The SWC in irrigated plots until the third decade of the late-stage was in FC – MAD range. In total, applied net irrigation on irrigated plots was 280 mm.

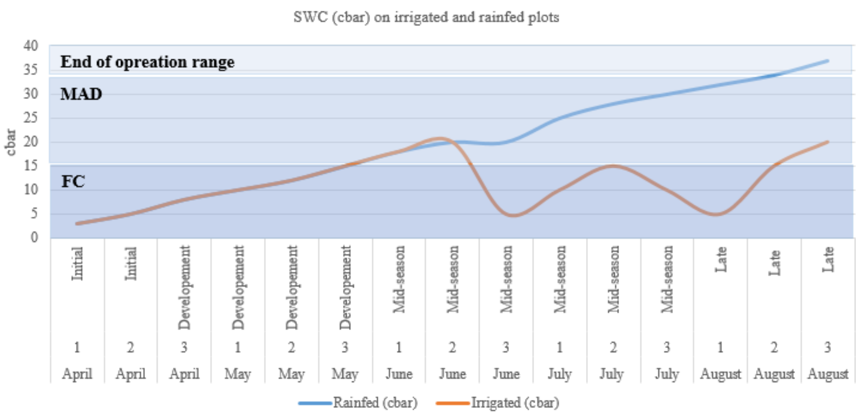

Fig. 3. Soil water content (SWC, cbar) on irrigated and rainfed plots with indicated MAD (management allowable depletion) and FC (field capacity)

In the mentioned period, the SWC on rainfed plots gradually decreased way below MAD and reached the wilting point (WP) in August. Irrigation water managed to compensate CWR until the end of the late-stage during which a significant amount of rainfall fell (figure 4, 52 mm).

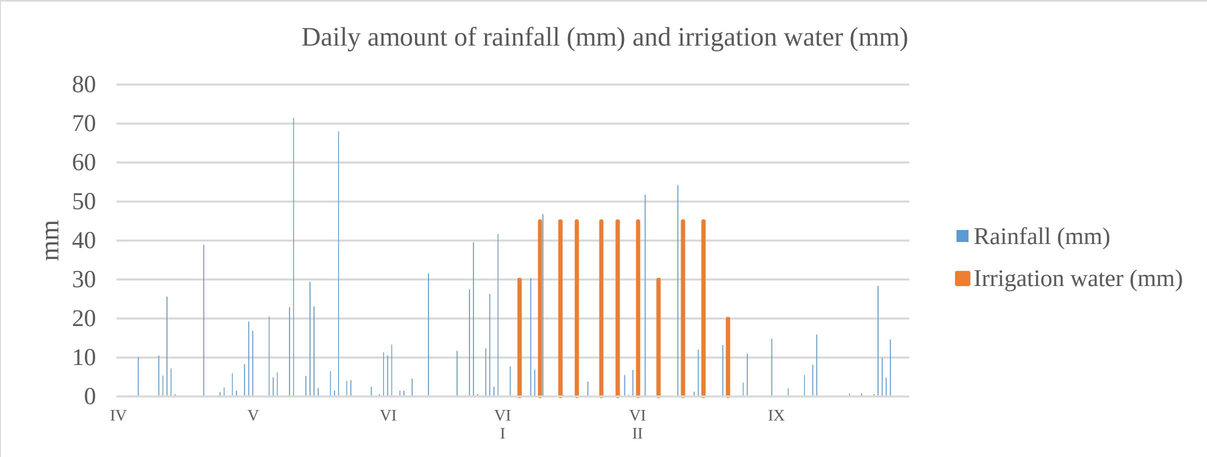

Fig. 4. The daily amount of rainfall (mm) and irrigation water (mm)

3.2. The effect of irrigation on yield and yield components

Table 2 shows the average values of the tested variables by research treatments and the results of statistical analysis. Maize GY ranged from 11.47 t/ha in rainfed (a2) to 16.44 t/ha in irrigated treatment (a1), that is, a significantly (p=0.05) higher GY was obtained in irrigated plots.

	Irrigation (a)		**Hybrid (b)**					
	a1	**a2**	**b1**	**b2**	**a1b1**	**a1b2**	**a2b1**	**a2b2**
GY	16.44*	11.47	12.79	15.12*	14.5	18.4**	11.1	11.9
GW/C	220*	181	175	227**	193	247**	156	206**
GM	11.22	10.34	10.72	10.84	11.77	10.67	9.67	11.0
GN/C	569*	497	510	556*	558	580	463	532*
HW	70.84	66.39	66.55	70.87*	68.00	73.67*	67.67	65.1
CW	264.5*	232.0	205.2	291.3**	231.0	298*	179.3	284.7**
CL	20.7	19.45	19.3	20.86	20.16	21.25	18.44	20.46
CD	47.84	46.02	45.84	48.02	46.34	49.33	45.33	46.71
CN/P	1.13	1.04	1.04	1.13	1.0	1.25	1.08	1.0
CH	114.92*	99.63	106.54	108	98.42	100.83	112.25	117.58*
TH	181.26*	159.42	167.68	173.46	175.94	186.58*	159.42	160.33

a1 = irrigated, a2 = rainfed; b1 = ossk515; b2 = po216; GY = grain yield (t/ha); GW/C = grain weight per cob (g); GM = grain moisture (%); GN/C = grain number per cob (n); HW = hectoliter weight (kg/hl); CW = cob weight (g); CL = cob length (cm); CD = cob diameter (cm); CN/P = cob number/plant; CH = cob height (cm); TH = tassel height (cm)

Table 2. Grain yield and yield components of maize as affected by irrigation and hybrid (ANOVA)

As for maize hybrid, a significantly ($p=0.05$) higher GY was noted for b2 maize hybrid (po216). On average, the GY of b2 hybrid was 18.2% higher than b1 (ossk515). In irrigated treatment, the b2 hybrid showed a significantly ($p=0.01$) higher yield (18.4 t/ha) than the b1 hybrid (14.5 t/ha). Significantly ($p<0.05$) higher GW/C was recorded on irrigated plot (a1=220 g; a2 = 181 g). Significantly ($p=0.01$) higher GW/C was recorded for b2 hybrid (a1=175 g; a2=227 g). In both, irrigated ($p=0.05$) and rainfed ($P=0.05$) plot, a higher GW/C was recorded for b2 maize hybrid (a1b2=247 g; a2b2=206 g). The GN/C significantly ($p<0.05$) vary across irrigation, it ranged from 497 (a2) to 569 (a1) in irrigation treatment. As for maize hybrid, a significantly higher ($p<0.05$) GN/C was recorded for b2 hybrid, and it ranged from 510 (b1) to 556 (b2). In rainfed plots, a significantly ($p<0.05$) higher HW was recorded for b2 hybrid (table 2). In irrigated plots, significantly higher HW was recorded for hybrid b2 (a1b2 = 73.67).

CW in irrigated plots ranged from 232 g (a2) to 264.5 g (a1). Significantly higher CW was recorded for b2 hybrid ($p<0.01$; 291.3 g). In both, irrigated and rainfed plots, a higher CW was recorded for b2 hybrid (a1b2=298 g; a2b2=284.7 g). No statistically significant differences were observed in terms of the impact of irrigation or hybrids on CL, CD, and CN/P. In general, CL and CD were higher in irrigated plots (a1) and b2 hybrid. CH was significantly ($p<0.05$) higher on irrigated plots (a1=114.92). On rainfed plots, the significantly ($p<0.05$) higher CH was recorded for b2 hybrid (a1b2=100.83 cm; a2b2=117.58 cm). Similar results were recorded for TH. Significantly ($p<0.05$) higher TH was recorded on irrigated plots (table 2). Also in irrigated plots, hybrid b2 had significantly higher TH (a1b2=186.58 cm).

4. DISCUSSION

Numerous physiological processes of plants are directly or indirectly dependent on the amount of water available to the plant. In our study during the initial, development and the second decade of the middle stage, the amount of rainfall as well the SWC were sufficient to meet the water needs of the maize crop. In the area of Osijek, this is the phenologic phase of the first ten leaves. It should be noted that maize yield formation is highly related to the sensitive growth stages. Abendroth et al. (2011) claim that for maize, significant yield loss can be expected if water stress occurs during the most sensitive growth stages, from tassel emergence to the beginning of grain filling. Mansouri-Far et al. (2010) claim that limited irrigation imposed on maize during the reproductive stage resulted in more yield reduction than that during the vegetative stage, compared with fully irrigated treatment. In our study, the maize crop exhibited water stress from the third decade of June when the amount of rainfall was significantly reduced (Figure 4). According to tensiometer readings as the indicator of SWC, plants on rainfed plots were exposed to additional drought stress (Figure 3), which at the end resulted in lower GY. Any kind of stress, for example, drought stress, during or around the stage(s) at which the yield components are formed may severely affect GY (Inamullah et al., 2011). Water stress occurring during emergence to tasseling, and before tasseling occurs, has a significant impact on crop height (Çakir, 2004). In our study, higher GY as well as tested yield components were recorded on irrigated plot (a1). In line with previous studies (Hossain et al., 2009, Marković et al., 2017a, Marković et al., 2017b), GY in our study was 43% higher on irrigated (a1), than on rainfed plots, while on average the IE was 49.7%. The net irrigation was 280 mm which completely compensated the CWR (264.3 mm) during the period of the drought (middle of June to the beginning of August). This means that the irrigation was properly scheduled with the use of tensiometers or measurements of SWC. The IWUE was 17.75 kg ha^{-1}/mm, while the IE_{index} was 0.1.

GY was best related to maize hybrids ($r=0.74$; $p<0.05$). In drought stress conditions, the yield of both maize hybrids was at the same level (11 t/ha, table 2), indicating the same genetic predisposition for drought tolerance. Adee et al. (2016) claim that the potential benefit of drought-tolerant maize hybrids may depend on drought intensity, duration, crop growth stage (timing), and the array of drought tolerance mechanisms present in selected hybrids. In our study, on average across irrigation treatment, the higher GY, as well as yield components, was recorded for b2 hybrid (po2016). As for IWUE, the hybrid b2 showed better water utilization (b2=23.21 kg ha^{-1}/mm, b1=12.25 kg ha^{-1}/mm).

Saini and Westgate (2000) claim that poor synchronization in the emergence of male and female flower components ends with low yield, meaning that the GY reduction is primarily caused by the reduction in

GN/C. Overall, these findings are in accordance with this study since the GN/C on the irrigated plot was 9% higher than on the rainfed plot. In general, the direct and indirect effect of genotypic and phenotypic grain yield components on GY must be taken into consideration. As stated by Carpici and Celik (2010) the efficiency of a breeding program depends primarily on the direction and magnitude of the association between the yield and yield components and on the relative importance of each factor to forage yield.

In our study, the strongest positive correlation (Figure 5) was found between GY and GN/C ($r=0.91$; $p<0.00$). This is consistent with what has been found in previous studies by Munawar et al. (2013) and Aman et al. (2019). In addition, a strong positive correlation was found between the GY and the position of the cob, i.e. CH ($r=0.65$; $p<0.05$). Furthermore, between GY and CL ($r=0.78$; $p<0.05$), GY and CW ($r=0.89$; $p<0.05$). A similar pattern of results was obtained in the study Carpici and Celik (2010), Alhussein and Idris (2017), Icoz and Kara (2009). It should be noted that the results of several studies indicate that there are no significant relationship between GY and yield components. For instance, the results of Ergul and Soylu (2009) indicated that there were no relationships between forage yield and forage yield-related components such as plant height, first ear height, ear diameter, stem ratio, leaf number, ear ratio, and leaf ratio.

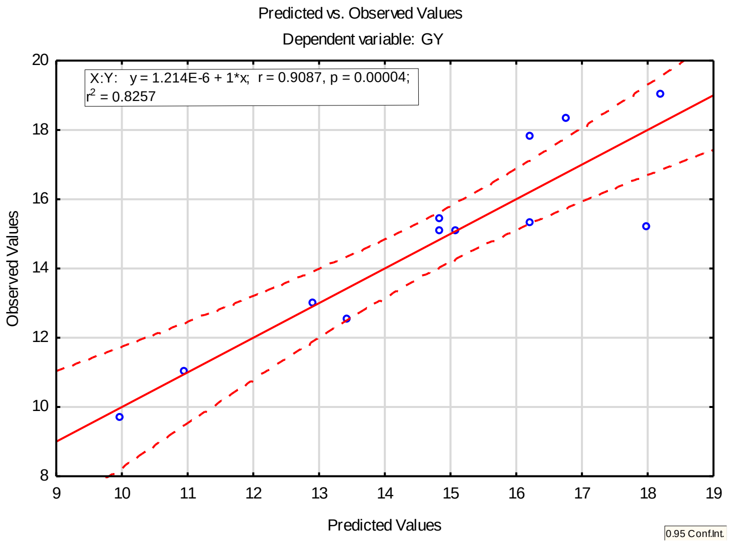

Fig. 5. Regression analysis for GY and GW

As for yield components, strong positive correlation was found between CW and CL ($r=0.89$; $p<0.05$), CW and GM ($r=0.73$; $p<0.05$), GN/C and TH ($r=0.82$; $p<0.5$) and GW/C and GN/C ($r=0.72$; $p<0.05$). As suggested by Muneeb et al. (2013) these findings suggested that improvement of grain yield in maize is linked with the development of these traits that might have a good impact on grain yield.

5. CONCLUSIONS

The results obtained in this study suggest that properly scheduled irrigation increases grain yield as well as yield components that are related to yield formation, grain number/cob (a1=220; a2=181), grain weight (a1=569; a2=497), and cob weight (a1=264.5; a2=232). When water is limited, it is important to select maize hybrid with good drought tolerance and to use irrigation water efficiently so that the water losses would be minimal. This study shows that the hybrid b2 has better water utilization (b2=23.21 kg ha^{-1}/mm, b1=12.25 kg ha^{-1}/mm) and therefore higher grain yield as well yield components. The results also indicate a strong positive correlation between grain yield and grain number/cob ($r=0.91$), cob weight ($r=0.89$), and cob length ($r=0.78$), traits that could be used as selection criteria in maize breeding program.

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