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Utjecaj tehnologije sjetve na prinos kukuruza

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THE IMPACT OF PLANTING TECHNOLOGY ON THE MAIZE YIELD

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SUMMARY

The three–year trials of the impact of the planting technology on the maize yield were carried out at the trial sites Jakšić and Tenja. The KWS Intelligens and KWS Kollegas hybrids were used in the research, planted at a standard row spacing of 70 cm, and in the twin rows with a spacing of 48 × 22 cm. In 2020, the highest average grain yield at the site Jakšić in standard planting, with the KWS Intelligens hybrid, was 12.064 t ha^{-1}, and in the twin row planting an increase in yield of +4.17% was recorded. The KWS Kollegas hybrid had the highest difference in grain yield between a standard and twin row planting in 2021 of +7.52%, in favor of the twin row. At the site Tenja, slightly higher grain yields were recorded in all three years of research. The major difference in yield was recorded in 2020 with the hybrid KWS Kollegas, of +8.22%, or 1.115 t more grain, when planting in the twin rows in comparison with a standard planting. The statistical tests indicate that planting in the twin rows at both trial sites obtained statistically significant results in all three years of research concerning the grain yield ha^{-1}, grain weight per ear, and grain moisture content.

***Keywords:** maize, twin row, planter, yield, hybrid*

INTRODUCTION

Maize is one of the most commonly cultivated crops and is important for human nutrition, animal feed, industrial raw materials, and biofuel energy (Anjum et al., 2017). An increase in economic profit in the production of maize grain has escalated significantly by processing it into ethanol as an ecological component in the production of internal combustion fuels. Maize is planted in most areas in the rows spaced at a distance amounting to 70 cm. When maize is planted with an uneven spacing within the row, the plants are in a disadvantageous position—that is, they "fight" for a vegetation space and cannot realize their full biological potential. A smaller part of the area is planted at 75 cm row spacing as part of the American technology to use the combine headers with the same spacing of the harvesting system. With the reduction of arable areas in the world, and especially in the USA area, an attempt was made to increase the yield by more favorable arrangement of seeds in planting. Under favorable climatic conditions of production with regard to the amount of precipitation and temperature, the distribution of seeds within the row is not significantly decisive for the achievement of grain yield ha^{-1}. However, if the production of maize takes place in a climatic area with reduced amounts of precipitation and high average daily temperatures, the position of the plants within the row becomes very significant. One of the attempts to reduce the impact of climate change is the planting in double rows, known as twin row technology. Twin rows are planted at a distance of 20, 22 or 25 cm, and the central distance of adjacent twin row is 70 or 75 cm, so that harvesting can be done with standard maize pickers. This planting technology allows, in addition to better use of soil, sunlight, and in most studies contributes to the realization of an equal or higher yield per hectare. Planting maize in twin rows increases the spacing between plants compared to standard planting with the same planting arrangement (Finck, 2004), as well as the utilization of vegetation space and an increase in the absorption of solar radiation. According to the literature that can be found in the part of the scientific bibliography, the application of twin row technology started already in the early eighties of

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twentieth century in the USA as an effort to increase the yield by increasing the planting of a larger number of plants per production area. The majority of European authors report similar results that confirm the existence of a statistically significant increase in the yield of maize grains when planting in twin rows compared to standard planting (García Ramos et al., 2014; Jócsák, 2014; Küper, 2014; Gutiérrez López et al., 2014; Blandino et al., 2013). Many scientists explain the increased yield achieved by planting in twin rows as an increased structure, where plants better utilize light and vegetation space and absorb nutrients and water better (Jarek et al., 2011; Cox et al., 2006; Balem et al., 2014). Mackey et al. (2016) state that twin row planting increases yield by 6.7% compared to standard row spacing maize planting. Since planting in twin rows makes better use of vegetation space and soil, the effects on maize grain yield are very different when researching individual hybrids in different combinations (from 40 000 to 84 000 plants ha^{-1}). Coulter and Shanahan (2012), while investigating the influence of row spacing when planting in twin rows with a spacing of 15, 20 and 22 inches, recorded statistically significantly higher yields (an increase of 4%) compared to standard planting with a row spacing of 30 inches (Minnesota). Balem et al. (2014) state that the increase in maize yield is directly related to good planting practices, and it is especially important to achieve uniformity in plant spacing during sowing. Authors also state that planting in twin rows achieved better results in stem diameter, number of grains per ear, absolute mass of 1000 grains, ear mass and average yield. By increasing the density, the specified values decreased. Kirilmaz and Marakoğlu (2018) state that the increase in row spacing in traditional maize planting causes a decrease in yield, and the authors further state that with twin row spacing of 20 cm with a central distance between adjacent rows of 50 cm, they achieved the best experimental results and recommend this technology for planting maize. Nzi et al. (2017) examined different methods of planting, and the results of the analysis of variance showed significant statistical differences between them. The authors state that the most optimal method of planting is in twin rows with a distance of 25 cm between two twin rows. Tilley et al. (2021) report that standard planting (single row) with spacing at 36 inches or more is the most preferred planting system among grain farmers in North Carolina. However, the twin row technology will continue to be an option for farmers who want to move from traditional wide–row to narrow–row systems. Farmers using twin row will continue to evaluate the benefits each year and determine whether or not these uses outweigh the associated disadvantages. There are many factors that affect crop yield (Kambulov, 2018), and precision sowing technology is considered one of the most important factors. The task of this research was using standard research methods to determine the justification of the application of twin row planting technology by sowing *KWS* maize hybrids at the trial sites Jakšić and Tenja in the growing years from 2020 to 2022.

MATERIALS AND METHODS

Field research was carried out over three growing years (from 2020 to 2022) at the trial site Jakšić in the Požega–Slavonia County and the trial site Tenja in the Osijek–Baranja County in Croatia. The experiment design of completely randomized block design (CRBD) in four repetitions has been applied each year on both sites, with two hybrids (KWS Inteligens–H1 and KWS Kollegas–H2) and two planting patterns (Standard–SR and twin row–TR), with the basic experimental plot size of 5.6 x 20 m (8 rows). Hybrid H1 belongs to FAO 430 vegetation group, with declared 125 days from emergence to physiological grain maturity. Being selected and created in France, its main purpose is for intensive grain production. Hybrid H2 belongs to FAO 470 vegetative group, with about a week longer vegetation period than the H1. It is selected and created in Romania, with the main purpose of achieving high grain yield in different agro–environment of southeast Europe. For planting in standard rows (SR), with row spacing of 70 cm, a *PSK OLT Osijek* pneumatic vacuum planter was used. For the predicted density of 70 000 plants ha^{-1} at the time of harvest in standard planting, a seed plate $n=31$ holes ø 5.5 mm with a transmission ratio was used (n_{wheel}–$n_{sowing\ plate}$) $i = 0.3593$. In this way, with an average theoretical seed spacing of 17.523 cm, a theoretical density of 81 036 plants ha^{-1} is realized. MaterMacc Twin Row–2 planter with a spacing of 22 cm between double rows was used for planting in twin rows (TR). Sowing was done at the same time as standard planting using a seed plate $n=$ 12 holes ø 5.5 mm with transmission ratio (n_{wheel}–$n_{sowing\ plate}$) $i = 0.3898$ where the theoretical planting spacing of 35.277 cm was achieved with the realization of the theoretical density of 80 505 plants ha^{-1}. The planting speed was 6 km h^{-1}. Planting with a *PSK* planter was done at 540 min^{-1} of PTO, i.e. at 4200 min^{-1} of the fan shaft. In this way, with a filled seed plate n=31, a negative pressure of 4.661 kPa was achieved at the holes of the plate. With the MaterMacc *Twin Row–2* planter, when using 540 min^{-1} of PTO, a negative pressure of 4.713 kPa was achieved. Maize was harvested with a six–row combine and weighed on a truck scale (d=500 g) in the field. At a length of 20 m (with four repetitions) at both trial sites, in all cultivation treatments, the number of plants and ears were determined. The weight of the ear was determined using an electronic balance (*Kern* electronic balance: d=10 g). Analysis of 10 average ears from each sowing treatment determined the proportion of grain mass in the ear and moisture content in the grain. Grain moisture was determined immediately after the ears were harvested and manually crowned (portable electronic moisture meter WILE–200, Agroelectronics, Finland). The total grain yield (t ha^{-1}) was determined by converting to a moisture value of 14%. All other agrotechnical procedures (soil tillage, fertilization, plant protection measures) were identical for all years and sites. During the research (Table 1, Graph 1.) of maize cultivation at the Jakšić test site in a three–year period (2020 to 2022) slightly less total average monthly precipitation was recorded in the growing season of maize (IV–X month) of 79.3 mm/m2 compared to the multi–year average (2002–2020) measured at the meteorological station Kutjevo–Vidim. A decrease in precipitation in the investigated period of 31.2 and 30.1 mm/m^2 was recorded during the months of May and June. The average total amount of precipitation for the investigated period in the maize vegetation was 481.6 mm/m2, and for the multi–year average 560.9 mm/m^2. The average means monthly air temperature (°C) at the Jakšić trial site in the maize vegetation (IV–X month) in the investigated period was higher by 0.4 °C (18.0 °C) compared to the multi–year average.

Table 1. Mean air temperature (°C) and total monthly precipitation (mm) for the trial sites Jakšić and Tenja

Tablica 1. Srednja temperatura zraka (°C) i ukupna mjesečna količina oborina (mm) za pokušalište Jakšić i Tenja

Months / *Mjesec*	Monthly Mean Air Temperature (°C) / *Srednja temperatura zraka* (°C)				Monthly Total Precipitation (mm) / *Ukupna mjesečna količina oborina*			
	Site / *Pokušalište* Jakšić		Site / *Pokušalište* Tenja		Site / *Pokušalište* Jakšić		Site / *Pokušalište* Tenja	
	2020.–2022.	2002.–2020.	2020.–2022.	1991.–2020.	2020.–2022.	2002.–2020.	2020.–2022.	1991.–2020.
IV	11.2	12.8	13.0	10.9	54.0	59.4	55.7	47.2
V	16.3	16.4	17.6	19.1	66.4	97.6	70.1	87.2
VI	22.0	20.3	21.6	23.4	63.9	94.0	11.4	78.3
VII	23.6	22.3	23.3	24.4	63.5	76.7	77.5	61.3
VIII	22.7	22.1	22.7	23.8	87.4	71.6	88.3	63.2
IX	17.7	17.2	17.5	17.0	84.2	75.6	22.2	56.5
X	12.8	12.4	12	13.6	62.2	86.0	67.7	61.3
$\bar{x}$ / Σ	18.0	17.6	19.3	18.88	481.6	560.9	392.9	393.7

Data: Croatian meteorological and hydrological service (2023) and maize vegetation over months April–October

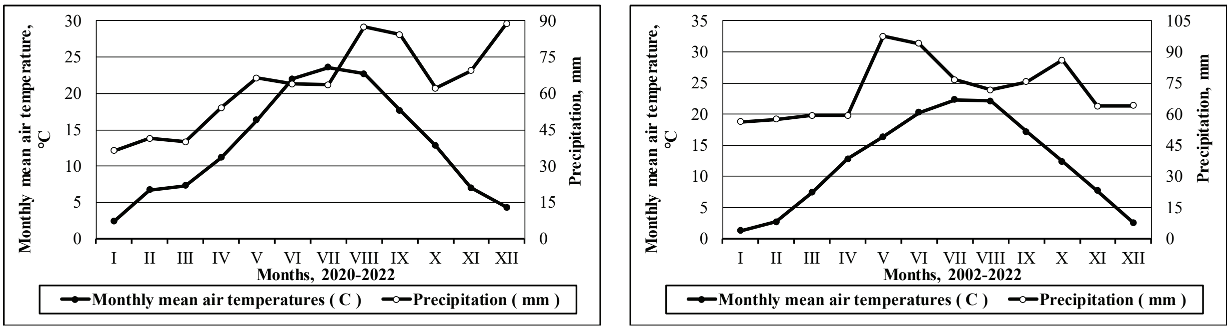

Figure 1. Climate diagram according to Heinrich–Walter for the investigated period (left) and multi–year average (right) for the trial site Jakšić

Grafikon 1. Klimadijagram prema Heinrich –Walteru za istraživano razdoblje (lijevo) i višegodišnji prosjek (desno) za pokušalište Jakšić

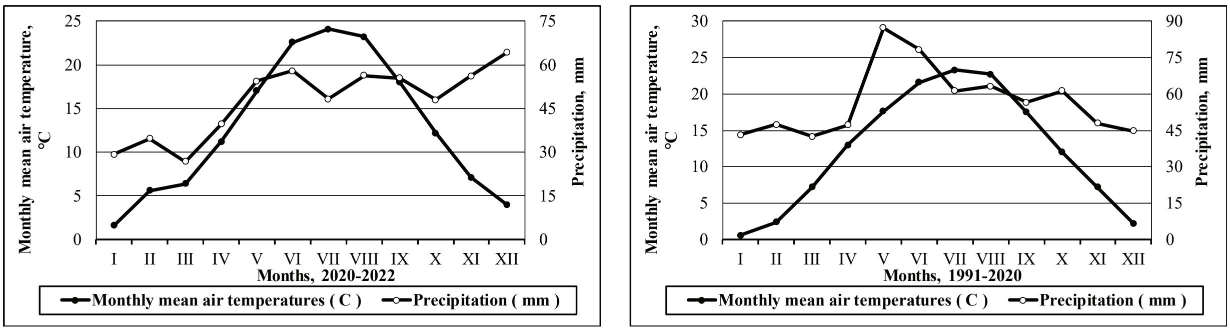

Figure 2. Climate diagram according to Heinrich–Walter for the investigated period (left) and multi–year average (right) for the trial site Tenja

Grafikon 1. Klimadijagram prema Heinrich –Walteru za istraživano razdoblje (lijevo) i višegodišnji prosjek (desno) za pokušalište Tenja

From Figure 2 in the examined period at the Tenja trial site, a constant lack of precipitation can be seen in the period from 4 to 8 months. In the mentioned period, there was a lack of precipitation of 80.4 mm/m2 compared to the multi–year average. The greatest lack of monthly precipitation was recorded in May (–32.7 mm/m^2) and in June (–20.3 mm/m2). Observing the amount of precipitation in the vegetation of maize cultivation in the investigated period, it was not worthy of about 30 mm/m^2. The average mean monthly air temperature (°C) at the Tenja trial site in the maize vegetation (IV–X month) in the investigated period was lower by 1 °C (18.33 °C) compared to the multi–year average. Research was conducted on soils with low humus (Tenja 2.45 and Jakšić 2.59% humus). The soil at the test site Jakšić had 23.66, and the soil at the test site Tenja 11.44 P2O5 mg/100 g of soil and based on this we can classify them as soils with a moderate and good supply of P_2O_5. By analyzing the K_2O content value, the soil at the trial site Jakšić (32.62 mg/100 g of soil) was classified into the group of soils with high supply, and the soil at the trial site Tenja into the group of soils with moderate supply because it contains 18.35 mg/100 g of soil. The soil at the trial sites were alkaline to very acidic (Tenja pH/KCL 7.64 and Jakšić pH/KCL 4.01). The collected results were processed by a statistical tool (SAS Enterprise Guide 7.1). For the ANOVA calculation, CRBD design was taken into consideration, with the year, site, hybrid and planting pattern as independent variables. Means of treatments which were statistically different using ANOVA were compared by the LSD test at $p < 0.05$ probability level.

RESULTS AND DISCUSSION

At the trial site Jakšić (Table 2), the highest average yield of 12.064 t ha^{-1} was recorded in 2020 when the KWS Inteligens hybrid was planted at standard spacing. In the same year, the twin row system achieved an average grain yield of 12.590 t ha^{-1} or 4.18% more compared to standard planting. In 2021, the lowest average grain yield in the experiment was achieved in the standard planting of 11.538 t ha^{-1}. However, in the twin rows of the same year, an average grain yield of 12.326 t ha^{-1} was achieved, i.e. 0,788 t ha^{-1} more grain than standard sowing. The hybrid KWS Kollegas in standard planting had a yield of 11.588 t ha^{-1} in 2020. In the same year, when planting in double rows, an average increase in grain yield of 0.792 t ha^{-1} was recorded.

Table 2. Plant density, grain yield, mass of grain per ear and grain moisture

Tablica 2. Sklop biljaka, prinos zrna, masa zrna po klipu i vlažnost zrna

Year / *Godina*	Hybrid / *Hibrid*	Pattern / *Sjetva*	Plant density / *Sklop biljaka* (plant ha^{-1})	Grain yield* / *Prinos zrna* (t ha^{-1})		Mass of grain per ear / *Masa zrna po klipu* (g)	Grain moisture / *Vlaga zrna* (%)
				$\bar{x}$	σ		
Site / *Pokušalište* Jakšić							
2020	H1	SR	70 823	12.064	0.222	170.37	18.68
		TR	71 284	12.590	0.700	176.65	18.30
	H2	SR	71 178	11.588	0.242	162.88	20.50
		TR	71 497	12.380	0.709	173.12	20.00
2021	H1	SR	68 409	11.538	0.444	168.65	20.00
		TR	68 657	12.326	0.539	179.88	19.45
	H2	SR	72 101	12.073	0.410	167.48	19.88
		TR	72 562	13.055	0.742	179.86	19.75
2022	H1	SR	69,332	11.803	0.294	170.30	20.38
		TR	70 574	12.621	0.464	178.90	18.90
	H2	SR	69 651	11.892	0.228	170.77	19.25
		TR	70 645	13.168	0.556	186.42	19.63
Site / *Pokušalište* Tenja							
2020	H1	SR	72 243	12.664	0.397	175.32	19.25
		TR	73 485	13.105	0.332	178.47	17.63
	H2	SR	72 882	12.442	0.372	170.88	19.38
		TR	72 491	13.557	0.584	187.05	18.50
2021	H1	SR	73 663	13.620	0.194	185.04	18.85
		TR	71 710	13.679	0.527	190.77	18.00
	H2	SR	69 048	12.806	0.181	185.50	17.88
		TR	69 438	13.599	0.324	195.90	18.20
2022	H1	SR	72 420	13.404	0.395	185.13	19.13
		TR	71 568	14.026	0,737	195.99	18.13
	H2	SR	72 101	12.802	0.355	177.29	18.33
		TR	71 923	13.624	0.686	189.38	18.88

*– Grain moisture / *vlaga* 14 %, H1: hybrid / *hibrid KWS Inteligens,* H2: *KWS Kollegas*), site / *pokušalište* J: Jakšić and T: Tenja), planting patterns / *sjetva* (SR: single row and TR: twin row)

The highest average grain yield in standard planting was achieved in 2021 with 12.073 kg ha^{-1}. In the same year, twin row planting recorded a yield of 13.055 or +7.52% more compared to standard planting. At the trial site Tenja (Table 4), slightly higher grain yields ha^{-1} were recorded in all three years of the research. When planting the KWS Inteligens hybrid in the standard method, the lowest average grain yield was achieved in 2020 of 12.664 t ha^{-1}. In the same year, when planting in twin rows, a grain yield of 13.105 t ha^{-1} was achieved, i.e. with a difference of +3.48%. The highest recorded grain yield, in standard planting with the same hybrid, was achieved in 2021 of 13.620 t ha^{-1}. However, that year, when planting in twin rows, the smallest difference in grain yield of only 0.43% was achieved. In the standard planting of the KWS Kollegas hybrid, the lowest grain yield was recorded in 2020 with 12.442 t ha^{-1}. Also, in 2020, the largest average difference in yield of +8.22% or 1.115 t of grain was recorded when planting in twin rows. It is evident that the twin row technology achieved significantly higher grain yields ha^{-1} in both sites. Similar results were achieved by the authors Banaj et al. (2019), in which they recorded an increase in the yield in the twin row technology for the Fao group 380 hybrids between 6.46 and 10.97%. The highest yield was recorded by the twin row technology in hybrid Fao group 450 of +11.74%. In contrast to the presented results, Farnham (2001) reported that hybrids of late maturity were better adapted to planting in twin row technology and achieved higher yields than hybrids of early maturity in narrow rows. Balkcom et al. (2011) determined that sowing in double rows achieved a 16% higher yield with the largest plant density (7.9 – 8.4 plants m^2) and 10% more with a medium plant density (5.9 – 6.4 plants m2) compared to standard planting. Similarly, Widdicombe and Thelen (2002) stated that by reducing row width from 76 cm to 56 cm and 38 cm increased yield by 2 and 4%. Twin row planting hybrids Kapitolis, Konfites and Kashmir which recorded a statistically significantly higher yield of maize grains in all three types of hybrids by 0.943 t ha^{-1} (Banaj et al., 2023). In terms of yield values, the twin row method provided 8.8% higher values in silage maize, 9.5% in maize grain and 8.1% higher in silage sunflower. In the economic analysis evaluations, it was determined that higher profitability was achieved with the twin row planting machine than the unit area (Bolat, 2022). The adequate manipulation of plant arrangements is a very important management strategy for optimizing maize grain yield because it affects the leaf area index, the leaf insertion angle, and the crop efficiency for intercepting solar radiation at different canopy layers (Argenta, 2021).

Table 3. Three – factor (3 × 2 × 2) analysis of variance for sites for the yield trait

Tablica 3. Trofaktorijalna (3 × 2 × 2) analiza varijance za svojstvo prinosa

	Site / *Pokušalište* Jakšić		Site / *Pokušalište* Tenja	
ANOVA Source of variation *Izvor variranja*	Grain yield / *Prinos zrna*			
	F	*p*	F	*p*
Year / *Godina* (A)	0.539	0.588	6.300	0.005
Hybrid / *Hibrid* (B)	1.561	0.220	4.808	0.035
Sjetva / *Pattern* (C)	33.039	< .001	23.478	< .001
A × B	3.740	0.033	2.355	0.109
B × C	0.833	0.368	4.040	0.052

Observing the results of variance analysis (Table 3) at the trial site Jakšić, a high significance level ($p < 0.01$) can be observed for the factor of planting method “C” on the investigated yield trait (Site Jakšić p=<.001**). A statistically significant difference is also visible in the interaction A × B, where it was achieved (p=0.033*). Statistically significant differences in the yield of maize grains were not confirmed in the years of cultivation of the hybrid “A” and other hybrids, as well as in their interaction (A × B). Also, with the interaction of all three traits of the test, no statistical differences in the yield were observed. At the trial site Tenja, the results of an analysis of variance indicate that there was a statistically significant difference ($p < 0.05$) for the investigated factors of year (A) (p=0.005), (B) hybrid (p=0.035), sowing method (C), and interactions (hybrid × planting pattern) (p=0.052). No statistically significant differences in grain yield were found for the other interactions of the tested traits.

Table 4. Group Variance analysis for the traits “grain yield” and “plant density”

Tablica 4. Grupna analiza varijance za svojstva prinosa zrna i sklopa biljaka

ANOVA Source of variation / Izvor variranja	Grain yield / *Prinos zrna*		Plant density / *Sklop biljaka*	
	F	p	F	p
Site / Pokušalište (A)	107.426	< .001	5.117	0.027
Year / *Godina* (B)	4.754	0.011	1.728	0.185
Hybrid / *Hibrid* (C)	0.286	0.595	0.026	0.873
Pattern / Sjetva (D)	56.464	< .001	0.063	0.803
A × C	5.732	0.019	5.072	0.027
C × D	4.086	0.047	0.020	0.889
A × B × C	5.779	0.005	3.753	0.028

Observing the results of the group variance analysis (Table 4) of the yield trait, a significant level ($p < 0.05$) can be observed for the factor site A ($p=<.001$), year B ($p=0.011$), and the factor D planting pattern ($p=<.001$). Significant statistical differences were also recorded in the interaction A × C ($p=0.019$), C × D ($p=0.047$), and in the interaction A × B × C. Analyzing the tested factors for the property plant density with planting pattern, the absence of statistical significance is observed, which was to be expected, because both sowing machines were adjusted to the acceptable exploitation factors before sowing (i.e., to the selection of the seed plate, position of the seed eliminator, working speed, etc.). Statistically significant differences in the trait of plant density ha^{-1} were recorded for the trait A ($p=0.027$) and for the interactions site × hybrid (A × C, $p=0.027$) and site × year × hybrid (A × B × C, $p=0.028$), respectively.

Table 5. *$LSD_{0.05}$* test of the achieved differences between the traits with regard to a research location.

Tablica 5. $LSD_{0.05}$ test ostvarenih razlika između lokacija istraživanja

Trait / *Svojstvo*	Site / *Pokušalište* Jakšić			Site / *Pokušalište* Tenja		
	TR	SR	$LSD_{0.05}$	TR	SR	$LSD_{0.05}$
Grain yield / *Prinos zrna* (t ha^{-1})	12.671^A	11.826^B	301.79	13.591^A	12.952^B	314.04
Plant density / *Sklop biljaka* (plants ha^{-1})	70 869.8^A	70 248.6^A	1667.3	71 733.7^A	72 059.1^A	1673.3
Grain mass per ear / *Masa zrna* (g)	178.867^A	168.407^B	2.9977	189.587^A	179.860^B	3.9018
Grain moisture / *Vlaga zrna* (%)	19.4000^B	19.8833^A	0.6015	18.2708^B	18.8292^A	0.5345

From Table 5, it can be seen that planting in the twin rows at both trial sites resulted in a statistically significant difference in yield (Jakšić $LSD_{0.05} = 301.79$ and Tenja $LSD_{0.05} = 314.04$) when compared to a standard planting. With both sowing systems, no statistically significant difference was detected in the realization of the plant density, as was expected.

According to the $LSD_{0.05}$ test results from Table 6, it can be seen that planting in the twin rows at both trial sites obtained statistically significant results in all the investigated years of research. Statistically significant differences were also observed for the trait of grain mass per ear, as well as for a grain moisture content. A slightly lower value of grain moisture in all three years of research was recorded in standard planting ($LSD_{0.05} = 0.4515$). Likewise, the differences in the realized plant density at trial sites at the time of the research were not statistically significant ($LSD_{0.05} = 1188.6$).

Table 6. *$LSD_{0.05}$* test for the main research traits—total ($\alpha=0.05$).

Tablica 6. $LSD_{0,05}$ test za glavna svojstva istraživanja–ukupno ($\alpha=0,05$).

Trait / Svojstvo	Pattern / *Sjetva* TR ($\bar{x}$)	Pattern / Sjetva SR ($\bar{x}$)	$LSD_{0.05}$
Grain yield / *Prinos zrna* (t ha^{-1})	13.131^A	12.389^B	299.18
Plant density / *Sklop biljaka* (plants ha^{-1})	71 301.8^A	71 153.8^A	1188.6
Grain mass per ear / *Masa zrna po klipu* (g)	184.227^A	174.133^B	3.3052
Grain moisture / *Vlaga zrna* (%)	18.8354^B	19.3563^A	0.4519

CONCLUSIONS

Based on the results of this research, conducted at two sites in Croatia (Jakšić and Tenja) during the 2020–22 period, it can be stated that the twin-row planting pattern, achieved by a twin-row planter (MaterMacc Twin Row–2), resulted in the statistically higher maize grain yields. The highest achieved yield in the experiment was recorded in 2020 at 12.064 t ha^{-1} at the trial site Jakšić, in the standard planting procedure involving the KWS Inteligens hybrid. In the same year, the average yield was 12.590 t ha^{-1}, or 4.18% more, in the twin rows, when compared to a standard planting. By sowing the KWS Kollegas hybrid, the highest average grain yield in a standard planting was achieved in 2021, with 12.073 t ha^{-1}. In the same year, the largest difference in the experiment, amounting to 7.52% if compared to a standard planting, was recorded in the twin-row planting. At the trial site Tenja, when the KWS Inteligens hybrid was planted in the standard way, the lowest average grain yield was recorded in 2020, amounting to 12.664 t ha^{-1}. In the twin rows, a grain yield of 13.105 t ha^{-1} was recorded with a difference of 3.36% if compared to a standard planting. By planting the KWS Kollegas hybrid, the lowest grain yield was recorded in 2020, with 12.442 t ha^{-1}. When planting in the twin rows, the recorded grain yields that year amounted to 13.557 t ha^{-1}, with a difference between the planting methods amounting to +8.23%. The $LSD_{0.05}$ tests with regard to the main research characteristics for both trial sites and both hybrids indicate that planting in the twin rows at both trial sites obtained statistically significant results in all three research years. Statistically significant differences were observed for the trait of grain weight per ear, as well as for the grain moisture content. In the research years, a slightly lower value of moisture in the harvested grain was recorded in standard planting. The differences in the realized plant density at the trial sites during the three–year research was not statistically significant.

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UTJECAJ TEHNOLOGIJE SJETVE NA PRINOS KUKURUZA

SAŽETAK

Trogodišnja istraživanja utjecaja načina sjetve na prinos zrna kukuruza (t ha^{-1}) provedena su na pokušalištima Jakšić i Tenja. Hibridi KWS Inteligens i KWS Kollegas, koji su korišteni u istraživanja , posijani su u redove s razmakom od 70 cm te u udvojene redove s razmakom od 48 × 22 cm. Najviši prosječan prinos zrna, od 12 064 kg/ha, utvrđen je 2020. godine na pokušalištu Jakšić u standardnoj sjetvi hibrida KWS Inteligens, a u sustavu udvojenih redova zabilježeno je povećanje prinosa od + 4,17%. Kod hibrida KWS Kollegas najveća je razlika u prinosu zrna, od + 7,52 %, ostvarena 2021. godine između standardne sjetve i sjetve u udvojene redove . Na pokušalištu Tenja zabilježeni su u sve tri godine istraživanja nešto veći prosječni prinosi zrna ha^{-1}. Najveća razlika u prinosima, od + 8,22% ili 1115 kg zrna, zabilježena je 2020. godine kod hibrida KWS Kollegas pri sjetvi u udvojene redove. LSD$_{0,05}$ test istraživanja „skupno" ukazuje da je sjetva u udvojene redove na oba pokušališta polučila statistički značajne rezultate u sve tri godine istraživanja s obzirom na prinos zrna ha^{-1} te masu zrna po klipu, kao i sadržaj vlage u zrnu.

Ključne riječi: kukuruz, sjetva u udvojene redove, sijaćica, prinos, hibrid

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