Original scientific paper

Influence of tillage methods on some agricultural properties of maize *(Zea mays L.)* and soybean *(Glicine max L.)* crops

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Abstract
The research was conducted on stagnic luvisol of loamy texture (N: 46º 01´ 12˝; E: 16º 34´ 28˝) on the testing ground of Križevci College of Agriculture. Research objectives were related to determining the influence of different tillage methods on the height of maize and soybean plants, number of soybean pods, average number of seeds in the pod, ear yield and maize grain yield. More intensive tillage variants hade a more favourable influence on the height of maize plants, ear yield and grain yield, i.e. the application of autumn basic soil tillage achieved better results for almost all researched agricultural properties. In the process of soybean cultivation, the most intensive tillage method indicated the biggest plant height and the biggest number of pods per plant, as well as the highest number of seeds within a pod (variant E). It was established that more intensive tillage had more favourable influence on the researched agricultural properties of maize and soybean in comparison to reduced tillage methods.

Key words: intensive and reduced soil tillage, agricultural properties, corn, soybean

Introduction

According to the cultivated agricultural land, maize *(Zea mays L.)* is one of the most frequent cereal crops in Croatia, and soybean (*Glycine max L.*) has been increasingly cultivated due to its high nutrition value, as well as its favourable influence on crop rotation. Applied tillage methods have significant influence on the allocation of nutrients within various soil levels (Gal et al., 2007), on development of root system, (Quin et al., 2006) and soil properties (Da Silva et al., 2004; Birkas et al., 2004; Rodrigues et al., 2009; Špoljar et al., 2009), as well as on the yield of maize grains and soybean seeds (Jug et al., 2010; Kisić et al., 2002; Kisić et al., 2010). The height of maize and soybean plants can be regarded as morphological indicator of grain yield, and if maize is grown for maize silage, it is desirable that the plant is as high as possible. Influence of soil tillage on the height of maize plants was researched by Najafinezhad et al., (2007). The authors established significantly bigger height of maize plants in the variants of conventional and reduced soil tillage in comparison to minimal tillage. After several years of research, Boomsma et al., (2010) established by means of regression analysis a considerable influence of corn height and climate conditions on grain yield. Lasisi and Aluko (2009) obtained bigger height of soybean plants, leaf surface and number of pods per plant in the variants of conventional soil tillage in comparison to reduced soil tillage. Rodrigeus et al., (2009) also established significant influence of various tillage methods on the height of soybean plant. It is therefore evident that soil tillage to a great extent

influences the agricultural properties of corn and soybean. With reference to the above mentioned, the influence of various tillage methods on height of corn and soybean plants, number of soybean pods, average number of seeds per pod and grain yield in the ear of corn were researched at testing grounds of Križevci College of Agriculture in the period from 2006 to 2009.

Material and methods

The research was conducted on stagnic luvisol of loamy texture (N: 46º 01´ 12˝; E: 16º 34 ´28˝) in Križevci, and research variants with five different tillage methods in four replications are shown in Table 1.

Table 1. Variants of tillage methods

	Autumn	Spring
A	-	Primary tillage at 30-35 cm depth, additional tillage by multi-tiller (one tillage pass), four-row seeder was used for planting maize and wheat sowing machine for soybean, herbicides according to the type of weed.
B	-	Primary tillage, sowing and herbicides as in variant A, additional tillage by rotary harrow (one tillage pass).
C -	Primary tillage at 30-35 cm depth	Additional tillage by spike and rotary harrow, sowing and herbicides, as in variant A.
D -	Primary tillage at 30-35 cm depth	Additional tillage by spike harrow and multi-tiller, sowing and herbicides, as in variant A.
E -	Primary tillage at 30-35 cm depth	Additional tillage by spike harrow, disc harrow and multi-tiller, sowing and herbicides, as in variant A. (intensive tillage)

The surface area of each variant was 1.162 m^2 (83 m x 14 m). Soybean cultivar Višnja (maturity group 00) was grown in 2007 and 2009, and maize hybrid Pioneer PR 38 A 24, FAO group 380 was grown in 2008. In maturity stage 120 randomly selected soybean plants were picked in each variant, followed by measuring of plant height, establishing the number of pods per plant and the number of seeds per pod. Height of maize plants was measured in the field and measuring was conducted from the soil surface to the maize tassel. 120 randomly selected maize plants were measured according to the respective tillage method. Ears from the surface area of 10 m^2 were picked and hand shelled, whereby grains and cob were weighed. Moisture content in grain and cob was established and results were calculated in relation to 14% humidity. Percentage share of grains in the ear according to the variants of soil tillage was also calculated. Data was statistically processed by means of variance analysis based on the simple model. Mean values were tested by means of LSD test for multiple comparisons using the programme package Statistica 7.1.

Results and discussion

The total amount monthly precipitation and average monthly air temperatures during vegetation period for weather station Križevci are shown in Table 2. Results of the established height of maize plants, ear yield per hectare and percentage share of grain in the ear are

shown in Table 3. Table 4 shows height of soybean plant in 2007 and 2009, number of pods per plant and number of seeds within a pod.

Mean air temperature for the vegetation period in all three years of research was higher, with less precipitation compared to the multi-annual average, Table 2. Mean monthly air temperature during vegetation period was also higher in comparison with the multi-annual average, except in September, 2007.

Table 2. Mean monthly air temperatures and monthly quantity of precipitation for respective years of research and multi-annual average for the period from 1927 to 2006 for Križevci

	Average montly temperature, ^{0}C				Total monthly of precipitation, mm			
	2007	2008	2009	1927-2006	2007	2008	2009	1927-2006
April	13.0	11.6	14.0	10.3	8.0	30.8	27.4	60.3
May	17.5	17.0	17.4	15.0	81.2	27.3	62.4	76.9
June	21.5	20.4	18.8	18.5	77.7	154.0	52.1	90.8
July	21.6	21.0	21.6	20.1	67.7	66.8	60.6	80.9
August	20.5	20.6	21.3	19.3	56.3	51.9	93.2	74.7
September	13.7	14.5	17.8	15.3	148.0	69.0	39.3	73.7
IV - IX	18.0	17.5	18.5	16.4	438.9	399.8	335.0	457.3

Vegetation period from 2007 to 2009 indicates great fluctuation of monthly precipitation quantity ranging from 8.0 to 154.0 mm. It can therefore be concluded that the research was conducted during the unfavourable drought climate conditions. Lack of water and somewhat higher air temperatures, as stated by Kvaternjak et al., (2008), significantly influenced the researched tillage methods and achieved grain yields of cultivated crops.

Table 3. Influence of soil tillage on the height of maize plants, ear yield and grain yield

Soil tillage variant	Height of maize plant, cm	Ear yield t/ha	Share of grain, %
A	273.6^{c}	12.42^{b}	83.4
B	276.7^{bc}	16.54^{a}	83.8
C	287.6^{a}	15.93^{a}	84.9
D	275.4^{c}	15.51^{a}	84.8
E	280.2^{ab}	15.96^{a}	85.0
F test	*	*	ns

*values in columns marked with different letters indicate significant fluctuations ($p<0.05$)

Significant influence of the applied tillage methods on the height of maize plants was established, Table 3. It can be concluded that maize plants achieved greater heights in the variants of intensive soil tillage in the combination with primary soil tillage in autumn. The greatest height of maize plants was established in the variant of autumn primary tillage and additional tillage with spike and rotary harrow (variant C), and the lowest height was established in the variant of spring primary tillage and additional tillage with multi-tiller (variant A). Statistical analysis indicates greater height of corn plants in C variant of soil tillage compared to other applied tillage methods, except for the E variant, where the soil tillage was most intensive ($p<0.05$). Statistical data indicates smaller ear yield per hectare in variant A compared to other researched soil tillage methods ($p<0.05$). The highest share of grain in the ear was established in variant E, and the smallest in variant A. However, statistically justified differences regarding the grain yield according to the variants of soil

tillage were not established ($p>0.05$). Yusuf and Saleem (2001) established positive correlation ratios between the number of grains on the ear of corn and plant height.

Based on the above stated it can be concluded that autumn primary soil tillage achieved better results for almost all researched agricultural properties, i.e. more intensive tillage variants had more favourable influence on the height of maize plants, ear yield and grain yield. Favourable influence of conventional soil tillage in comparison with reduced tillage regarding the height of maize plants was established by other authors as well (Najafinezhad et al., 2007; Lasisi and Aluko, 2009). Within research regarding influence of tillage on soil, Špoljar at al., (2010) established favourable influence of reduced tillage on most physical properties of soil. However, the authors established higher yield of maize grains with intensive soil tillage. Other authors also achieved higher grain yields in intensive cultivation system in comparison with the extensive one (Jug et al., 2006; Varga et al., 2004).

Table 4. Influence of soil tillage on height of soybean plant, number of pods per plant and number of seeds within the pod

Soil tillage method	Plant height, cm	Number of pods per plant	Average number of seeds in the pod
	2007		
A	76.11^{c}	18.67^{c}	2.0
B	91.18^{a}	27.91^{ab}	2.0
C	87.67^{c}	26.73^{b}	2.1
D	83.92^{d}	20.38^{c}	2.1
E	94.05^{a}	30.79^{ab}	2.2
F test	**	**	ns
	2009		
A	79.34^{d}	26.48^{d}	1.88^{bc}
B	88.08^{b}	29.01^{cd}	1.95^{b}
C	83.00^{c}	30.89^{bc}	1.82^{c}
D	82.31^{cd}	31.90^{b}	1.95^{b}
E	98.08^{a}	35.50^{a}	2.30^{a}
F test	**	**	*

* values in columns marked with different letters indicate significant fluctuations (**$p<0.01$, *$p<0.05$)

During soybean cultivation in 2007 and 2009 the most intensive soil tillage indicated the biggest height of soybean plants and number of pods per plant and the highest average number of seeds per pod (variant E). In 2007 statistically justified bigger height of plants was established in variant E in comparison with the other applied soil tillage methods, except for variant B ($p<0.01$). Similar results were achieved in 2009, with justifiably higher values of height of soybean plants for variant E compared to other researched soil tillage methods ($p<0.01$). Justifiably larger number of pods per plant was observed in 2007 in variant E when compared to variants A and D, and in 2009 when compared to all other applied tillage methods ($p<0.01$). Furthermore, the application of primary tillage in autumn followed by additional tillage with by spike harrow, disc harrow and multi-tiller resulted in the highest average number of seeds within the (variant E). Statistically justified bigger number of seeds in the pod was observed in variant E when compared to the other soil tillage methods ($p<0.05$). Bigger height of soybean plants and bigger number of pods per plant in the variants of conventional soil tillage compared to the reduced tillage was also observed by Lasisi and Aluko (2009). Higher soybean grain yields with regard to the application of intensive tillage

in relation to reduced tillage were observed by other authors (Jug et al., 2010; Špoljar et al., 2009).

Bigger height of maize and soybean plants, grain yield, number of pods, as well as the average number of seeds in the pod was observed with more intensive soil tillage methods, whereas maize ear yields were also higher with more intensive soil tillage methods. The above mentioned indicates visible and mostly favourable influence of more intensive soil tillage on the researched agricultural properties of maize and soybean.

Conclusion

Based on the above stated, it can be concluded:

- More intensive tillage variants had to a large extent more favourable influence on height of maize plants, ear yield and maize grain yield, i.e. application of autumn primary soil tillage achieved better results in almost all researched agricultural properties.
- The biggest height of soybean plants and the biggest number of pods per plant was observed with the most intensive soil tillage method (variant E).
- The research established mostly favourable influence of more intensive soil tillage on researched agricultural properties of corn and soybean.

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