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The Importance of Harvest Residues in Corn Production

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ABSTRACT

Harvest residues of field crops are important for matter cycling in the agroecosystem, especially when organic fertilizers are not applied in adequate amounts. The aim of this study was to assess the influence of increasing nitrogen doses and harvest residues (HR) on corn yield. The international stationary field trial (ISDV) has been established on a calcareous chernozem soil, at Rimski Šančevi, on Institute of Field and Vegetable Crops, Novi Sad. This paper review two-year average yields on corn hybrid NS 3022. The trial had six treatments, three with HR (0, 100, 200 kg N ha^{-1}) and three without HR (0, 100, 200 kg N ha^{-1}). The experiment was set up in three-crop rotation (corn, soybean, wheat). The average yield with and without HR treatments was 7.22 t ha^{-1}. The average yield obtained on treatments with HR was 7.64 t ha^{-1}, which was higher by 0.85 t ha^{-1} (12.52%) than the average yield on treatments without HR (6.79 t ha^{-1}). The highest yield on treatments with HR was achieved with 100 kg N ha^{-1}a (8.44 t ha^{-1}) while the highest yield on treatments without HR was obtained with 200 kg N ha^{-1} (8.56 t ha^{-1}). On average, HR increased the yield of corn grain in the control treatment by 1.18 t ha^{-1}. To achieve good yields of corn grain, optimal nitrogen doses on treatments with HR should range from 100 kg N ha^{-1} to 200 kg N ha^{-1}, while on treatments without HR optimal doses of nitrogen should be closer to 200 kg N ha^{-1}.

Keywords: corn, nitrogen, yield, crop residues.

INTRODUCTION

Along with rice and wheat, corn insures about 30% of total calories for more than 4.5 billion people in 94 countries. Corn has high genetic potential for production, high plasticity in selection and creation of hybrids for different purposes and conditions (Latković et al., 2014). In developed countries corn is mostly used indirectly in food, while in undeveloped countries corn is directly used for people nutrition. Increase in world population in 2050 is estimated to be near 10 billion people, which will be followed with an increased need for corn, so its production will be doubled, especially in developing countries (Rosegrant et al., 2008). In 2012-2016, corn production was on the first place in the world, with more than one billion tons (www.fao.org). Corn needs intensive growing conditions that have a prolonged effect on the subsequent culture in crop rotation. Future

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perspectives for corn production should go in two different ways: increase in area and intensification of production (Marinković et al., 2012). Because of high yearly yield oscillations, attention should be paid to the corn selection and breeding, that will create genetically superior hybrids, tolerant to stress and heat (Marinković et al., 2008, 2011).

In Serbia, a significant reduction of soil organic matter that affected decreased animal production and manure use (Novković et al., 2010) is observed. Compared to 1971, from 1993 in Vojvodina, average decrease in humus content was 0.38% (Hadžić et al., 2004), where in arable land of the Central Serbia humus content was 1-3 %, while in Vojvodina 3-5 % (Agency for environment protection, 2015). Use of organic fertilizer allowed improving the soil nutrition potential, water, air, heat regimes and a microbiological activity (Čuvardić, 1993). Malinović and Meši (2008) concluded that adding organic fertilizers enables easier and more efficient tillage with a reduction in fuel consumption. If there is no possibility for manure use, the plowing over the harvest residues is a good alternative that leads to the improved soil properties and high yields. The effect of plowing over harvest residues on the yield and quality of corn and grains was investigated worldwide and the country (Lemon-Ortega et al., 2000; Pracházková et al., 2002; Jaćimović et al., 2009; Latković et al., 2015; Jaćimović et al., 2016).

Considering the very important physiological role of nitrogen in plants and the fact that nitrogen is "yield and quality carrier", addition of this element as fertilizer in corn production requires special attention (Latković et al., 2011). The deficit of nitrogen in corn is manifested by the smaller leaves, green-yellow color of the whole plant and lower plants since the created organic matter is spent on the root growth. On the other hand, the optimal amount of nitrogen enables better heat stress tolerance and better water use efficiency, especially in the semiarid climate (Cossani et al., 2012). Too much amount of nitrogen can cause oversized leaves, irrational transpiration, longer stem and a greater possibility of lodging, decreased resistance to diseases and pests, and more pronounced yield reduction.

The aim of this study was to assess the influence of increasing nitrogen doses and harvest residues (HR) on corn yield in 2016/17 and 2017/18.

MATERIAL AND METHODS

Weather conditions in 2016/2017 and 2017/2018

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Corn yield in our country is subjected to fluctuation from year to year and is greatly depend on the weather conditions, especially on precipitation (Marinković et al., 2012). Corn has the greatest needs for water and nutrients before silking and through grain filling period.

Figure 1 shows that autumn 2016 had a high amount of precipitation with temperatures similar to the long-term average, which led to the increase in the soil moisture. December and January were much colder and dryer than the long-term average. Temperatures begin to increase from February and continued to increase by the middle of April. Average daily temperatures from March to July were higher than the long-term average, but the monthly sum of temperatures in March and the first half of April were within the long-term average. The higher amount of precipitations was in the middle of April, the third decade of May and at beginning of June. Higher temperatures and much lower amount of precipitations than long-term average started from June and continued over a critical period, which had a negative influence on corn yield and quality.

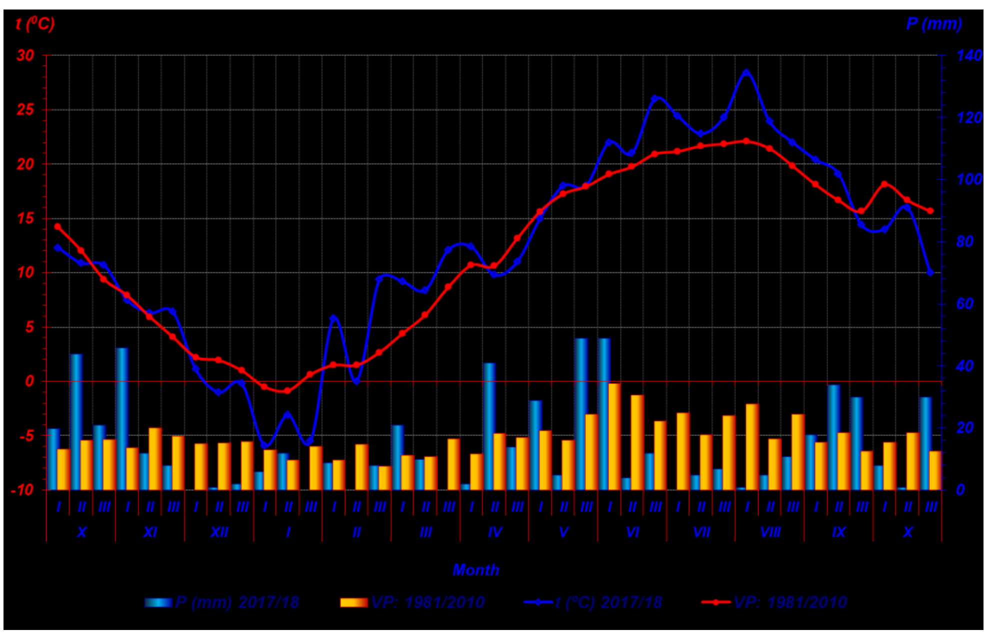

Figure 1. Weather conditions in year 2016/2017

In the first and second decade of October 2017 significantly fewer precipitations than the long-term average was observed, with higher amount of precipitation at the end of October. The first decade of the next month was also dry, followed by two decades with an optimum precipitation. Vice versa, in December the first decade had more precipitation than average, but

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the other two decades were dryer. In the first two months of winter, the temperatures were slightly higher than average. But the temperature significantly increased by the end of the first decade of December and lasts until the middle of February that was characterized with higher amounts of precipitation than the long-term average. Sudden drop of temperature below 0^{o}C was recorded at the end of February and continued to the beginning of next month. Figure 2 shows that the temperatures were much higher than the average from the beginning of April until the end of June. This period was characterized by high amounts of rainfall at the beginning of April, mid May and end of June. Higher amounts of rain than average continued in the first decade of July, together with lower temperatures than average. In a moisture critical period, corn had a higher amount of precipitations only at the end of July and end of the next month. The critical period for corn was distinguished by higher temperatures than average and shortage of water in some periods.

The effects of harvest residues with different amounts of nitrogen fertilization on corn yield was done on a stationary field trial established in 1971 at the Institute of Field and Vegetable Crops, at Rimski Šančevi, Novi Sad, Serbia.

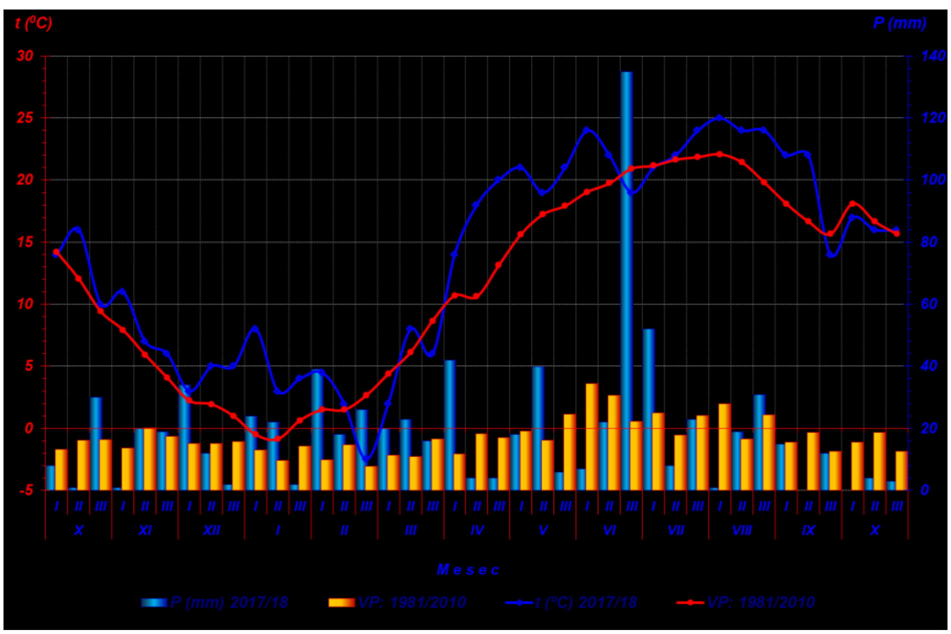

Figure 2 Weather conditions for year 2017/2018

The trial was established on the calcareous chernozem soil in three- crop rotation system: corn, soybean, and wheat. This paper reviews two-year average yield on the corn hybrid NS

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3022. There were four rows of corn with space rows of 75 cm and space between the plants in the row of 25 cm. The row length in each plot was 7 m. The precedeing crop was wheat. All agrotechnical operations were completed in an optimal time for Vojvodina conditions. The trial had six treatments, three with HR (0, 100, 200 kg N ha^{-1}) and three without HR (0, 100, 200 kg N ha^{-1}). Nitrogen fertilizer was applied two times: one half before the main tillage and one half before planting. All treatments received equal amounts of phosphorus and potassium, 80 kg for P_2O_5 and K_2O, applied before the main tillage. The data of corn yield (adjusted to 14% moisture) were statistically processed by the analysis of variance for a one way ANOVA (in Randomized blocks) (the statistical software STATISTICA 13.5, TIBCO Software Inc. USA). Testing of the significant of differences between treatments was performed by the Duncan's Multiple Range Test (significance level 5%). Effect of increasing doses of N on corn yield was processed with regression analysis (OriginPro 8. OriginLab Corporation, Northampton, MA 01060, USA).

RESULTS AND DISCUSSION

Corn yield

The treatments had a highly significant effect on corn yield (F probability <0.003**) (Table 1).

Table 1. Analysis of variance for NS 3022 corn hybrid

Source of variation	d.f	s.s	m.s	v.r	F pr.
Repetitions	3	2.490	0.830	0.210	-
Treatments	5	87.983	17.597	4.44	0.003**
Residual	39	154.495	3.961	-	-
Total	47	244.967	-	-	-

Average yield of corn for the whole experiment was 7.22 t ha^{-1} (Table 2). Average yield obtained on the treatments with HR was 7.64 t ha^{-1}, which was higher by 0.85 t ha^{-1} (12.5%) than the average yield on treatments without HR (6.79 t ha^{-1}).

The highest yield (8.56 t ha^{-1}) was achieved with 200 kg N ha^{-1} on treatment without HR that was significantly higher than the control with HR by 2.42 t ha^{-1} (39%) and without HR by 3.60 t ha^{-1} (73%) (Table 3). The second highest yield was achieved on the treatment with 100 kg N ha^{-1} and with HR (8.44 t ha^{-1}) that was significantly higher than the control with HR by 2.3 t ha^{-1} (37%) and control without HR by 3.48 t ha^{-1} (70%). The same trend was observed for the treatment with HR but with 200 kg N ha^{-1} (8.35 t ha^{-1}). The lowest yield was achieved on the control treatment without HR (4.96 t ha^{-1}). This treatment didn't have a statistically lower yield than the control with HR (6.14 t ha^{-1}). Also, there were no statistical differences between the treatments number 2, 3, 5 and 6.

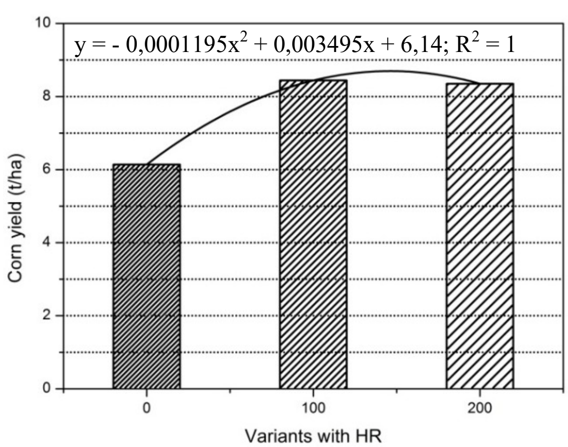
Table 2. The corn yield (t ha^{-1}) at different rates of nitrogen on treatments with HR and without HR

Treatments	Number	Amount (kg N ha^{-1})	Corn yield (t ha^{-1})
	1	0	6.14
With HR	2	100	8.44
	3	200	8.35
	average		7.64
	4	0	4.96
Without HR	5	100	6.84
	6	200	8.56
	average		6.79
	average (1-6)		7.22

Table 3. Duncan's Multiple Range Test (significance level 5%) for corn yield (t/ha)*

Treatments	Corn yield with 14% water (t ha^{-1}) - Mean	1	2
1	6.14		****[b]
2	8.44	****[a]	
3	8.35	****[a]	
4	4.96		****[b]
5	6.84	****[a]	****[b]
6	8.56	****[a]	

* Letters in the table show the statistical difference between treatments. Treatments with letter (a) have statistically higher yields than treatments with letter (b). There are no statistical differences among treatments with letter (a) or treatments with letter (b). If treatment has both (a) and (b) letter than it has no statistical difference from any other treatment.



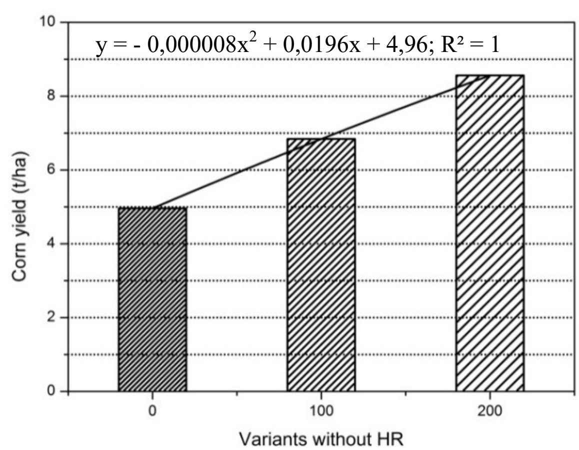


Figure 3. 3a (left) and 3b (right): Effects of different doses of N on corn yield with HR and without HR

Figures 3a and 3b show the effect of increasing amount of N on corn yield, explained by the nonlinear regression curve. The maximum yield of around 8.70 t ha^{-1} was achieved with

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approximately 146 kg N ha^{-1} (Fig 3a). There was no statistical difference between the yield obtained with 100 kg N ha^{-1} and with 200 kg N ha^{-1}. Since both of them have statistically higher yields than the control treatment, conclusion is that the optimal amounts of N on HR treatments should go from 100 kg N ha^{-1} to 200 kg N ha^{-1}, but closer to 100 kg N ha^{-1}. Figure 3b shows that the amounts of N on the treatments without HR should be closer to 200 kg N ha^{-1}.

Table 4 represents the effect of HR between the control and the treatments with 100 kg N ha^{-1} and 200 kg N ha^{-1}. A positive effect of long-term HR incorporation was between the control treatments, where the difference of 1.18 t ha^{-1} (24%) was in favor of the HR treatment. The same trend was observed for the treatments with 100 kg N ha^{-1}. A positive effect on the yield increase by 1.60 t ha^{-1} (23%) was observed. On the treatments fertilized with 200 kg N was observed the difference between yield was negative, where higher yield was achieved on the treatment without HR with difference between two treatments of 0.21 t was observed (only 2%; not significant). This could be explained with poor mineralization of soil organic matter at the HR treatments in 2016/17 because of the very low amount of precipitation in combination with high temperatures (Figure 1). Plowing of HR during high temperatures in combination with low precipitation didn't show full benefit on yield in those years, since there was no chance for their SOM mineralization. In average, the yield difference between the HR treatments and treatments without HR was positive and resulted in 0.85 t ha^{-1} (12.5% increases).

Table 4. Effect of HR on corn yield (t ha^{-1})

Amount (kg N ha^{-1})	Treatments	Corn yield (t ha^{-1})
	With HR	6.14
0 kg N ha^{-1}	Without HR	4.96
	Difference:	1.18
	With HR	8.44
100 kg N ha^{-1}	Without HR	6.84
	Difference:	1.60
	With HR	8.35
200 kg N ha^{-1}	Without HR	8.56
	Difference:	-0.21
	With HR	7.64
Average	Without HR	6.79
	Difference:	0.85

CONCLUSION

Based on the results of a two year trial, the effect of increasing doses of nitrogen on the yield of corn grains on the treatments with and without HR, the following conclusions could be drawn:

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- The grain yield obtained on the HR treatments was 7.64 t ha^{-1} and was 0.85 t ha^{-1} (or 12.5%) higher than in the treatment without HR (6.79 t ha^{-1}) (average for all treatments of nitrogen fertilization).
- The highest yield for the tested hybrid (8.56 t ha^{-1}) was obtained at fertilization with 200 kg N ha^{-1} without HR.
- In the HR treatment, the highest grain yield (8.44 t ha^{-1}) was achieved with 100 kg N ha^{-1}.
- To achieve good corn yields, the optimal nitrogen doses on the HR treatments should be between 100 kg N ha^{-1} and 200 kg N ha^{-1}, while on the treatments without HR the doses should be closer to 200 kg N ha^{-1}.
- Positive effect of long-term plowing over the harvest residues on the corn grain yields varied depending on the amount of nitrogen used and reached 1600 kg of grain ha^{-1}.

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Značaj žetvenih ostataka u proizvodnji kukuruza

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IZVOD: Žetveni ostatci u ratarstvu su važni u kruženju materije u agroekosistemu, posebno kada se organska đubriva ne primenjuju u adekvatnim količinama. Cilj ove studije je bio da se proceni uticaj povećanja doze azota i žetvenih ostataka (HR) na prinos kukuruza. Stacionarno terensko ispitivanje (ISDV) je postavljeno na krečnjačkom černozemu, Rimski Šančevi, Instituta za ratarstvo i povrtarstvo, Novi Sad. Ovaj rad prikazuje dvogodišnje prosečne prinose hibrida kukuruza NS3022. Ogled se sastoji od šest tretmana, tri sa HR (0, 100, 200 kg N ha^{-1}) i tri bez HR (0, 100, 200 kg N ha^{-1}). Ogled je postavljen sa tri kulture u rotaciji (kukuruz, soja, pšenica). Prosečan prinos na tretmanima sa i bez HR bio je 7.22 t ha^{-1}. Dobijeni prosečni prinos na tretmanima sa HR bio je 7.64 t ha^{-1}, što je za 0.85 t ha^{-1} (12.52%) veće od prosečnog prinosa na tretmanima bez HR (6.79 t ha^{-1}). Najveći prinos na tretmanima sa HR je postignut sa 100 kg N ha^{-1}a (8.44 t ha^{-1}) dok je najveći ostvareni prinos na tretmanima bez HR bio sa 200 kg N ha^{-1} (8.56 t ha^{-1}). U proseku, HR je povećao prinos kukuruznog zrna u kontrolnom tretmanu za 1.18 t ha^{-1}. Da bi se postigli dobri prinosi kukuruznog zrna, optimalne doze azota na tretmanima sa HR trebalo bi da se kreću u opsegu od 100 kg N ha^{-1} do 200 kg N ha^{-1}, dok na tretmanima bez HR optimalne doze azota trebale bi da budu blizu 200 kg N ha^{-1}.

Ključne reči: kukuruz, azot, prinos, žetveni ostatci.

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