INFLUENCE OF CROP RESIDUES AND INCREASING RATES OF NITROGEN ON THE YIELD OF CORN

Dragana LATKOVIĆ[1], Branko MARINKOVIĆ[1], Jovan CRNOBARAC[1], Goran JAĆIMOVIĆ[1], Janoš BERENJI[2], Vladimir SIKORA[2]

[1]Faculty of Agriculture, University of Novi Sad, Square Dositeja Obradovića 8, Novi Sad, Serbia
[2]Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, Serbia
E – mail: dragana@polj.uns.ac.rs

Abstract: *Results from an international stationary field trial (ISDV) have been analyzed for effects of increasing nitrogen doses on yield of corn. Effects of increasing nitrogen doses and harvest residues on corn yield were assessed in a three-crop rotation of corn, soybean and wheat. The trial had nine variants, six with and three without plowing under of harvest residues. The trial had been established on a calcareous chernozem soil, at Rimski Šančevi experiment field of Institute of Field and Vegetable Crops, Novi Sad. This paper reviews 3-year average yields (one rotations) of two currently tested corn hybrids, NS 510 and NS 6010. The average yield of grain obtained in the variants with plowed under harvest residues was 9.80 t ha^{-1}. It was higher by 3.28 t ha^{-1} than the average yield obtained in the fertilized variants that received no harvest residues. On average for both analyzed hybrids, the highest average yield (11.67 t ha^{-1}) was achieved in the fertilization variant with 150 kg ha^{-1} of nitrogen combined with plowing under of harvest residues. The hybrid NS 6010 had a statistically highly significant yield in relation to the other hybrid, NS 510. In the case of individual hybrids and their average, in variants both with and without plowed under harvest residues, the increase of grain yield in response to the increasing nitrogen doses created a quadratic regression curve. On average for the two hybrids, plowed under harvest residues increased the yield of corn grain in the control variant by 2780 kg ha^{-1}.In the comparable variants, the effect of long-term plowing under of harvest residues on grain yield of corn ranged from only 2450 kg of grain (in the case of the hybrid NS 510 in the variant with 90 kg N ha^{-1}) to a amount of 4180 kg ha^{-1} (in the case of the hybrid NS 510 fertilized with 150 kg N ha^{-1}).*

Key words: *corn, nitrogen, fertilization, crop residues, yield*

INTRODUCTION

Corn *(Zea mays,* L.*)* is a major field crop on the global scale. Yielding potential of corn hybrids was significantly increased during last 50 years, particularly in regions favorable for corn growing (RUSSEL, 1991; TOLLENAR et al., 1994). Yield increases have been achieved thanks to the development of genetically superior hybrids, increased stand density, intensified application of mineral fertilizers, decreased row distance and improved crop protection, in the first place against weeds and pests (CARLONE & RUSSEL, 1987., DWYER et al. 1991., TOLLENAR, 1991).

Nitrogen is a constitutive element of various compounds present in plants. Most of these compounds play important physiological roles – those are proteins, chlorophyll, enzymes, chromosomes, nucleic acids (HAGEMAN and BELOW, 1984). EARL & TOLLENAR (1997) and TOLLENAR et al. (1994) maintained that nitrogen is essential for leaf area duration in corn, as well as that it tends to increase all yield components of corn.

Harvest residues of field crops comprise voluminous biomass which is important for matter cycling in the agroecosystem, especially when organic fertilizers are not applied in adequate amounts. Regular removal of harvest residues from fields or their burning in combination with irregular application of organic fertilizers may be quite harmful in the long run (KASTORI and TEŠIĆ, 2006).

Analyzing a period of 18 years, STARČEVIĆ *et al*. (1999) concluded that a significant increase of corn grain yield was achieved with 110 kg Nha^{-1}, was maximum yield was obtained with 195 kg Nha^{-1}. Taking into account production economy and nitrogen balance, these authors found that optimum nitrogen amounts ranged from 110 to 150 kg ha^{-1}, when harvest residues were plowed under.

MATERIAL AND METHODS

A stationary field trial was established at Rimski Šančevi experiment field of Institute of Field and Vegetable Crops, Novi Sad, in 1971/72. The trial was established on the calcareous chernozem soil. Effects of increasing nitrogen doses and harvest residues on corn yield were assessed in a three-crop rotation of corn, soybean and wheat. The trial had nine variants, six with and three without plowing under of harvest residues. The experiment included the following variants of nitrogen fertilization (factor A):

a) treatments with plowed under wheat straw: 0, 60, 90, 120, 150 and 180 kg N ha^{-1} (every third year 5 tha^{-1} of absolutely dry wheat straw are plowed under before corn planting; 50 kg N ha^{-1} of fertilizer are added (10 kg of mineral N per 1t of straw) for more efficient decomposition),

b) treatments without plowed under wheat straw: 0, 90 and 150 kg N ha^{-1}.

The trial included 2 corn hybrids annually (factor B). This paper reviews 3-year average yields (one rotations) of two currently tested corn hybrids, NS 510 and NS 6010.

Nitrogen was applied two times, one half before basic tillage, another before planting. All variants invariable received equal amounts of phosphorus and potassium, 80 kg of P_2O_5 and K_2O ha^{-1}. These fertilizers were added before basic tillage.

The data obtained for corn yield (adjusted to 14% moisture) were statistically processed by the analysis of variance for a two-factor split-plot experiment (the statistical software GenStat v.9), testing the significance of differences between treatment means by the LSD test. The effect of increasing nitrogen doses on yield was assessed by the regression analysis and it was shown graphically.

RESULTS AND DISCUSSION

The results showed that fertilization system and hybrid had highly significant effects on grain yield in the experiment (Table 1). On average for the entire 3-year trial, the yield of grain was 8.71 t ha^{-1}. However, the yield of grain in the variants with plowed under harvest residues was 9.80 t ha^{-1} (an average for all variants that received N fertilizer), which was 3.28 t ha^{-1} higher than the average for the variants without harvest residues.

The highest yield on average for the two hybrids (11.67 t ha^{-1}) was obtained in the variant with 150 kg N ha^{-1} combined with plowed under harvest residues. This yield was highly significant in relation to the control variant and the variants with 60 and 90 kg N ha^{-1} and plowed under harvest residues, while it was not statistically significant in relation to the variant with 120 kg N ha^{-1}. These results indicate that it is not economically justifiable to apply more than 120 kg N ha^{-1}, as had been reported earlier by STARČEVIĆ et al. (1999).

The hybrid NS 6010 had a statistically highly significant yield in relation to the other hybrid, NS 510. In the variant with and without harvest residues, the hybrid NS 6010 out yielded NS 510 by 1.78 tha^{-1} and 1.58 tha^{-1}, respectively.

In the variants with plowed under harvest residues, with both hybrids and on their average, the curve for grain yield increase followed the quadratic regression pattern (Figure 1). Based on the calculated regression equations, the theoretically averaged maximum grain yield (10.76 t ha^{-1} on average for the studied hybrids) is obtained with 170.00 kg N ha^{-1} (r^2=0.8339).

The theoretically maximum yields of the hybrids NS 6010 and NS 510 (11.80 and 9.75 t ha^{-1}, respectively) are obtained with 162.00 kg N ha^{-1} and 186.00 kg N ha^{-1}, respectively.

Table 1.

Grain yields (t ha^{-1}) with different N doses in variants with and without harvest residues

Fertilization variant (A)			Hybrid (B)		Average(A)
	No.	N dose (kg ha^{-1})	NS-510	NS-6010	
With harvest residues	1	**0**	7.24	8.05	**7.65**
	2	**60**	8.20	9.71	**8.96**
	3	**90**	8.69	10.76	**9.73**
	4	**120**	9.61	11.62	**10.62**
	5	**150**	10.46	12.88	**11.67**
	6	**180**	9.22	11.07	**10.15**
		Average	**8.90**	**10.68**	**9.80**
Without harvest residues	7	**0**	4.66	5.07	**4.87**
	8	**90**	6.24	7.82	**7.03**
	9	**150**	6.28	9.05	**7.67**
		Average	**5.73**	**7.31**	**6.52**
Average (B)			**7.84**	**9.56**	**8.71**

		A	B	AxB
LSD	**5%**	1.39	0.46	1.69
	1%	1.88	0.61	2.25

The highest grain yield (7.67 t ha^{-1}) in the variants without plowed under harvest a residue (Table 1) was obtained with 150 kg N ha^{-1}. However, this yield was significant only in relation to the yield in the control variant (4.87 t ha^{-1}), and it was not significant in relation to the yield in the variant with 90 kg ha^{-1} (7.03 t ha^{-1}).

In the case of the variants without plowed under harvest residues, the curve for the grain yield increase also followed the quadratic regression pattern. On average for both hybrids, the theoretically maximum yield of 7.74 t ha^{-1} would be obtained with 179.00 kg N ha^{-1} (Figure 2). Similar effects of increasing N doses on grain yield of corn were reported by STARČEVIĆ *et al*. (1999) and LATKOVIĆ & STARČEVIĆ (2006).

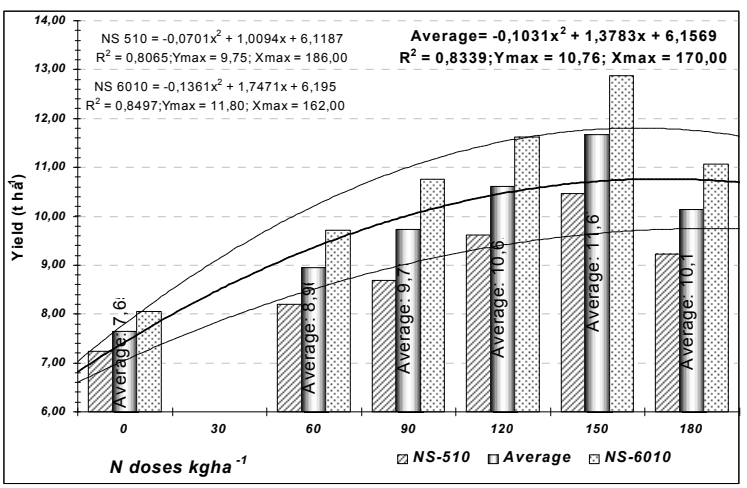

Figure 1. Effect of nitrogen dose on grain yield of corn in variants with plowed under harvest residues

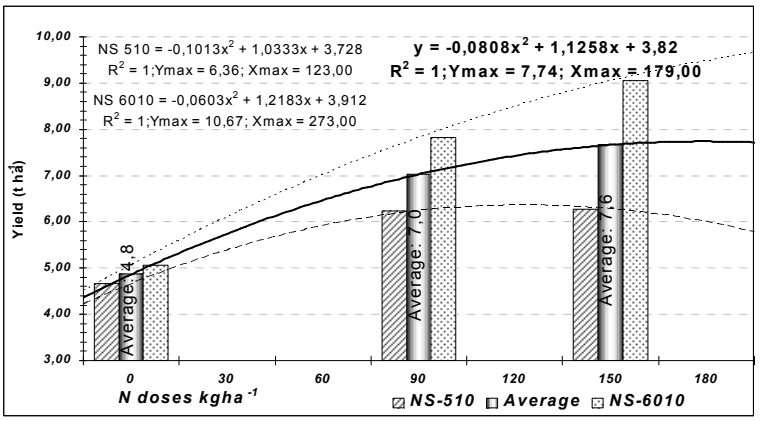

Figure 2. Effect of nitrogen dose on grain yield of corn in variants without plowed under harvest residues

As shown in Table 2, when comparable variants were considered, the effect of long-term plowing under of harvest residues on grain yield of corn ranged in dependence of the tested hybrids and nitrogen doses from 2450 kg (in the case of the hybrid NS 510 in the variant with 90 kg N ha^{-1}) to amount of 4180 kg ha^{-1} (in the case of the hybrid NS 510 in the variant with 150 kg N ha^{-1}). On average for the two hybrids, plowed under harvest residues increased the yield of corn grain in the control variant (without N application) and the variant with 90 kg of N by 2780 kg ha^{-1} and 2700 kg ha^{-1}, respectively. In the variant with the most intensive fertilization (150 kgN ha^{-1}), the plowed under harvest residues increased the yield of grain by 4000 kg ha^{-1}.

Table 2.

Effect of plowed under harvest residues on grain yield of corn (t ha^{-1})

N dose	Harvest residues (HR)	Hybrid (B)		Average
		NS-510	NS-6010	
0 kg N ha^{-1}	With HR	7.24	8.05	7.65
	Without HR	4.66	5.07	4.87
	Difference	**2.58**	**2.98**	**2.78**
90 kg N ha^{-1}	With HR	8.69	10.76	9.73
	Without HR	6.24	7.82	7.03
	Difference	**2.45**	**2.94**	**2.70**
150 kg N ha^{-1}	With HR	10.46	12.88	11.67
	Without HR	6.28	9.05	7.67
	Difference	**4.18**	**3.83**	**4.00**
Average for all 3 N doses	**With HR**	**8.80**	**10.56**	**9.68**
	Without HR	**5.73**	**7.31**	**6.52**
	Difference	**3.07**	**3.25**	**3.16**

Literature references mention a number of instances where plowing under of harvest residues is as effective as manure application with respect to soil properties and yield performance improvement. Experiments conducted in various countries including ours have

indicated that plowing under of harvest residues affected yield performance and quality (KASTORI, 1990; LATKOVIĆ et al., 2011, 2012), increased total N and C contents, improved soil fertility and reduced nitrogen leaching (NICHOLSON et al., 1997), and increased grain yield (ORTEGA et al., 2000; PRACHÁZKOVÁ et al., 2002; SILGRAM et al., 2002). Application of nitrogen fertilizers significantly affects the amount of harvest residues whose incorporation increases the humus content and efficiency of carbon retention in the soil (HALVORSON et al., 1999).

CONCLUSION

Following conclusions can be drawn on the basis of the study of the effect of increasing nitrogen doses on grain yield of corn in variants with and without plowed under harvest residues.

- The average yield obtained in the variants with plowed under harvest residues was 9.80 t ha^{-1} or higher by 3.28 t ha^{-1} in relation to the average of the fertilization variants without plowed under harvest residues.
- The highest average yield for the two hybrids (11.67 t ha^{-1}) was achieved in the fertilization variant with 150 kg ha^{-1} of nitrogen combined with plowing under of harvest residues.
- The average yield of the hybrid NS 6010 was highly significant as compared with that produced by the hybrid NS 510.
- In the case of individual hybrids and their average, in variants both with and without plowed under harvest residues, the increase of grain yield in response to the increasing nitrogen doses created a quadratic regression curve.
- In the comparable variants, the effect of long-term plowing under of harvest residues on grain yield of corn ranged from only 2450 kg of grain (in the case of the hybrid NS 510 in the variant with 90 kg N ha^{-1}) to a amount of 4180 kg ha^{-1} (in the case of the hybrid NS 510 fertilized with 150 kg N ha^{-1}).

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