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ECONOMIC COST – EFFECTIVENESS OF DIFFERENT NITROGEN APPLICATION IN THE PRODUCTION OF CORN ON CHERNOZEMS SOIL

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Summary

The aim of this study is to determine the optimum quantity of nitrogen applied in corn production at which maximum profit is achieved.

Optimal nitrogen application is important for two main reasons: first for achieving maximum profitability in the production of maize and other is to avoid environmental pollution as the nitrogen is one of the main polluters.

In the three-year period (2005 - 2007) were performed research on the effects of nitrogen quantity (control - without fertilization, PKNfon, PKN_{60}, PKN_{120} and PKN_{180}) and hybrids of different vegetation length (ZPSC 434 ZPSC ZPSC 578 and 677) on yield and profitability.

Increasing application of nitrogen tended to raise grain yield by 9.9 - 13.5%. The lowest average corn grain yield (9.49 t ha^{-1}) was registered with the hybrid ZP 434. It was somewhat higher (9.75 t ha^{-1}) with the hybrid ZP 578 and the highest corn grain yield (10.03 t ha^{-1}) with ZP 677. Study shows that highest yield is not always most profitable. In production year with good water supply (2005) highest profit is achieved with moderate use of nitrogen (60 kg ha^{-1}). In draught production years (2006 and 2007) highest profit was achieved with application of 60 to 120 kg ha^{-1}.

Key words: *corn production, profitability of corn production, fertilizer application.*

JEL: *E61, Q13*

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Introduction

The increase in the yield of maize in Serbia is achieved during the four cycles of selection and introduction into production of new hybrids, yield increase varied between 69,4 and 113,2 kg ha^{-1} yearly (Kojić, 1991). The largest increase was by introduction of two-line hybrids characterized by a larger genetic potential, and a greater phenotypic uniformity. Further increase in the yield of corn requires increasing the genetic yield potential of new hybrids, as well as improved cultivation technology (Kojić, Ivanović, 1986; Vasić et al., 2001; Jovanović et al., 2006). However, for a number of years in Serbia corn yields are stagnant or declining. Since 2006, until 2010, the average grain yield went down for about 170 kg ha^{-1} compared to the world average, fell by about 1,900 kg ha^{-1} compared to the EU average and less for 4,800 kg ha^{-1} than the average achieve the American corn producers (FAOSTAT, 2010). Such results are caused by a number of organizational - economic, and agro-technical reasons.

It is known that the agro-technical measures are of great importance in maize production in the context of these measures is choice of hybrids and adequate application of nitrogen. Proper selection of hybrids that will in specific conditions of climate, soil and other environmental factors lead to achieve high and stable yields of maize is the first step on this path. In this respect, the modern hybrids, beside high genetic yield potential, are characterized by a higher tolerance to stress conditions. The newest hybrids submitted earlier and denser sawing, a more rational use of nutrients and better use of water (Stojaković et al., 1996; Živanović, 2005).

On the other hand, the mineral nitrogen nutrition is one of the main factors that determine the productivity of plants and agricultural products quality. Nitrogen as an element of the proteins shows a major impact on the character of the physiological and biochemical processes, the processes of organs developments, time duration for certain phases of growth and development, the size, structure and quality of yield (Jevtić, 1986). For corn nitrogen has a major role as the constitutive element of proteins, the basic ingredients of protoplasm. The optimal nitrogen nutrition positive effect on the development of the root system and aboveground biomass, as well as the nutritional value of grains (Glamočlija, 2004). Numerous authors noted the existence of dependence between the intensity and productivity of photosynthesis and plant nitrogen nutrition, by increasing the concentration of nitrogen in the nutrient medium, the enzyme activity increases in carbon metabolism (Kastori, Petrović, 1980).

In numerous studies that have been performed worldwide today it has been found that the application of nitrogen fertilizer largely increases grain yield (Brković, 1985; Hojka, 2004; Blackmer, White, 1998; Binder et al., 2000; Katsvairo et al., 2003). In addition to the impact on grain yield, nitrogen fertilizers increase grain protein content (Rajković, 1978). However, the results of field trials, which are related to the problems of corn production related to use of the nitrogen are often significantly different. This is understandable if bears in mind that the effect of mineral fertilizers, especially nitrogen, depends largely on the type and soil fertility, weather conditions, manner and time of their use and others. According to the Nedić et al. (1991), increased quantity of nitrogen in corn production significantly increases the yield and nutritional value of grains under the conditions of optimal water regime during the growing period of the plants. The effect depends also on the hybrids (Nedić et al., 1990). Late maturity hybrids strongly respond to intensive nitrogen nutrition because they have a longer growing period and a longer period of adoption of nitrogen from the soil.

Other aspect of excessive application of nitrogen fertilizers may result in many awkward and harmful effects. First of all, to have a prolonged duration of the growing season, reducing harvest index, increased susceptibility of plants to pathogenic microorganisms and lodging. Excessive use of nitrogen fertilizers can cause some environmental problems such as pollution of groundwater with nitrates and the occurrence of dense vegetation in drainage canals. The use of nitrogen in quantity that exceed the needs of plants, leading to increased levels of nitrates in the soil, and increased concentrations of NO_3 - N in the soil after harvest, increasing the risk of their leaching in groundwater (Schepers et al., 1991). Nitrogen at a dose greater than 300 kg ha^{-1} and the concentration of nitrate in ground water drainage more than 11,3 mg L^{-1} (Villar Mir et al., 2002) are the maximum content of NO_3 - N allowed in drinking water (EU Nitrates Directive).

Planning and use of optimal use of nitrogen increases the profitability of agricultural production (Zakić, Stojanović, 2008).

Further application of appropriate agricultural technology reduces business risk faced by producers in agricultural production (Zakić, Kovačević, 2012). All activities leading to the possibility of more certain planning of production and product quality have led to farmers increased certainty when entering into forward sales and the application of appropriate hedging strategies.

All mentioned above leads to an increase in the food security. No less important is the environmental aspect with regard to the reduction of excessive use of nitrogen fertilizer related to environmental protection.

Methodology and experiment model

These researches conduct two factors:

1. Nitrogen quantity (A)

   A_1 – Control trial (without fertilizers applied)

   A_2 – $P_{\mathbf{90}}\ K_{\mathbf{60}}\ N_{\mathbf{30}}$ $kgha^{-1}$

   A_3 – $P_{90} K_{60} N_{\mathbf{60}}$ $kgha^{-1}$

   A_4 – $P_{90} K_{60} N_{\mathbf{120}}$ $kgha^{-1}$

   A_5 – $P_{90} K_{60} N_{\mathbf{180}}$ $kgha^{-1}$

2. Hybrids (B)

   B_1 – ZPSC 434 (FAO 400)

   B_2 – ZPSC 578 (FAO 500)

   B_3 – ZPSC 677 (FAO 600)

Agricultural technology in the experiments is standard, usual for regular production of corn. In all three studding years preceding crop was winter wheat. After the wheat harvest plowing was done stubble to a depth 10-15 cm. Before primary tillage fertilization with 300 kg ha^{-1} fertilizer NPK 10:30:20 was applied. Primary tillage was performed in the fall, depending on weather conditions, the depth was about 25 cm. During the spring was conducted additional soil tillage, then additional nitrogen fertilization KAN (27% N) in quantities 30, 90 and 150 kg ha^{-1}, active ingredient (NH_4NO_3), and finally seedbed preparation.

Sowing was done manually in the second half of April, according to the plan of sawing, inter-row spacing of 70 cm with 2 seeds in whole. After germination thinning was carried out at a steady, planned number of plants. Hybrids were grown in the recommended (optimal) plant density, depending on the FAO group, and ZP 434-64.935 plants per hectare (70x22 cm), then ZP 578-57.143 plants per hectare (75x25 cm) and ZP 677-51.020 plants per hectare (70x28 cm).

The plant care are done by appropriate herbicides for weed control (after planting and before emergence: Acetochlor two l ha^{-1} + Atrazine 1 l ha^{-1}, and during the growing season Motivell 1 l ha^{-1} + Cambio two l ha^{-1}) and needed hoeing.

Harvest (harvest) of corn was done manually at the end of September or early October, depending on the year.

Grain yield of 14% with water was calculated by the following formula:

$$QV = Pi \times (100 - U)/100 - US$$

Where is:

- QV – corn yield with 14% moisture,
- Pi – yield of raw grains,
- U – grain' water content at harvest,
- US – calculated grain water content (14%).

The research results were analyzed by statistical analysis and presented in tables and graphs.

Weather conditions

Mean monthly air temperatures in all years of study, as well as the long-term average (1995 - 2004) are shown in Table 1.

Table 1. Mean monthly air temperature (^{0}C) for the growing season of maize (IV - IX), in 2005 - 2007 at Zemun Polje in the years of study, as well as the long-term average (1995 - 2004) at the locations for the vegetation period

Year	Location	Month						Average
		IV	V	VI	VII	VIII	IX	
2005	Zemun Polje	13,1	17,6	20,2	22,8	21,4	18,9	19,0
2006	Zemun Polje	14,1	17,6	20,3	24,6	21,7	19,7	19,7
2007	Zemun Polje	14,7	19,7	23,6	25,7	24,4	16,8	20,8
Average (1995 - 2004)	Zemun Polje	12,9	18,7	21,8	23,2	23,4	17,8	19,6

Source: RHSS, reports for 2005, 2006 and 2007.

Data on rainfall by months within growing period in the years of study, as well as the long-term average (1995 - 2004) are shown in Table 2, years in which the tests are performed are differed significantly, both in terms of total amount rainfall during the growing period, and in terms of their schedule by months.

Table 2. Amounts of rainfall (mm) for the growing season of maize (IV - IX), in 2005 - 2007 (Zemun Polje)

Year	Location	Month						Average
		IV	V	VI	VII	VIII	IX	
2005	Zemun Polje	53,0	48,0	94,0	90,0	145,0	56,0	486,0
2006	Zemun Polje	97,0	40,0	137,0	22,0	123,0	26,0	445,0
2007	Zemun Polje	4,0	79,0	108,0	18,0	72,0	85,0	366,0

Source: RHSS, reports for 2005, 2006 and 2007.

Soil characteristic

Chernozems are formed under natural conditions that differ significantly from the evaluations of other soil types. Chernozems is evaluated under semi-arid continental climate and steppe grassland vegetation. However, the important for creation of chernozems are other natural factors, such as relief, geological substrate, terrain and other natural factors. Chernozems is the soil type with two specific genetic horizons: humus - accumulative A1 horizon and the parent rock, and C horizons. However, transitional AC horizon can appear.

Humus A1 horizon is the most distinctive horizon after which chernozems is named. It has an average depth of 40 to 60 cm, depending on the subtypes of the relief and chernozems. Humus horizon color is dark brown to black, depending on the amount of humus and soil moisture condition, structure of chernozems is crumbly and grainy. The transition of the humus horizon of forest is gradual, so it is not easy to determine where the first ends and where another begins.

Transitional AC horizon in color, structure and other properties is located in the middle between the dark colored humus horizon above and below the yellow les. The color of this horizon is dark grey, with frequent intersections of the black soil. The structure of the transitional horizon is somewhat coarser than in humus and can be coarse-grained, granulated or vague. Transitional horizon is enriched with calcium - carbonate ($CaCO_3$). The depth of the transitional horizon is different for different chernozems, and usually about 50 cm or more. This horizon is also suitable for development of rooting plants, therefore, together with humus horizon is one of the most active layer of soil. C horizon in Serbian chernozems is mostly les. Color and other characteristics of the les are mostly affected by the groundwater and the amount of lime in the surface layer of the horizon. Chernozems soil has medium texture, but there are chernozems with more clay and sand. For the physical of cehrnozems of particular importance is chernozems structure. Among the structural aggregates in chernozems dominate those whose dimensions are between 3 and 7 mm. Chernozems structure is usually worst in the upper layers, and in the depth gets better and structural units are more stable. Chernozems has good water, and air characteristic.

The chemical characteristic of chernozems are conditioned by its richness in humus and mineral clay and richness in lime and adsorbed calcium (Ca^{++}). The amount of humus in chernozems can vary greatly, and in our chernozems amounts of 2,5 to 6%. The content of lime can be different in the chernozems. The amount of calcium - carbonate in the surface layer is not large, but rapidly increases with depth, so the transition AC horizon in the surface layer of the C horizon may range from 25 to 35%, and more. Chernozems is characterized by favourable biological characteristics as a consequence of a chernozems pH neutral soil reaction.

Total porosity varies in different depth profiles. Basically, it is the largest in the humus - accumulative horizon. Chemical properties of the soil in the experimental field are presented in Table 3.

Table 3. Chemical characteristics of carbonate chernozems (Zemun Polje)

Depth (cm)	pH		Humus (%)	Nitrogen (%)	C/N	$CaCO_3$ (%)	mg in 100 g	
	H_2O	n1KCl					P_2O_5	K_2O
0 - 30	7,71	7,34	2,86	0,19	8,6:1	4,40	25,40	22,20
30 – 60	7,81	7,48	2,47	0,17	8,6:1	11,60	17,10	18,40
60 – 90	7,87	7,66	1,11	0,08	8,4:1	24,10	2,70	7,00

Source: Živanović, 2012.

Total Content of mineral nitrogen before sowing maize is presented in Table 4.

Table 4. Content of mineral nitrogen before sowing maize (mg kg^{-1})

Year	Depth (cm)	Cernozems			Average	Index (%)
		NH_4^+	NO_3^-	Sum		
2005	0 - 30	4,9	17,5	22,4	18,9	42,1
	30 - 60	3,5	10,5	14,0	14,3	31,8
	60 - 90	2,8	8,5	11,3	11,7	26,1
	0 - 90	11,2	36,5	47,7	44,9	100,0
	%	23,5	76,5	100,0	-	100,0

Year	Depth (cm)	Cernozems			Average	Index (%)
		NH_4^+	NO_3^-	Sum		
2006	0 - 30	8,0	14,7	22,7	21,1	39,1
	30 - 60	7,0	12,7	19,7	18,2	33,7
	60 - 90	6,0	8,0	14,0	14,7	27,2
	0 - 90	21,0	35,4	56,4	54,0	100,0
	%	37,2	62,8	100,0	-	120,3
2007	0 - 30	4,0	19,5	23,5	22,6	45,5
	30 - 60	2,8	13,7	16,5	15,2	30,6
	60 - 90	2,0	11,5	13,7	11,9	23,9
	0 - 90	8,8	44,7	53,5	49,7	100,0
	%	16,5	83,5	100,0	-	110,7
Yearly average		13,7	38,9	52,6	49,7	-
Index (%)		26,0	74,0	100,0	-	-

Source: Živanović, 2012.

The soil has the mineral nitrogen content (52,6 mg kg^{-1}). At the same time, the amount of nitrate nitrogen (NO_3) in chernozems was 74,0%. (Bogdanović 1986) reported that the nitrogen nutrition of plants on chernozem soil types is mostly absorbing nitrate form of nitrogen, whether it is applied into the soil as fertilizer or created in the process of mineralization of organic matter. The relatively higher content of ammonium ions in the soil solution in relation to the content of nitrate ions is caused by various factors, of which the most important are the accumulation of organic matter, soil pH and soil temperature (Dijk, Eck, 1995). Low pH, low temperature and anaerobic conditions in the soil affect the increased nitrification.

The minimum content of mineral nitrogen was in the spring of 2005 (44,9 mg kg^{-1}), the larger content is in 2007 (49,7 mg kg^{-1}) and the largest in 2006 (54,0 mg kg^{-1}). This study confirms the results of Hojka (2004), that in years with more precipitation and lower air temperature in the period before the amount of mineral nitrogen in spring is lower than in years with lower rainfall and higher temperatures.

The largest content of mineral nitrogen is in the topsoil layer, where the microbiological and mineralization process are fast. The chernozems on loess terrace highest nitrate nitrogen is in a layer up to 60 cm, and then decreases and at depth 120-140 cm is found only in trace amounts. In this research, in both soil types, the highest content of mineral nitrogen was found in the soil layer 0 - 30 cm (between 39,1 and 45,5%), while in the depth profiles decreased to 30,6 to 33,7% (30-60 cm) and 23,9 to 27,2% (60-90 cm), depending on the year.

Results and discussion

Highest yields in corn production is not always most profitable. It is of importance to establish most profitable use of inputs and chose optimal hybrids in corn production.

Highest average yields is for hybrids FAO group 600 which is expected because of longer vegetation periods, second highest yields is with hybrids FAO group 500 and lowest with FAO group 400.

Highest profitability is achieved in average with application of 60 kg ha^{-1} of nitrogen.

Profitability related to nitrogen application is calculated according following calculation:

D = Y*Py – Pf

D - Profitability of additional application of nitrogen,

Y - Difference in yield in tons compared with the control test,

Py - Price of corn \$ 192,7 t^{-1},

Pf - Fertilizer price \$ ha^{-1},

Pf (PKN_{fon}) – 195 \$ ha-[4],

Pf (PKN_{60}) – 239,61 \$ ha^{-1},

Pf (PKN_{120}) – 328,77 \$ ha^{-1},

Pf (PKN_{180}) – 418,13 \$ ha^{-1}.

Table 5. Influence of nitrogen application and hybrid types on the yield of maize production in the 2005

Nitrogen quantity (A)	Hybrid(B)			
	ZP 434 Yield t ha^{-1}	ZP 578 Yield t ha^{-1}	ZP 677 Yield t ha^{-1}	**Average yield t ha^{-1}**
Control trial	10,85	10,98	11,97	11,27
PKN_{fon}	11,13	11,29	12,53	11,65
PKN_{60}	12,44	12,71	13,46	12,87
PKN_{120}	13,03	13,45	13,95	13,48
PKN_{180}	12,87	12,84	13,52	13,08

Source: Živanović, 2012.

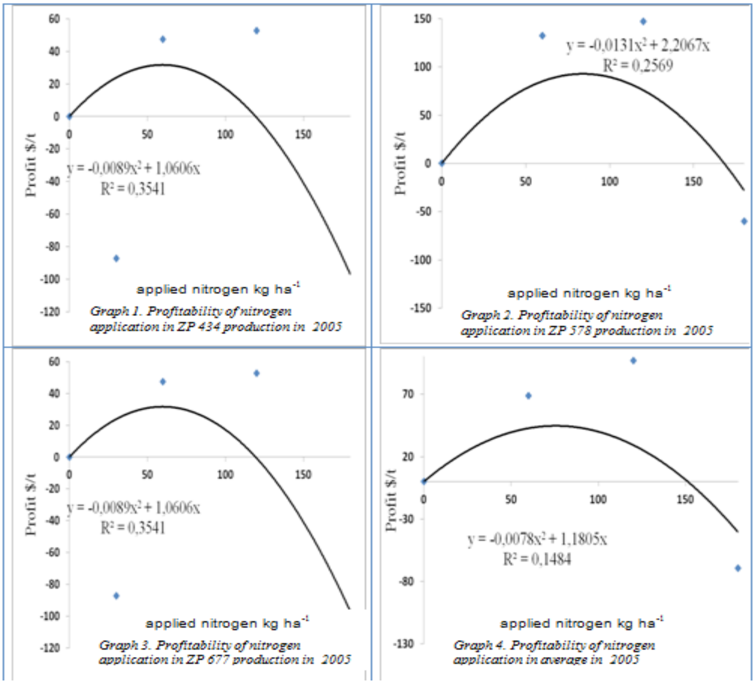
Table 6. Cost effectiveness of application of different rate of nitrogen

Nitrogen quantity (A)	Hybrid(B)			D average \$ ha^{-1}
	D(ZP 434) \$ ha^{-1}	D(ZP 578) \$ ha^{-1}	D(ZP 677) \$ ha^{-1}	
Control trial	-	-	-	0
PKN_{fon}	-108,25	-135.26	-87,08	-121,77
PKN_{60}	66,78	132,3	47,51	68,71
PKN_{120}	91.32	147,20	52,76	97,10
PKN_{180}	-28.88	-59,71	-119,44	-69,34

Source: Authors calculation based on data from Table 5.

4 Average retail fertilizer price in the period 2005.-5013, C Source: Ministry of Agriculture, Forestry and water Management of the R. Serbia (data received upon request).

On the graphs 1, 2, 3 and 4 are presented regression' correlation between nitrogen application and profitability of production in 2005.



Source: Regression analyses based on data from Table 6.

Year 2005 was with favourable weather conditions. According to the experimental results (Graph 1) for ZP 434 optimal quantity of applied nitrogen was in the quantity of 120 kg.

According to the experimental results (Graph 2) for ZP 578 optimal quantity of applied nitrogen was in quantity of 60 and 120 kg. The highest additional profitability is achieved in amount of 147,20 \$ ha^{-1} with application of 120 kg ha^{-1}.

According to the experimental results (Graph 3) for ZP 677 optimal amount of applied nitrogen was 60 and 120 kg. The correlation between the applied and the yield of nitrogen is higher than the previous hybrids and R-square is 0,2569. According to the average results of the experiment (Graph 4) for all three hybrids optimum quantity of nitrogen was in the rate between the 60 and 120 kg ha^{-1}.

Table 7. Influence of nitrogen application and hybrid types on the yield of maize production in the 2006

Nitrogen quantity (A)	Hybrids(B)			Average yield t ha^{-1}
	ZP 434 Yield t ha^{-1}	ZP 578 Yield t ha^{-1}	ZP 677 Yield t ha^{-1}	
Control trial	9,29	9,52	9,93	9,58
PKN_{fon}	10,10	10,30	10,50	10,30
PKN_{60}	11,23	11,25	11,38	11,29
PKN_{120}	11,28	11,71	10,86	11,28
PKN_{180}	10,90	11,15	10,65	10,90

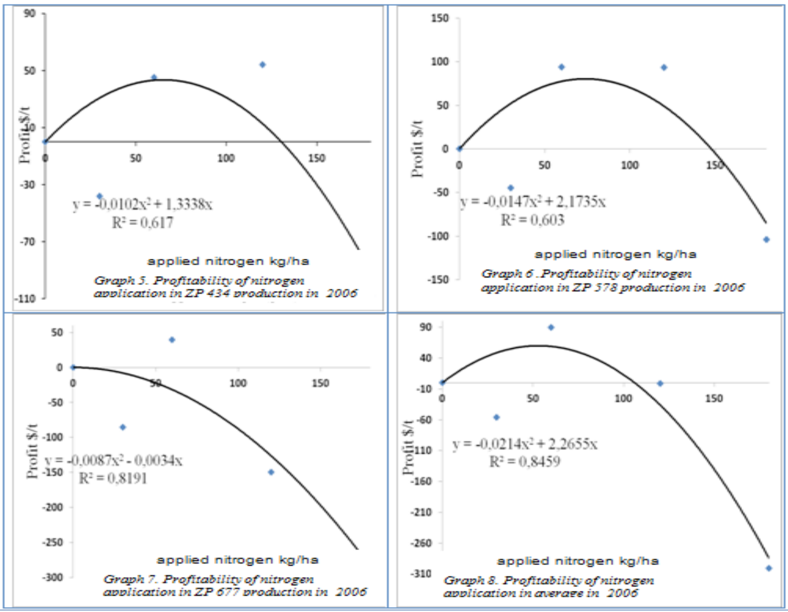
Source: Živanović, 2012.

Table 8. Cost effectiveness of application of different rate of nitrogen

Nitrogen quantity (A)	Hybrids(B)			D average $ ha^{-1}
	D(ZP 434) $ ha^{-1}	D(ZP 578) $ ha^{-1}	D(ZP 677) $ ha^{-1}	
Control trial				
PKN_{fon}	-38,19	-44,69	-85,16	-56,26
PKN_{60}	45,07	93,71	39,80	89,91
PKN_{120}	54,07	93,2	-149,56	-1,18
PKN_{180}	-107,88	-104,03	-279,39	-198,11

Source: Authors calculation based on data from Table 7.

On the graphs 5, 6, 7 and 8 are presented regression' correlation between nitrogen application and profitability of production in 2006.



Graph 5. Profitability of nitrogen application in ZP 434 production in 2006

Graph 6. Profitability of nitrogen application in ZP 578 production in 2006

Graph 7. Profitability of nitrogen application in ZP 677 production in 2006

Graph 8. Profitability of nitrogen application in average in 2006

Source: Regression analyses based on data from Table 8.

The 2006 was with less favourable weather conditions. According to the experimental results (Graph 5) for ZP 434 optimal quantity of applied nitrogen was in the quantity of 60 to 120 kg ha^{-1}.

According to the experimental results (Graph 6) for ZP 578 optimal amount of applied nitrogen was in quantity of 60 and 120 kg. The highest additional profitability is achieved in amount of 93,71 $ ha^{-1} with application of 60 kg ha^{-1}.

According to the experimental results (Graph 7) for ZP 677 optimal amount of applied nitrogen was 60 kg ha^{-1}.

In average in 2006 highest profitability (Graph 7) was 89,91 $ ha^{-1} with nitrogen application of 60 kg ha^{-1}.

Table 9. Influence of nitrogen application and hybrid types on the yield of maize production in the 2007

Nitrogen quantity (A)	**Hybrids(B)**			**Average yield t ha^{-1}**
	ZP 434 Yield t ha^{-1}	ZP 578 Yield t ha^{-1}	ZP 677 Yield t ha^{-1}	
Control trial	7,75	7,78	8,31	8,70
PKN_{fon}	8,51	8,57	9,03	9,76
PKN_{60}	9,97	9,46	9,84	9,64
PKN_{120}	9,90	9,40	9,62	9,37
PKN_{180}	9,35	9,39	9,38	10,90

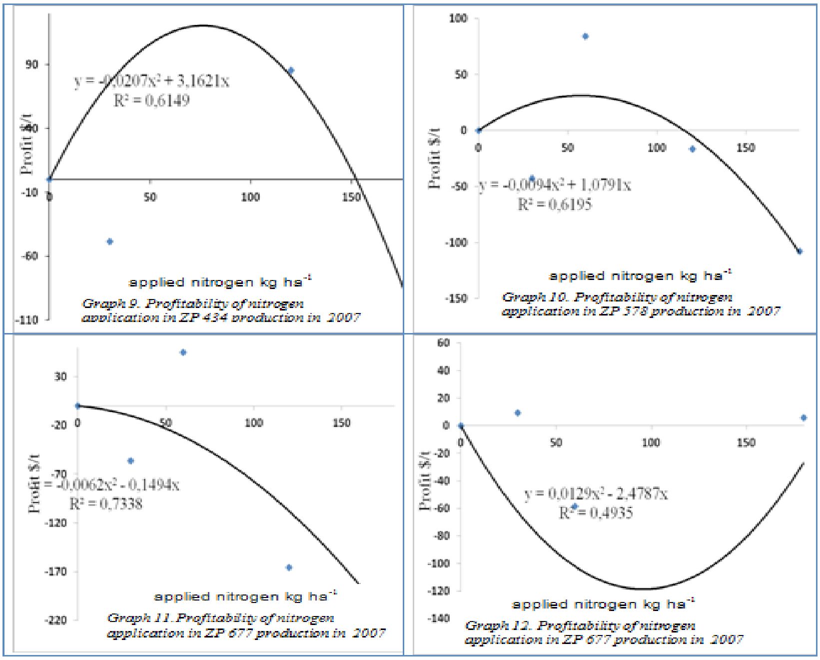
Source: Živanović, 2012.

Table 10. Cost effectiveness of application of different rate of nitrogen

Nitrogen quantity (A)	**Hybrids(B)**			**D average $ ha^{-1}**
	D(ZP 434) $ ha^{-1}	D(ZP 578)	D(ZP 677) $ ha^{-1}	
Control trial				
PKN_{fon}	-48,55	- 42,77	-56,26	-49,19
PKN_{60}	188,18	84,13	55,21	109,17
PKN_{120}	85,53	-16,6	-165,70	-32,26
PKN_{180}	-109,81	-107,89	-211,94	-143,21

Source: Authors calculation based on data from Table 9.

On the graphs 9, 10, 11 and 12 are presented regression' correlation between nitrogen application and profitability of production in 2007.



Graph 9. Profitability of nitrogen application in ZP 434 production in 2007

Graph 10. Profitability of nitrogen application in ZP 578 production in 2007

Graph 11. Profitability of nitrogen application in ZP 677 production in 2007

Graph 12. Profitability of nitrogen application in ZP 677 production in 2007

Source: Regression analyses based on data from Table 10.

The 2007 was draught year. According to the experimental results (Graph 9) for ZP 434 optimal quantity of applied nitrogen was in the quantity of 60. This hybrid amounts highest additional profit amount all three hybrids of 188,18 \$ ha^{-1}.

According to the experimental results (Graph 10) for ZP 578 optimal quantity of applied nitrogen was in quantity of 60 kg ha^{-1}.

According to the experimental results (Graph 11) for ZP 677 optimal quantity of applied nitrogen was 60 kg ha^{-1} with moderate additional profit of 55,21 \$ ha^{-1}.

In average in 2006 highest profitability (Graph 7) was 109,17 \$ ha^{-1} with nitrogen application of 60 kg ha^{-1}.

Table11. Influence of nitrogen application and hybrid types on the yield of maize production in average (2005-2007)

Nitrogen quantity (A)	**Hybrids (B)**			**Average yield t ha^{-1}**
	ZP 434 Yield t ha^{-1}	ZP 578 Yield t ha^{-1}	ZP 677 Yield t ha^{-1}	
Control trial	9,30	9,43	10,07	9,60
PKN_{fon}	9,91	10,05	10,69	10,22
PKN_{60}	11,21	11,14	11,56	11,30
PKN_{120}	11,40	11,52	11,48	11,47
PKN_{180}	11,04	11,13	11,18	11,12

Source: Živanović, 2012.

Table 12. Cost effectiveness of application of different rate of nitrogen

Nitrogen quantity (A)	**Hybrids (B)**			**D average $ ha^{-1}**
	D(ZP 434) $ ha^{-1}	D(ZP 578)	D(ZP 677) $ ha^{-1}	
Control trial				
PKN_{fon}	-77,45	-75,53	-75,53	-75,53
PKN_{60}	128,45	140	47,51	132,59
PKN_{120}	75,9	73,97	-37,79	31,58
PKN_{180}	-82,83	-90,54	-204,23	-109,81

Source: Authors calculation based on data from Table 11.

Summing up the results of the experiment can be concluded that on average for all three years of profitability achieved in the application of 60 kg nitrogen per ha^{-1} lead to additional profit. The use of nitrogen in an amount of 120 kg ha^{-1} has a positive impact on the increase in the yield while the profit was decreased, while the application of the quantity of 30 kg of nitrogen ha^{-1} resulted in the reduction of profit as well.

Conclusion

The research is conducted on influence of the applied quantity of nitrogen and different maize hybrids on the profitability of maize production, have difference largely depending on weather conditions, both in quantity and distribution of rainfall, as well as thermal conditions.

Based on the results of our three-year study, carried out in agro ecological conditions of Srem-Serbia following conclusions can be drawn.

Grain yield varied largely depending on the weather conditions. Compared with the 2005, which is characterized by optimal environmental conditions for growth and development of corn in the year with the uneven distribution of rainfall (2006) grain yield was reduced by 14,4 %, and in the dry 2007 by 27,2 %.

Increased nitrogen application caused an increase in grain yield of 1,08 to 1,25 t ha^{-1} (10,6 to 12,2 %).

A high degree of dependence between the quantity of applied nitrogen and grain yield of maize hybrids surveyed a stream of increasing yield is quadratic regression fit. Hybrid ZP 677 reacted by increasing the grain yield only with quantity of 60 kg ha^{-1}.

Planning and use of optimal use of nitrogen increases the profitability of agricultural production. No less important is the environmental aspect with regard to the optimal recharge reduces excessive use of nitrogen fertilizer and the team and pollution.

Due to the perceived high dependence adoption of nitrogen by maize plants, which is related to the quantity and distribution of rainfall during the growing season of maize, it would be important that such experiments carried out under irrigation.

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EKONOMSKA ISPLATIVOST PRIMENE RAZLIČITIH KOLIČINA AZOTA U PROIZVODNJI HIBRIDA KUKURUZA RAZLIČITIH FAO GRUPA ZRENJA NA ZEMLJIŠTU TIPA ČERNOZEM

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Sažetak

Cilj rada je utvrđivanje optimalne količine primene azota u gajenju kukuruza pri kojoj se ostavruje maksimalni prihod.

Optimalna aplikacija azota je važna iz dva razloga: prvo za postizanje maksimalne profitabilnosti u proizvodnji kukuruza i drugih je da se izbegne zagađenje životne sredine s obzirom da je azot je jedan od glavnih zagađivača. Istraživanja su sprovedena u periodu od tri godine (2005 - 2007) o efektima količine primenjenog azota (kontrola - bez đubrenja, PKNfon, PKN_{60}, PKN_{120} i PKN_{180}) i hibrida različite dužine vegetacije (ZPSC 434 ZPSC ZPSC 578 i 677) na prinos i profitabilnost proizvodnje.

Povećanje primena azota ima tendenciju da podigne prinos od 9,9 - 13,5%. Najniža prosečan prinos zrna kukuruza (9,49 t ha^{-1}) je registrovan kod hibrida ZP 434. Prinos je bio nešto veći (9,75 t ha-1) kod hibrida ZP 578 i najviši prinos zrna (10,03 t ha^{-1}) sa ZP 677. Studija pokazuje da najveći prinos nije uvek najprofitabilnija. U proizvodnoj godini sa dobrim vodnim režimom (2005) najveći profit je ostvaren sa umerenom upotrebom azota (60 kg ha^{-1}). U sušnim proizvodnim godinama (2006 i 2007) najviši profit ostvaren je sa primenom 60 do 120 kg ha^{-1}.

Ključne reči: *proizvodnja kukuruza, profitabilnost proizvodnje kukuruza, primena đubriva.*

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