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The Seminar

**AGRICULTURE AND RURAL DEVELOPMENT -
CHALLENGES OF TRANSITION AND
INTEGRATION PROCESSES**

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EFFECTS OF INTENSIFYING GRAIN PRODUCTION IN FAMILY HOLDINGS¹

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Summary

The starting point of the present study was the assumption that the intensity of grain production (wheat and maize), on family farms/holdings, can be raised to a higher level by increasing the use of mineral fertilizers per unit area as one of the fastest, simplest and economically most rational measures (does not require additional investments). Determination to increase the level of grain production intensity in this way is the result of survey conducted on family farms/holdings on the territory of Vojvodina. Namely, the survey established that family farms/holdings, despite of analyses of soil fertility and received recommendations for the optimal application of mineral fertilizers, by extension services, in most cases (83%) do not respect the recommendations, and apply mineral fertilizers in accordance with their habits and budget.

The results obtained indicated that there were significant opportunities to increase the intensity of grain production by using larger amounts of mineral fertilizers per unit area. Namely, because of the lower use of mineral fertilizers in relation to the recommendations given by the agricultural extension, lower wheat yields were achieved in average by 18.7% and 17.6% for maize than planned, which had the effect of considerably reducing not only the actual value of production of these crops, but also the total profit of family farms/holdings.

Key words: economic effects, production intensity, fertilizers, cereals, family farms

JEL classification: Q12; D10; D13; D24

1. Introduction

Mineral fertilizers are one of the key inputs for the intensification of plant production. In the past, their use per unit area was much higher in developed

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countries than in developing countries. However, in recent years the use of fertilizers increased faster in developing countries than in developed countries and has reached nearly three-quarters of the total global consumption of mineral fertilization (Sekulić, P. et al. 2009). This is associated with the overproduction in the agricultural industry in developed countries and measures aimed at limiting of the production, protection of the environment and production of safe food which are limiting and excluding the use of chemical inputs. A large number of conducted experiments, in particular the results achieved in practice over the last forty years, confirmed that the increase in yield per unit area can be realized in the fastest, easiest and most efficient way through rational use of mineral fertilizers. In conditions of modern (conventional) farming, the amount of realized yield is influenced by the application of appropriate, adequate agricultural practices (fertilization, the creation of new varieties and hybrids, irrigation, use of pesticides, modern mechanization). All these agricultural measures and practices have similar impact on yields. The application of fertilizers is of particular importance, as confirmed by the FAO estimates showing that the application of fertilizers contributes to the increase of yields with 50% (Mirjana Kresović 2010). From the above stated it can be concluded that mineral fertilizers represent a powerful tool to increase yields with high impact on the level of intensity of production. At the same time, the fact cannot be overlooked that the costs of mineral fertilizers represent significant part of the total cost of production. So these costs participate in total cost of wheat production with 19.7% and 28.2% in production of maize (Jovanović, M., Bošnjak Danica 1997). Also the results of the analysis of the economic efficiency of crop production on family farms/holdings in the period 2005-2009, have shown that the share of the cost of mineral fertilizers in the total variable costs of wheat production averaged 37% and ranged from 31.2 to 45.5%, and in production of commercial maize averaged 39.7% and ranged from 35.8 to 41.5% (Munćan et al. 2010).

In the initial stages of agricultural intensification mineral fertilizers are used in large quantities in order to achieve maximum yield. However, experience has shown that the increase in yield is not always proportional to the consumed quantities of fertilizer and that it is necessary to examine the amounts of fertilizer that are optimal for a given level of return (Pejin, D., Ljesov Dušanka 1973). Given that in our conditions, production capacities (84% of utilized agricultural land; 98.5% of the total number of tractors)⁴ are mainly owned by family farms/holdings, it is questionable how realistic are the expectations of these farms/holdings to find a solution to the economic optimum yield, and hence the economically optimal use of mineral fertilizers necessary for this yield. Under the current conditions, it could be concluded that family farms are not able to do this.

⁴ According to the results of Agricultural census in year 2012, preliminary results, Statistical Office of the Republic of Serbia, Belgrade.

In most developed countries this is done for them by experts of agricultural extension services. Hence, the Agricultural Land Act from 2006 (The (Official Gazette of RS, 62/06) provided that "for the purpose of protection and preservation of chemical and biological properties of agricultural land, from first to fifth cadastral class, and ensuring the correct use of mineral and organic fertilizers and pesticides, the owner or user of arable land is obligated to control the fertility of arable land and keep a records of the quantities of introduced mineral fertilizers and pesticides. Control of fertility of arable land and of quantities of introduced mineral fertilizers and pesticides is done as needed and minimum every five years ". In laboratories of agricultural services, research institutes and universities in the field of agriculture fertility parameters are analysed and recommendations made for rational fertilization with mineral fertilizers. In the period after the adoption of the Law, owners and users of land, as well as experts of regional agricultural services, sampled the land of family farms/holdings. Total of 70,189 samples were collected and analysed (*Sekulić, P. et al. 2009*). For each analysed sample recommendations for cost-effective and proper fertilization with mineral fertilizers was given in order to ensure an adequate yield.

In this paper, The starting point was the assumption that the intensity of grain production (wheat and maize) can be raised to a higher level by increasing the use of mineral fertilizers per unit area as one of the fastest, simplest and economically most rational measures (does not require additional investments). Determination to increase the level of grain production intensity in this way is the result of survey conducted on family farms/holdings on the territory of Vojvodina. Fact that indispensable information was provided by this survey conducted in Vojvodina has influenced the decision to put this area in the focus of the analysis in this study. Namely, the survey established that family farms/holdings, despite of analyses of soil fertility and received recommendations for the optimal application of mineral fertilizers, by extension services, in most cases (83%) do not respect the recommendations, and apply mineral fertilizers in accordance with their habits and budget. The subject of research presented in this paper is intensity of grain production (wheat mercantile and commercial maize) on family farms/holdings in lowland areas. The research included family farms/holdings covering more than 20 hectares of arable land. The commitment of these farms to be surveyed was based on the fact that according to the last census from 2012, mentioned farms/holdings, although they account for only 2.9% of the total number of farms in Serbia, have the 918,103 ha, or about 33% of the total land used by agricultural family holdings.

Based on the study subject, the research objectives were formulated:

- analysis of the trend of consumption of mineral fertilizers on family farms/holdings in Vojvodina;
- analysis of trend in grain production and yields realized on family farms/holdings in Vojvodina;

- assessment of the effects of intensification of grain production using the recommended amounts of mineral fertilizers.

2. Method and data sources

According to the research objectives, several mathematical and statistical methods were applied. The relative indicators of the structure were used in the analysis of the distribution of wheat and maize on arable land of family farms/holdings. Developments in production and realized yields of wheat and maize, as well as the use of mineral fertilizers on family farms/holdings in Vojvodina were perceived through the relative indicators of dynamics (intersecting growth rate), as well as indicators of descriptive statistics (coefficient of variation, the variation interval).

The effect of application of mineral fertilizers on the yields of wheat and maize in the period 1971-2000 on family farms/holdings in Vojvodina was analysed using the method of correlation-regression analysis. The following types of functions were tested: linear, quadratic, semi-logarithm, double-logarithm and hyperbole. The type of function was finally selected according to the usual indicators of the degree of adjustment to the actual phenomena relation, such as the standard error of regression and correlation coefficient and determination.

Investigated forty year period (1971-2010) was divided into four sub-periods in the following way:

- 1971-1980.
- 1981-1990.
- 1991-2000.
- 2001-2010.

Data on consumption of mineral fertilizers on family farms/holdings in the period 1971-2001 were obtained from statistical newsletters "Crop production, fruit growing and viticulture," published by the Federal Statistical Office until year 2001. Since the Statistical Office of the Republic of Serbia no longer monitors or publishes data on the use and consumption of mineral fertilizers, the data on their consumption for the period 2001-2010 were obtained from FAO databases and related to the total consumption of fertilizers in Republic of Serbia.

The survey conducted on 20 targeted family farms/holdings and 197 cadastre plots of total area of 1,096 ha was used as another important source of data for analysis in this paper. The surveyed farms operated in 6 cadastral municipalities from the territory of the South Banat, as one of the most important agricultural areas in grain production in Serbia. The survey was conducted over four consecutive calendar years (from years 2009 to 2012) and included, among others, the following elements:

- The number and area of cadastral plots;

- Seeding structure, total production and realized yields of wheat and maize;
- Consumed quantities of mineral fertilizers per cadastral plots, and the recommendations of the agricultural extension services for their fertilization;
- The type, amount and cost of mineral fertilizers used in cadastral plots.

In the selection of family farms/holdings in the survey, farms equipped with modern means of mechanization in production and apply the most advanced cropping practices and achieve above average yields in wheat and maize were considered.

When calculating the value of indicators used to determine the economic effectiveness of increasing the intensity of production of wheat, four-year (2009-2012) averages of prices realized on the surveyed family farms/holdings were used. Average prices were used to avoid the influence of extreme environmental conditions on the results achieved in some years (such as drought in year 2012).

3. Results of the research

3.1. Representation of wheat and maize in the sowing structure of family farms/holdings in Vojvodina

Based on the presence of different groups of crops in sowing structure, the direction of crop production and the intensity of use of arable land can be estimated. In addition, analysis of the share of individual crops in planted area indicates to the character of crop rotation and the organizational-economic characteristics of the use of arable land. According to *Molnar (1999)*, crop rotation, in addition to the agro-technical it also has an important organizational - economic and phyto-sanitary meaning in terms of the most rational use of land. On over two-thirds of the arable land of family farms-holdings in Vojvodina, maize and wheat are sown. The average share of wheat and maize in sowing structure in the period 1971-2010 was 69.1% (Table 1). The highest share of these two crops was observed in the second sub-period (1981-1990) when it amounted to maximum of 71.6%. After this period, the share of wheat and maize gradually declined and in the last observed sub-period (2001-2010) it amounted to 64.5%. Maize as the most abundant arable crop on family farms/holdings in Vojvodina is sown on more than 50% of arable land, which determines the crop rotation, the direction and intensity of crop production of family farm/holding. High presence of maize is characterized by constant participation in sowing structure ($C_v = 7,76$).

Table 1: The share of wheat and maize in sowing structure of family farms/holdings in Vojvodina (%)

Period	Average	Variation coefficient	Variation interval	
			minimum	maximum
Wheat				
1971-2010	16,8	17,48	10,4	22,38
1971-1980	17,1	12,71	13,4	19,25
1981-1990	15,8	17,54	10,4	18,81
1991-2000	18,3	17,57	11,50	22,38
2001-2010	16,3	15,21	13,49	21,22
Maize				
1971-2010	52,3	7,76	43,75	60,66
1971-1980	52,1	6,60	43,75	52,92
1981-1990	55,8	5,14	52,55	60,66
1991-2000	51,4	6,19	45,61	58,89
2001-2010	48,2	2,19	47,07	50,71

Source: authors' calculations based on data from the bulletin "Crop production, fruit growing and viticulture" and documentary material, RSO; Belgrade

3.2. The use of mineral fertilizers and the yields realized on family farms/holdings

Keeping in mind the research objective, the starting point was the analysis of mineral fertilizer consumption on family farms/holdings in Vojvodina in the period 1971-2000. This period was taken into consideration because until 2001 data on the consumption of fertilizers on family farms/holdings in Vojvodina were monitored and published by the statistic services. Because since 2001, there is no statistical monitoring of the consumption of mineral fertilizers in Serbia, the single source of data for the period 2001-2010 was FAO database. But the data from this database are not comparable with data for the period 1971-2000 as they relate to the entire territory of the Republic of Serbia. For this reason, testing of interdependence of consumption of mineral fertilizers and achieved yields of wheat and maize on family farms/holdings in Vojvodina was realized through application of correlation-regression analysis, only for the thirty-year period (from 1971 to 2000). The following types of functions were tested: linear, quadratic, semi-logarithm, double-logarithm and hyperbole. The final selection of linear function was made according to the correlation coefficient which was in the production of wheat 0.57 and production of maize 0.74. The data obtained confirmed the initial hypothesis that mineral fertilizers contribute to increases in yields of about 50%.

The use of mineral fertilizers is shown as average consumption per unit area for the entire period and by individual sub-periods. Data on the average consumption of mineral fertilizers were analysed by variation coefficient, interval of variation and

the rate of change (Table 2). The greatest variation in the consumption of mineral fertilizers was recorded in the third sub-period (Cv 111.49) when their consumption ranged from a maximum of 354 kg/ha (in 1991) to only 33 kg/ha (2000). It was in this period that the highest average rate of decline was recorded (23.2% annually). These trends in the consumption of mineral fertilizers were result of the severe economic crisis in Serbia that marked the nineties of the last century.

Table 2: Consumption of mineral fertilizers on family farms/holdings in Vojvodina

Period	Average (kg/ha)	Variation coefficient	Variation interval		Average growth rate
			Minimum	Maximum	
1971-2000	275	57,6	33	474	-6,82
1971-1980	314	17,63	256	426	5,82
1981-1990	428	10,08	323	474	-2,16
1991-2000	84	111,49	33	354	-23,2
2001-2010	123	19,89	80	153	5,51

Source: authors' calculations based on data from the bulletin "Crop production, fruit growing and viticulture" and documentary material, RSO; Belgrade

Average realized yields of wheat and maize were also expressed per unit area, both for the individual sub-periods, and for the total period, and were statistically analysed using the coefficient of variation, the interval of variation and the rate of change (Table 3). The degree of yield variability (Cv) can be regarded as an indicator of the degree of intensity of production. In intensified productions coefficient of variation is lower, because more intensive investing practically reduces the impact of objective factors on yield. In addition, the high coefficient of variation of yield indicates also the changes in the degree of production intensity, which is most often caused by changes in the economic conditions of production.

During the forty-year period, the yield of wheat had general tendency of increase (rate of 0.26% per year) and was accompanied by significant variation (Cv = 16.79). At the beginning of the analysed period, wheat yield exhibited a tendency to increase at an average annual rate of 1.07 to 1.93%. The nineties of the last century were marked by the great economic crisis (caused by UN sanctions and war events in the former Yugoslavia) that had exceptional major impact on wheat production. Namely, the trends in wheat yields in this period are characterized by the greatest variation (Cv = 17.05) showing the tendency of decrease at an average annual rate of - 5.33%. Yield decrease was primarily caused by low consumption of mineral fertilizers per unit area as a consequence of the depletion of family farms/holdings due to the economic crisis. Despite this state, the trend in yield of wheat at the end of the analysed period (2001-2010) exhibited a slight tendency of increase (growth rate 1.07%), but the level of realized average yields decreased by

11% compared to the level realized in the first period of analysis (1971-1980) and decreased by 22% compared to the level achieved in the period 1981-1990, characterized by the highest average yields achieved in total analysed period. The above stated results show that the potentials of family farms/holdings in the production of grain are not used sufficiently. This can be ascertained by comparing the actual average yields in the developed European countries. Thus, the average wheat yields achieved in the period 2001-2010 were: in France, 6.96 t/ha, Germany 7.42 t/ha, in the Netherlands, 8.57 t/ha while on family farms/holdings in Vojvodina it was only 3.53 t/ha.

Table 3: The trend in regard to yield of wheat and maize on family farms/holdings in Vojvodina

Period	Average (t/ha)	Variation coefficient (Cv)	Variation interval		Average growth rate
			Minimum (t/ha)	Maximum (t/ha)	
Wheat					
1971-2010	3,94	16,79	2,69	5,22	0,26
1971-1980	3,69	15,66	2,69	4,75	1,07
1981-1990	4,51	7,59	3,99	5,22	1,93
1991-2000	3,63	17,05	2,77	5,11	-5,33
2001-2010	3,53	15,34	2,09	4,36	1,07
Maize					
1971-2010	4,93	21,81	3,62	6,83	-0,38
1971-1980	5,23	11,64	4,33	6,18	3,38
1981-1990	5,56	18,55	3,62	6,61	-4,99
1991-2000	4,12	25,09	3,88	6,83	-6,09
2001-2010	5,08	16,91	3,34	6,18	1,36

Source: authors' calculations based on data from the bulletin "Crop production, fruit growing and viticulture" and documentary material, RSO; Belgrade

The trend in yield of maize during the whole period was accompanied by a much higher variation (Cv = 21.28), with a tendency of decline at an average annual rate of 0.38%. The highest rate of growth in maize yield was in the second sub-period average of 3.38%, while the most significant decline in yield was characteristic of the nineties (rate - 6,09). The last ten years of the analysed period, were characterized by somewhat smaller variation of maize yield and average annual growth rate of 1.36%. Based on the comparison of average maize yield achieved during this period (5.08 t/ha) with the same in France (8.77 t/ha), Germany (9.03 t/ha) and the Netherlands (11.42 t/ha) it can be concluded that in this production there may well be great opportunities for its intensification.

3.3. The main features and results achieved by surveyed family farms/holdings

The average area of arable land used by surveyed family farms/holdings was 54.8 ha (Table 4) and ranged from 32.5 to 96.8 ha.

Table 4: Properties of the farms investigated

Indices	Average for the farms
Arable land area (ha):	54,8
- Own land	36,7
- Leased land	18,1
Number of plots per holding	9,85
Average plot size (ha)	5,56
Share of wheat and maize in sowing structure (%):	
- wheat	24,3
- maize	53,1
Consumed quantities of mineral fertilizers in	
- NPK	250
- AN	200
Consumed quantities of mineral fertilizers in	
- NPK	300
- UREA	200
The cost of use of mineral fertilizers (RSD/ha):	
- Production of wheat	15.400
- Production of maize	18.500
Realized yields (t/ha):	
- wheat	5,12
- maize	7,58

Source: author's calculation based on Survey data

The average size of the land plot was 5.56 ha, and the average total number of plots per farm was 9.85 and ranged from 6 to 18. Grain (wheat and maize) crops represent a dominant crop group in the studied family farms/holdings with an average share during the study period of 77.4%. Sowing structure which, in addition to wheat and maize, included also sunflower, can be explained by the fact that the farms were very well equipped with modern means of agricultural machinery allowing them rational implementation of modern agricultural measures and practices (techniques) and manufacturing technology and the realization of very high labour productivity.

The average realized yields of wheat and maize on family farms/holdings surveyed in period 2009-2012 were higher than the same in Vojvodina by 33% and 42%. Compared to the average achieved yields in developed European countries (France,

Germany, the Netherlands) it can be concluded that the average yields of wheat achieved by the studied family holdings were lower by about 30% and of maize by 13 to 32%.

3.4. Economic Effects of intensification of grain production

Based on data collected in the survey on elements of technology and agricultural practices and measures (techniques) in grain production present on observed family farms/holdings, analytic calculations were composed on the basis of direct variable costs (Table 5). As the main indicator of economic efficiency of intensification of wheat production, the gross margin was used representing the difference between the realized value of production and total variable costs (seed, mineral fertilizer, pesticides, diesel fuel, the cost of land lease, etc.).

Table 5: Calculation of wheat and maize production

Elements	Average	Projected	Difference
1	2	3	4
W h e a t			
Yield t/ha	5,12	6,3	1,18
A) Value of production (RSD)	79.360	97.650	18.290
B) Direct variable costs			
- seed	9.800	9.800	-
- mineral fertilizer	15.400	21.210	5.810
- plant protection preparations	3.360	3.360	-
- diesel fuel	10.814	10.814	-
- cost of land lease	7.800	7.800	-
Total variable costs (RSD)	47.174	52.984	5.810
C) Gross margin C = (A-B) (RSD)	32.186	44.666	12.480
M a i z e			
Yield t/ha	7,58	9,2	1,62
A) Value of production (RSD)	109.910	133.400	23.490
B) Direct variable costs			
- seed	12.544	12.544	-
- mineral fertilizer	18.500	26.019	7.519
- plant protection preparations	5.170	5.170	-
- diesel fuel	14.860	14.860	-
- cost of land lease	7.800	7.800	-
Total variable costs (RSD)	58.874	66.393	7.519
C) Gross margin C = (A-B) (RSD)	51.036	67.007	15.971

Source: Authors' calculations based on data from the Survey

*Actual direct variable costs of the surveyed holdings for the period 2009-2012.

**Projected direct variable costs based on recommendation of the agricultural extension services, in regard to fertilization using the mineral fertilizers

Respecting of the recommendations given by the agricultural extension services, in regard to rational fertilization with mineral fertilizers, for family farms would mean additional production costs in production of wheat and maize by 37.7% and 40.6%, respectively. The increase of average wheat yield of 18.7% and 17.6% for maize was a result of additional investments in mineral fertilizers, their production value increased by 23% and 21%, and gross margins per unit area by 38.7 and 31.3%, respectively. Based on the presented results it can be concluded that the increased costs of using mineral fertilizers are fully justified because of the increased value of production which fully covers these costs and makes a positive difference in gross margins. Therefore, the obtained results indicated that there were significant opportunities to increase the intensity of grain production on family farms/holdings, using larger quantities of mineral fertilizers per unit area.

4. Conclusion

In the last twenty years, the total consumption of mineral fertilizers on family farms/holdings, both absolutely and per unit area manifested a tendency of decrease. The decrease was particularly characteristic of the nineties of the last century, caused by the economic crisis and the reaction of farmers to disruptions in regard to price parities of fertilizer and grain prices. Decline in use of mineral fertilizers resulted in a decrease in the yield of wheat and maize. Compared to the average achieved yields in developed European countries (France, Germany, the Netherlands) it can be concluded that the average yields of wheat achieved by the studied family holdings were lower by about 30% and of maize by 13 to 32%. The above stated results show that the potentials of family farms/holdings in the production of grain are not used sufficiently and that there is potential to increase the intensity of this production by increased use of mineral fertilizers per unit area as one of the fastest, simplest and economically most rational measures.

If we accept the estimate that in the foreseeable future it will not be possible to significantly improve the level of expertise of family farmers and owners of family holdings, then this unfavourable situation can be alleviated with increased efforts of agricultural extension agents, as well as scientists, researchers and experts in the field of agronomy. In this way, the results of the analysis of soil fertility would be taken seriously and used in the practice of family farms/holdings which would create conditions for increasing not only the intensity of grain production but also its competitiveness.

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