The effect of the application of complex and mixed fertilizers on wheat yield and soil fertility

Nikola Koković[1*], Mirjana Kresović[2], Vesna Mrvić[1], Biljana Sikirić[1], Darko Jaramaz[1], Elmira Saljnikov[1]

[1]Soil Science Institute, Teodora Drajzera 7, 11000 Belgrade, Serbia

[2]Faculty of Agriculture, Belgrade University, Nemanjina 6, 11080, Belgrade

**Corresponding author*: Nikola Koković: nkokovicml@yahoo.com

Abstract

Crop productivity and soil fertility of arable lands largely depends on the applied fertilizer, including their composition, dosage and way of application. In the paper, a comparison of the fertilization values of different composite fertilizers was performed. The complex composite and different mixed fertilizers with fillers (lime and zeolite) were used in two experiments on two types of soil, Pseudogley and Cambisol. The grown crops were wheat and corn. The results showed no significant differences between applied fertilizers in terms of crop yield and nutrient uptake. Use of lime and zeolite as filler didn't result in increase of the fertilization effect of the applied fertilizers. The way of distribution of composite fertilizers influenced on the overall fertilization effect. Manual application of mixed fertilizers had better fertilization effect in comparison to mechanical spread, while use of complex fertilizers mechanically had better effect in comparison to blended mixed fertilizers.

Keywords: composite fertilizer, mixed fertilizer, fillers, nutrients

INTRODUCTION

In today's agronomic practice the complex fertilizers represent irreplaceable factor of successful fertilization. Using the complex spreader simultaneously provides a number of essential nutrition and application of all three main (NPK) macroelements that has a better effect on the crop yield and reduces the total cost of application of fertilizers on the other side (Popović et al., 1970). Composite fertilizers are divided into: complex, semi-complex and mixed.

To increase the efficiency of fertilizers is necessary to ensure uniformity of scattering, and this should be done so that all plants have the same amount of added nutrients. Uniformity of granulometric composition of fertilizer is of great influence because it depends on the uniformity of dispersion. Unevenly applied fertilizers lead to uneven development of plants, because of uneven nutrition of plants resulting in no real gain from the use of fertilizers, but great economic

losses in the agricultural production (Đevic et al., 2009), because mixed blended fertilizer does not provide homogeneous distribution of applied fertilizer over the entire surface.

Thus, for obtaining a good mixed fertilizer, the starting components or individual fertilizers should be not much different in grain size and bulk density.

Stanojlović and Milovanovic (1983) considering the application of fertilizers in bulk, indicated the advantages of this method of use of fertilizers, but also to the very small application of it in Serbia. The same authors point out the following defects, which occur during the handling and application of mineral fertilizers in bulk: possibility of greater wastage of fertilizers, difficulties in the precise dosing, problematic downloading and transport and storage of bulk fertilizers, or their application. Main aim of the study is to compare the fertilization value of mixed versus complex fertilizers.

MATERIALS AND METHODS

Site description

To establish the fertilization values of the complex and different mixed fertilizers the filed experiments were set up on to two soil types: Eutric Cambisol in Mladenovac and Pseudogley in Varna, Serbia. Grown crop was wheat, "Europe" variety. The plot area was 24 m^2.

The first experiment on Pseudogley soil was performed in a randomized, block system with four replications with the following treatments: 1. Non-fertilized (Control); 2. Complex blended granulated composite fertilizer NPK (15:15:15) 400 kg/ha; 3. Mixed blended granulated composite fertilizer with lime as a filler (NPK (15:15:15)) 400 kg/ha; 4. Mixed blended granulated composite fertilizer with zeolite as a filler (NPK (15:15:15)) 400 kg/ha; 5. Mixed blended granulated composite fertilizer without filler (NPK (15:15:15)) 400 kg/ha; 6. Mixed composite fertilizer without filler, non-granulated (powdered); 7. Compacted mixed granulated composite fertilizer (NPK (15:15:15)) 400 kg/ha.

The second experiment was set up on two soil types (Cambisol and Pseudogley) with three treatments, each of four replications: 1. 600 kg blended mixed fertilizer, treated by cyclone spreader, NPK 15:15:15; 2. 600 kg blended mixed fertilizer, treated manually NPK 15:15:15; 3. 600 kg complex fertilizer NPK 15:15:15, treated by cyclone spreader.

In the 1st and 2nd treatments the used mixed fertilizer originated from local factory in Pancevo. The fertilizer was obtained by mixing single fertilizers: potassium chloride, mono-

ammonium phosphate and calcareous ammonium nitrate. In the 3rd treatment a complex fertilizer from Russia was used.

As a main parameter of fertilizer effect on plant, a grain yield was measured. As a main parameter of fertilizer effect on soil, a soil fertility parameters were determined. Every composite soil sample was an average of 20 sub-samples.

Analytical methods

Content of soil humus was determined by Tyurin method (Nelson & Sommers 1996) and total nitrogen (N) by the Kjeldahl method (Mineev et al., 2001). Available P and K were determined by the Egner-Riehm method (Enger and Riehm1958); soil acidity was measured in KCl solution electrometrically; content of available Ca and Mg was determined in soil solution extracted by CH_3COONH_4 and measured on AAC.

RESULTS

Table 1 presents the air temperature and precipitation in the studied years (2005-2007), and average for 40 years. Average air temperatures and precipitation during the experimental period were similar to the long-term average in both sites, correspondingly. Between the sites, sum of precipitation was higher in Varna site than in Mladenovac. For both sites, a shortage of precipitation was observed at the end of vegetation season.

Agrochemical analyses showed that both soil types are very acidic, moderately supplied with humus, phosphorus and potassium. In spite of low pH, content of Ca and Mg in soil is satisfactory (Table 2).

Effect of composite fertilizers on wheat yield on Pseudogley was significant (Table 3), where yield gain in fertilized treatments was for average 1.47 t/ha higher than in the control treatment. Fertilizer application resulted in the yield increased compared to the unfertilized treatment from 2 to 2.42 times depending on the treatment. The largest increase in yield was observed in the treatment with a complex fertilizer, although it was not statistically significant compared to the other treatments with various mixed fertilizers.

Table 1. Climatic characteristics of the studied sites

Varna experimental site													
years	Months												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aver.
	Average monthly air temperatures (°C)												
2005	0.0	-2.9	4.4	11.1	16.9	19.2	21.5	19.7	17.3	11.6	4.9	2.2	10.5
2006	-1.4	0.9	5.6	12.5	16.4	19.6	22.8	19.1	17.5	13.1	7.1	2.7	11.3
Ave. 1964-2002	0.0	2.4	7.0	11.7	17.2	20.4	21.9	21.5	17.0	11.7	6.1	1.5	11.6
	Precip[pitation (mm)												Sum
2005	37.3	75.7	56.6	63.3	78.4	97.8	113	139	60.8	16.3	38.9	82.4	859.1
2006	38.8	46.7	98.9	89.8	59.5	115	38.7	165	24.9	32.2	29.7	55.8	795.2
Ave. 1964-2002	48.2	41.3	46.1	54.6	62.0	84.6	72.1	57.7	56.7	58.4	60.5	61.4	701.0
Mladenovac experimental site													
years	Months												Aver.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
	Average monthly air temperatures (°C)												
2007	6.1	6.6	9.3	12.2	18.5	22.7	24.6	23.4	15.5	10.9	5.0	0.6	13.0
Ave. 1964-2002	-0.4	2.0	6.3	11.5	16.3	19.3	20.9	20.4	16.7	11.2	6.2	1.6	11.0
	Precipitation(mm)												Sum
2007	46.0	48.8	47.4	1.1	121	64.5	15.3	41.8	62.0	86.9	91.8	41.4	667.9
Ave. 1964-2002	44.4	39.9	46.9	50.0	69.9	91.0	58.9	46.6	47.5	39.8	52.5	48.8	636.2

Table 2. Soil fertility characteristics of studied soils

Soil type	pH in KCl	Humus %	P_2O_5	K_2O	Ca mg/100g	Mg	Ca/Mg
Pseudogley	3.85	2.81	8.11	12.15	271	42.2	6.4
Eutric Cambisol	4.01	3.01	7.92	19.01	305	24.5	12.5

Table 3. Effect of different composite fertilizers on wheat yield on Pseudogley soil (2005-2006)

No.	Treatments	Yield, t/ha	Index
1	Control (non-fertilized)	0.68a*	100
2	Complex blended granulated composite NPK 15:15:15-400 kg/ha	2.33b	342
3	Mixed blended granulated composite fertilizer with lime as a filler NPK (15:15:15) 400 kg/ha	2.14b	314
4	Mixed blended granulated composite fertilizer with zeolite as a filler NPK (15:15:15) 400 kg/ha	2.05b	300
5	Mixed blended granulated composite fertilizer without filler (NPK (15:15:15)) 400 kg/ha	2.13b	312
6	Mixed composite fertilizer without filler, non-granulated (powdered)	2.20b	323
7	Compacted mixed granulated composite fertilizer (NPK (15:15:15)) 400 kg/ha	2.12b	311

*different letters mark significant differences at p = 0.01

A relatively small average yield can be explained by a very unfavourable climatic condition for the year. There was strong rainfall in November and December, well above the long-term average for these months. Such conditions in this poorly permeable soil caused the occurrence of surface water and its adverse impact on the development of plants and tillering of wheat. On the other hand, we can say that the use of fertilizers in such unfavourable conditions was very effective.

The results of this experiment show that manual spreading of fertilizers leads to more homogenous distribution of nutrients over arable land, and to approximately equal effect of mixed and complex fertilizers on yield. Similar results, using a mixed and complex fertilizers was reported by Šestić (1969). However, Popovic et al., (1962) by using a single, mixed granular and complex fertilizers, in a field trial with number of crops did not confirm the priority of any of the mentioned types of fertilizers. They just emphasize some advantages of mixed granular and complex fertilizers comparing to the fertilizer powder. Šestić (1969), based on three-year experiment concluded that the single, mixed and complex fertilizers on all soils resulted in approximately the same yield, and one cannot be sure about substantial impact of some fertilizer elements on the utilization of other elements. Benyuan (2001), in a trial with rice in water deficit conditions, also found no difference in the effect on yield, between the complex and mixed fertilizers. Our results had shown that the use of different fillers in mixed fertilizer was not effective in terms of crop yield.

Applied fertilizers contained following nitrogen forms: in the blended mixtures in treatments 6, 3 and 4, the urea form, in a complex and compacted mixed in the treatments 2 and 7 the ammonia, nitrate and urea in the mixture, and in the treatment 5 the ammonia nitrate. Therefore, it can be concluded that the plants equally reacted to form of nitrogen in composite fertilizers, and that the quantity of nutrients was the main factor which affected the yield.

Results of the second experiment show that in both types of soil the highest yield was obtained in the treatment that received the complex fertilizer (treatment 3), and the smallest (except 2005 in Varna) in the treatment with the mixed fertilizer applied with spreader (treatment 2).

Table 4. Effect of fertilizer type on corn yield as influenced by composite fertilizers applied manually and mechanically

No.	Treatments	Pseudogley Wheat, 2006		Cambisol Wheat, 2007	
		t/ha		t/ha	
1	Mixed fertilizer, NPK 15:15:15 (manually)	2.85a*	100	4.87a	100
2	Mixed fertilizer, NPK 15:15:15 (spreader)	2.69a	94	4.78a	97
3	Complex fertilizer, NPK 15:15:15 (spreader)	3.08a	108	5.25a	104

*the same letters signify no significant differences between treatments in a column

Application of the complex fertilizer by spreader machine manure (treatment 3) resulted in yield gain of corn for 4 % and for wheat for 10 % in both soil types (in Mladenovac and Varna, respectively) in comparison to a mixed fertilizer applied in the same way (treatment 2). Complex

fertilizer had a favorable effect comparing to the treatment with a mixed fertilizer with manually spread (treatment 1).

In comparison to the mixed fertilizers spread out mechanically (treatment 2), the treatment with manual spreading (treatment 1) resulted in higher yields of wheat (for 2-6%) in Mladenovac and Varna, but the differences were not statistically significant. The results assume that the manual application of mixed fertilizers leads to a more homogenous distribution of nutrients in relation to mechanical dispersion, thereby achieving a better fertilizing effect. Studies of the influence of uneven distribution of fertilizer have shown that it has a considerable influence in respect to a possible increase in the yield, and this influence is more pronounced at higher amount of applied fertilizer (Popovic, 1985). Mijušković (1960), based on the yields of wheat and corn was found that the same amount of active substance, i.e., nutrient in complex fertilizers showed a greater effect than the same amount of active substance from the ordinary mixed fertilizers. Schmitt (1961), based on the results of comparative testing of single and complex fertilizers concluded that both systems provide substantially the same results, although in some cases the complex fertilizers give slightly higher yields than single fertilizer.

To determine whether different types of composite fertilizer and the method of application influence the uniformity of distribution of nutrients in soil, the contents available forms of P and K at a different distance (0.5, 2 and 3.5 m) from the edge of the plot were analysed Table 5).

Table 5. Content of available P and K in Eutric Cambisol after 3-years application of composite fertilizers applied manually and mechanically

No.	Treatments	Distance from the edge of the plot, m	P_2O_5 mg/100g	K_2O mg/100g
1	Mixed composite fertilizer, NPK-15:15:15, (manually) 600 kg/ha	0.5	8.50a*	20.11a
		2	8.30a	22.30a
		3.5	9.08a	21.90a
2	Mixed composite fertilizer, NPK-15:15:15, (spreader) 600 kg/ha	0.5	8.89a	23.20a
		2	8.36a	21.80a
		3.5	7.96a	22.40a
3	Complex composite fertilizer, NPK-15:15:15, (spreader) 600 kg/ha	0.5	8.87a	21.02a
		2	9.19a	19.80a
		3.5	9.15a	20.90a

**the same letters signify no significant differences between treatments in a column

The results indicate no significant difference in homogeneity of distribution of basic nutrients in the soil surface of different treatments. Brkovic et al. (2002) found that the poor harvest of some vineyards was due to positional accessibility of nutrients, which occurs due to uneven distribution of mineral fertilizers.

Koković et al (2013) experimentally proved that application of mixed fertilizer by cyclone spreader doesn't allow even distribution of nutrients over the entire surface due to inhomogeneities of the fertilizer and due to the different bulk density of the granules of individual fertilizers.

CONCLUSIONS

Between the complex and mixed, as well as between different mixed fertilizers, applied manually in the same amount of NPK nutrients, no statistically significant difference in the overall effect on the yield and the removal of nutrients except for a small increase in yield in the treatment with a complex fertilizer, but not statistically confirmed.

The use of lime and zeolite as a filler in the manufacture of mixed NPK fertilizer did not resulted in an increase of their fertilization value. The use of zeolites as fillers obviously decreased the hygroscopicity and caking of mixed NPK fertilizers, comparing to the lime

The way of distribution of complex fertilizers has affected their overall fertilizing effect. Manual application of mixed fertilizer had a better fertilizing effect due to homogenous distribution of nutrients in comparison to the machine cyclonic distribution. Also the application of the complex fertilizer by machine showed better effect compared to the blended mixed fertilizers.

After three years the application of complex and mixed fertilizers in two soil types (Pseudogley and Cambisol), were not recorded significant differences in the amount of applied NPK nutrients in soil, and in the homogeneity of their distribution.

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