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THE INFLUENCE OF ORGANIC AND MINERAL FERTILIZATION ON YIELD OF THE WHEAT GROWN ON REDDISH PRELUVOSOIL

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Abstract

The purpose of this paper is to present the results obtained on the reddish preluvosoil of the Moara Domnească experimental field belonging to the Department of Soil Sciences from Faculty of Agriculture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, in the agricultural year 2014-2015. Wheat crop was part of a wheat-barley-sugar beet crop rotation. The experiment was a two-factor concept based on the split plot method, organised in three replications, with factor A - organic fertilization and factor B - mineral fertilization. Plant residues and manure were used as natural organic fertilizers. The variants of factor B were different rates of mineral nitrogen. Obtained results showed that organic and mineral fertilization increased wheat yield. Variant a_3 was the best for organic fertilization - 40 t/ha leaves and epicotyls of sugar beet+N_{50}, while the optimum solution for mineral fertilization was b_4 - N_{150}. For the organically unfertilized variants, the highest yield resulted from mineral fertilizer with N_{200} (b_5), but N_{100} (b_2) was the best economic solution because of the number of fall plants.

***Key words**: wheat, organic fertilization, mineral fertilization, nitrogen.*

INTRODUCTION

Wheat is a multi-purposes cereal, which is rich in nutrients necessary for human consumption (carbohydrates, proteins, lipids), but which is also used for feeding animal. Wheat straw can be used in animal nutrition and bedding, and not least as fertilizer. Wheat stubble incorporated under the furrow increases organic matter in the soil (Săndoiu et al., 2012; Ştefanic et al., 2015). To obtain a high yield of wheat, it is recommended to include it in a rational rotation (Ciontu et al., 2010; Săndoiu et al., 2007). Wheat monoculture should be avoided as it leads to the expansion of wheat-specific diseases, pests and weed appearance, which results in the gradual reduction in the obtained yields (Săndoiu et al., 2008, 2012). As a basic element in plant nutrition, nitrogen is the main ingredient of wheat proteins and additional application helps increase its protein content (Borlan and Hera, 1994; Criste, 2012)

In their nutrition, plants accumulate nitrogen from the soil in ammonia and nitric form, and convert it through amination and transamination reactions in protein substances (Borlan and Hera, 1994).

To optimize the application of mineral nitrogen, wheat requirements must be taken into consideration, together with the conditions provided by the soil (Dincă et al., 2010; Gîdea et al., 2015). The exclusive use of chemical fertilizers does not reduce the importance of manure. The largest gains at harvest are obtained from the combined action of chemical fertilizers with manure (Obrişcă et al., 2010; Criste, 2012).

MATERIALS AND METHODS

Research on organic and mineral fertilization for growing winter wheat on reddish preluvosoil began in 1991, in the experimental field belonging to the Department of Soil Sciences from Faculty of Agriculture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, which is located at Moara Domnească Farm (Ilfov County from South Romania). The present paper presents the results obtained in 2014-2015. Wheat crop was part of a wheat-barley-sugar beet rotation.

The two factors experience was organised by the split plot method, in three replications with factor A - organic fertilization and B - mineral fertilization.

Factor A - organic fertilization included three experimental graduations: a_1 - unfertilized; a_2 -

30 t/ha of manure applied at preceding crop (wheat benefited of the residual effect of the manure applied at the preceding crop, which was sugar beet); a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50} (50 kg/ha of nitrogen applied in autumn).

Factor B - mineral fertilization included five graduations: b_1 - unfertilized; b_2 - N_{60}; b_3 - N_{100}; b_4 - N_{150}; b_5 - N_{200}.

A mineral background of 70 $kg.ha^{-1}$ of phosphorous was provided for all experimental plots. In the field experiment, it was used Glosa wheat cultivar.

Each variant of organic and mineral fertilization was placed in three replications for a better accuracy of the results. So, the field experiment had in total 45 experimental variants.

The determinations carried out in the experimental variants were aimed at measuring the yield, the hectoliter mass and the thousand grains weight (TGW). The results were calculated and statistically interpreted by method of variance analysis.

RESULTS AND DISCUSSIONS

The influence of organic fertilization on the winter wheat yield is presented in Table 1.

Table 1. Influence of organic fertilization on winter wheat yield (Moara Domnească, 2014/2015)

Experimental variant	Yield		Difference		Significance
	q/ha	%	q/ha	%	
a_1 - unfertilized organically	52.17	100.00	Control	-	
a_2 - 30 t/ha of manure applied to the preceding crop	55.60	106.57	3.43	6.57	*
a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N_{50}	75.35	144.43	23.18	44.43	***

$LSD_{5\%}$ = 2.235 q/ha; $LSD_{1\%}$ = 3.698 q/ha; $LSD_{0.1\%}$ = 6.922 q/ha

The analysis of the data presented in Table 1 shows the following outcome: the yield of winter wheat was influenced by organic fertilization, so it increased from 52.17 q/ha for a_1 - unfertilized organically variant, to 55.60 q/ha in a_2 - 30 t/ha of manure applied to the preceding crop, reaching 75.35 g/ha in a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N_{50}.

The 30 t/ha of manure applied to the preceding crop caused an increase in yield by 3.43 q/ha, which represented an increase of 6.67%.

The application of 40 t/ha leaves and epicotyls of sugar beet + N_{50} resulted in an increased wheat yield by 23.18 q/ha, which represented a 44.43% growth in yield.

In terms of organic fertilization, optimal variant is the variant a_3, which ensures the highest yield increase.

Table 2 shows the influence of mineral nitrogen fertilization in the absence of organic fertilization on wheat yield.

Table 2. Influence of mineral nitrogen fertilization in the absence of organic fertilization on yield of winter wheat (Moara Domnească, 2014/2015)

Experimental variant	Yield		Difference		Significance
	q/ha	%	q/ha	%	
$b_1 – N_0$	52.17	100.00	Control	-	
$b_2 – N_{60}$	70.08	134.33	17.91	34.33	***
$b_3 – N_{100}$	81.99	157.16	29.82	57.16	***
$b_4 – N_{150}$	83.97	160.95	31.80	60.95	***
$b_5 – N_{200}$	95.31	182.69	43.14	82.69	***

$LSD_{5\%}$ = 1.526 q/ha; $LSD_{1\%}$ = 2.074 q/ha; $LSD_{0.1\%}$ = 2.779 q/ha

Winter wheat yield increased proportionally with the amount of applied mineral nitrogen, as follows: for the unfertilized variant 52.17 q/ha, for N_{60} - 70.80 q/ha, for N_{100} - 81.99 q/ha, for N_{150} - 83.97 q/ha, and for N_{200} - 95.31 q/ha. Compared to the control variant (unfertilized), the rate of N_{60} resulted in a yield increase by 17. 91 q/ha, meaning a growth of 34.33%.

The application of a rate of N_{100} generated an increased yield, compared to the control variant of 29.82 q/ha, representing 57.16%.

The rate of N_{150} led to an increase in yield by 31.8 q/ha, representing 60.95%. Increasing the rate of nitrogen to N_{200} generated a yield growth of 43.14 q/ha, compared to the control variant by 82.69%

N_{200} variant was not recommended for mechanized harvesting since the degree of fall plants was 42% on average, which would decrease the harvested yield.

Variant b_4 - fertilization N_{150}, was also not recommended from an economic point of view because, compared with the N_{100} variant, it led to an increase of yield of only 1.98 q/ha. The added yield value was 99 lei/ha while the amount of fertilizer applied in addition to the N_{100} cost about 181 lei/ha. Therefore, from the economic point of view, the optimal variant was b_3 - N_{100}.

The analysis of the data presented in Table 3 shows the following results: mineral nitrogen fertilization, without any organic fertilization, had the greatest influence on all experimental variants; the maximum increase in yield was 43.14 q/ha at b_5 - N_{200}.

Mineral nitrogen application rates on a background of 30 t/ha of manure applied to the preceding crop resulted in a progressive yield increase; however, the increase rates were much lower, compared with the variant unfertilized organically. In variant a_2 - 30 t/ha of manure applied to the preceding crop, the optimal economic choice was N_{150}.

The influence of mineral nitrogen fertilization on a background of 40 t/ha of leaves and epicotyls of sugar beet + N_{50} has a much lower effect, of only 29.46 q/ha, although it obtained the highest yield of winter wheat.

Variant b_5-N_{200} caused a decrease in yield with 1.08 q/ha, compared to version b_4 - N_{150}, plus a high degree of fall plants; therefore, the optimal variant was b_4 - N_{150}.

Table 3. Influence of organic and mineral fertilization on the yield of winter wheat (Moara Domnească, 2014/2015)

Mineral fertilization	a_1 - unfertilized organically			a_2 - 30 t/ha of manure applied to the preceding crop			a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N_{50}		
	Yield (q/ha)	Difference (q/ha)	Significance	Yield (q/ha)	Difference (q/ha)	Significance	Yield (q/ha)	Difference (q/ha)	Significance
b_1 - N_0	52.17	Control		55.60	Control		75.35	Control	
b_2 - N_{60}	70.08	17.91	***	71.01	15.41	***	86.37	11.02	***
b_3 - N_{100}	81.99	29.82	***	76.07	20.47	***	100.38	25.03	***
b_4 - N_{150}	83.97	31.80	***	87.92	32.32	***	104.81	29.46	***
b_5 - N_{200}	95.31	43.14	***	89.23	33.63	***	102.73	27.38	***

$LSD_{5\%}$ = 2.645 q/ha; $LSD_{1\%}$ = 3.595 q/ha; $LSD_{0.1\%}$ = 4.815 q/ha

The analysis of the data presented in Table 4 shows the following: organic nitrogen fertilization recorded in 40 t/ha of leaves and epicotyls of sugar beet + N_{50}, determined the most significant yield increase.

Table 4. Influence of organic fertilization on the yield of winter wheat at the same levels of mineral fertilization (Moara Domnească, 2014/2015)

Mineral fertilization	Comparison between organic fertilization variants					
	a_2 - a_1		a_3 - a_1		a_3 - a_2	
	Difference (q/ha)	Significance	Difference (q/ha)	Significance	Difference (q/ha)	Significance
b_1 - N_0	3.43	*	23.18	***	19.75	***
b_2 - N_{60}	16.29	***	16.29	***	15.36	***
b_3 - N_{100}	5.92	**	18.39	***	24.31	***
b_4 - N_{150}	3.95	*	20.84	***	16.89	***
b_5 - N_{200}	-6.08	00	7.42	**	13.50	***

$LSD_{5\%}$ = 3.218 q/ha; $LSD_{1\%}$ = 4.752 q/ha; $LSD_{0.1\%}$ =4.752 q/ha

Organic fertilization on a mineral background of N_{200} caused lower yield than mineral fertilization on a N_{150} background, therefore is not justified economically and the optimal variant for mineral fertilizer must be lower than N_{150}.

As we can see, the yield was lower than the control variant with 6.08 q/ha. The best option was organic fertilization variant of a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50}, with a mineral fertilization background b_4 - N_{150}. The influence of 40 t/ha leaves and epicotyls of sugar beet + N_{50} is visible for all variants of mineral fertilizer.

In the analysis of the data presented in Table 5, there is shows that hectoliter mass was influenced by the increase of organic fertilization. The highest hectoliter mass was obtained in variant a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50}, generating a variation (1.76%) between a_2 - 30 t/ha of manure applied to the preceding crop.

Table 5. Influence of organic nitrogen fertilization on hectoliter mass for winter wheat (Moara Domnească, 2014/2015)

Experimental variant	Hectoliter mass		Difference		Significance
	kg/hl	%	kg/hl	%	
a_1 - unfertilized organically	79.8	100.00	Mt	-	
a_2 - 30 t/ha of manure applied to the preceding crop	80.1	100.37	0.30	0.37	
a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N_{50}	81.5	102.13	1.7	2.13	***

$LSD_{5\%}$ = 0.52 kg/hl; $LSD_{1\%}$ = 0.86 kg/hl; $LSD_{0.1\%}$ = 1.60 kg/hl

The hectoliter mass analysis is widely used in agriculture and cereal processing industry. Hectoliter mass is mainly used in determining the degree of extraction of flour and determining storage space.

The analysis of the data in Table 6 shows that hectoliter mass increased with the amount of total nitrogen and variant a_3b_5 ensured the highest hectoliter mass (82 kg/hl). For some organic fertilization variants, using b_5 - N_{200} was not the best option as the hectoliter mass decreased once the rate of mineral nitrogen was higher. For the variant a_1 - unfertilized organically, we can observe that the hectolitre mass increases until a certain dose of mineral nitrogen (b_4 - N_{150}), after that it declines. For organic variant a_2 - 30 t/ha of manure applied to the preceding crop, the maximum hectolitre mass is reached for mineral dose of b_3 - N_{100}, after which the decline starts. Nevertheless, analysing the values below we can see that the best results were obtained in the organic variant a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50}, regardless of the mineral nitrogen used. The variation between the nitrogen rates used for variant a_3 was not significant, meaning that for the hectoliter mass the plant residue worked very well in combination with mineral nitrogen.

Table 6. Influence of mineral and organic fertilization on winter wheat hectoliter mass (Moara Domnească, 2014/2015)

Mineral fertilization	a_1 - unfertilized organically			a_2 - 30 t/ha of manure applied to the preceding crop			a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N_{50}		
	H.M. (kg/hl)	Difference (kg/hl)	Significance	H.M. (kg/hl)	Difference (kg/hl)	Significance	H.M. (kg/hl)	Difference (kg/hl)	Significance
b_1 - N_0	79.8	Control		80.1	Control		81.5	Control	
b_2 - N_{60}	80.6	0.80		81.3	1.20	**	81.8	0.30	
b_3 - N_{100}	81.3	1.50	**	81.7	1.60	***	81.7	0.20	
b_4 - N_{150}	81.7	1.90	***	81.5	1.40	**	81.6	0.10	
b_5 - N_{200}	81.0	1.20	**	81.2	1.10	*	82.0	0.50	

$LSD_{5\%}$ = 0.86 kg/hl; $LSD_{1\%}$ = 1.17 kg/hl; $LSD_{0.1\%}$ = 1.56 kg/hl

Thousand grains weight (TGW) is also an important indicator in evaluating cereal yield. TGW is the mass of a thousand seeds, with the humidity at time of measurement and it is expressed in grams with two decimals. TGW is a good indicator in determining the protein content. In this respect, it was found that thousand grains weight is directly proportional to the protein content in cereals.

The data presented in Table 7 reveal a general trend of decreasing, with increasing the amount of total nitrogen (mineral and organic) for thousand grains weight. As we can see below, for variant a_1 - unfertilized organically and a_2 - 30 t/ha of manure applied to the preceding crop, the thousand grains weight reaches it's maximum value, for mineral variant b_3 - N_{100}, after that it begins to decline. For a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50}, the maximum thousand grains weight it is found for variant b_2, and a dose of only N_{60}.

Table 7. Influence of mineral and organic fertilization on TGW in winter wheat (Moara Domnească, 2014/2015)

Mineral fertilization	a_1 - unfertilized organically			a_2 - 30 t/ha of manure applied to the preceding crop			a_3 - 40 t/ha leaves and epicotyls of sugar beet + N_{50}		
	TKW (g)	Difference (g)	Signification	TKW (g)	Difference (g)	Signification	TKW (g)	Difference (g)	Signification
b_1 - N_0	48.53	Control		48.89	Control		49.71	Control	
b_2 - N_{60}	50.02	1.49		49.45	0.56		49.99	0.28	
b_3 - N_{100}	50.46	1.93		50.07	1.18		48.68	-1.03	
b_4 - N_{150}	48.61	0.08		47.05	-1.82		47.82	-1.89	
b_5 - N_{200}	46.80	-1.73		46.01	-2.88	o	47.57	-2.14	

$LSD_{5\%}$ = 2.65 g; $LSD_{1\%}$ = 3.60 g; $LSD_{0.1\%}$ = 4.82 g

CONCLUSIONS

Organic and mineral fertilization resulted in the increased winter wheat yield. The best option for organic fertilization was considered to be variant a_3 - 40 t/ha of leaves and epicotyls of sugar beet.

The variants of mineral fertilization depended on organic fertilization.

Winter wheat yield increased proportionally with the amount of applied mineral nitrogen.

For the organically unfertilized variant, the highest yield was obtained with mineral fertilization of N_{200} (b_5); however, economically, the optimum solution was N_{100} (b_2) because of the number of fall plants.

For the organically fertilized variant a_2 - 30 t/ha of manure applied to the preceding crop, the best mineral fertilizer variant was N_{150} (b_4), which also represented the best economic choice.

For the organically fertilized variant a_3 - 40 t leaves and epicotyls of sugar beet + N_{50}, the optimum solution for mineral fertilizer, in terms of yield, was N_{150} - b_4, but variant b_3 with N_{100} was the most suitable economically.

Mineral nitrogen application rates on a background of 30 t/ha manure applied to the preceding crop resulted in a progressive yield increase; however, the increase rates were much lower, compared with the variant unfertilized organically.

The variation between the nitrogen rates used for variant a_3 was not significant, meaning that for the hectoliter mass the plant residue worked very well in combination with mineral nitrogen.

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