ROLE OF MANURE IN INCREASING SOIL FERTILITY AND YIELD OF WHEAT AND MAIZE

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ABSTRACT

The paper presents the results obtained at A.R.D.S. Turda during 1982-2002, concerning the influence of manure in a long-term experiment in wheat and maize, on a clay-illuvial vertic chernozem, under dryland conditions. The soil is typical for the forest steppe region in the plain of Transylvania, with good fertility, well supplied with total nitrogen (0.196%), medium supplied with assimilable phosphorus (15-20 ppm P), with high content of mobile potassium (250 ppm K) and organic matter (3.92%). The experiment was carried out in a bean-wheat-maize rotation. The maize was fertilized with 20 t and 40 t fermented manure/ha and 20; 40; 60 t fermented manure + mineral fertilizers/ha; the wheat was fertilized only with chemical fertilizers in doses of 80-120 kg N/ha and 80 kg P_2O_5/ha. According to the research results of the last 20 years, a controlled organic fertilization is recommended firstly on maize, which utilizes small doses, 20-40 t/ha and then on wheat, wich utilizes the remanent effect of fertilization. The average increases of yields within the reference period has varied between 20.1 q/ha and 24.9 q/ha, i. e. 50-60% in comparison with the unfertilized plots. The stationary use of fertilizers has also influenced the quality of wheat and maize crops, increasing the nitrogen and therefore the protein content. Systematic fertilization with manure has contributed to an increase of the humus content as well as the total nitrogen, phosphorus and mobile potassium content.

Key words: crop rotation, maize, organic and mineral fertilizers, wheat

INTRODUCTION

The main goal of any agricultural system should be to increase agricultural production and improve soil fertility. The contemporary agricultural system is based upon the intensive use of soil in order to obtain increased yields both in quantity and in quality and soil fertility is often neglected. Increasing soil fertility is essential for the superior capitalization of all links in the technological chain.

It is generally acknowledged that organic matter, especially humus, plays an important role in maintaining a high level of soil fertility. The main sources of humus are vegetable residues of crops and fertilizers, especially organic ones.

The positive influence of organic fertilizers on soil fertility, on crop yield and quality has been demonstrated in the works of many researchers (Hera et al., 1986; Patel et al., 1992; Sarkadi, 1993; Ciobanu, 1999; Stefanescu, 2002; Hoffman, 2001; Sattar and Hossain, 2001).

In our country, as the quantity of chemical fertilizers has continuously dropped in the last few years and the soil organic matter has recorded a descending trend, it is necessary to use organic fertilizers, considering the much higher frequency of weeding crops in the rotation, as apposed to leguminous or fodder crops.

The objective of this paper is to present the results obtained in long-term experiments regarding the effect of organic and mineral fertilizers on certain indices of soil fertility, on the yield and quality of wheat and maize.

MATERIAL AND METHODS

Experiments were conducted in a stationary rotation haricot beans-wheat-maize. Studies were performed on manure, used both alone, in doses of 20, 40 and 60 t/ha and combined with mineral fertilizers (NP), in comparison with mineral fertilizers used alone and with the unfertilized plots.

The trial was planted in blocks of three reps, and the calculation of the results was achieved by ANOVA. The best cultivars and hybrids recommended in the area have been planted.

After 30 years of experiments, in 1997, a laboratory analysis was performed in order to establish the influence of organic and mineral fertilizers on certain soil fertility indices.

RESULTS AND DISCUSSION

1.The influence of fertilization on certain soil fertility indices

A prominent part in maintaining the fertility features of a soil is played by the deposit of organic matter. It is an important factor of physical

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and chemical improvement, being a means of stocking water and nutritional elements, a protection agent against certain unfavourable pedological phenomena (erosion, phosphorus blockage etc.).

According to the great biologist Bronovski, quoted by Hera et al. (1986), „manure is still a fertilizer, not a miracle". The special role played by manure must be highlighted especially in preserving and increasing soil fertility, in protecting the environment, as it is an important component of a rational agriculture.

Organic and mineral fertilization, through its cummulative effect, influences both the harvest (in quality and quantity) and the evolution of certain soil fertility indices.

On the clayey chernozem soil of Turda, during a 34 year experiment, organo-mineral fertilization in a rotation of two, then three years of haricot beans-wheat-maize constituted an extremely efficient phytotechnical method with a view to increase the soil fertility and productivity.

From an analytical point of view, an increase of the total nitrogen content (Nt%) has been noticed (Table 1).

The unfertilized plots had a total nitrogen content of 0.230 %, whereas, by mineral fertilization with 30 kg/ha and 60 kg P_2O_5/ha in maize and 80 kg N+ 80 kg P_2O_5/ha in wheat, the total nitrogen content increased to 0.257% and in the trial fertilized with 40 t manure/ha, the total nitrogen content reached 0.302%, exceeding by 0.072% the unfertilized plots.

The data presented in table 1 show that the soil reaction, both in unfertilized trial and in organically, minerally or organo-minerally fertilized ones was unaltered, neutral or slightly alkaline, favourable to plant growth and development.

Under the influence of fertilizers, especially of organic ones, an important increase in the content of phosphorus and potassium in soil was found. The highest content (from 78 to 91 ppm P and from 720 to 748 ppm K) was recorded in plots fertilized with manure, in a dose of 20-60 t/ha. The content for these trials reached the level considered to be very well supplied.

The fertilization with manure influenced favourably the humus content of soil. In comparison with a content of 4.04% without fertilizers, chemical or organo-chemical fertilization improved the humus content with up to 0.32%. A stronger mineralization of the organic matter was recorded in the trial fertilized exclusively with mineral fertilizers (NP), reflected through the humus content, lower in percentage, of 4.21% in comparison with the trial fertilized with 60 t manure/ha + 25 kg N + 25 kg P_2O_5/ha, where the humus content was 4.36%.

Mineral fertilization had a positive influence on the quality and quantity of the wheat and maize crops, but contributed less to the increase in humus content.

The content of microelements, zinc and manganese, did not vary as a result of fertilization. The presence of some heavy metals: Cu, Pb, Co,

Table 1. The influence of organic and mineral fertilization on certain soil fertility indices

Variant of fertilization kg/ha	pH water	Nt %	PAL ppm	KAL ppm	Humus %	Cu ppm	Zn ppm	Pb ppm	Co ppm	Ni ppm	Mn ppm	Cr ppm	Cd ppm
$N_{30}P_{60}$	7.97	0.257	48.44	656	4.21	32.5	163.5	57.7	25.3	58.8	654.5	127.3	2.75
20 t manure + $N_{120}P_{50}$	7.89	0.257	63.97	646	4.26	35.3	181.3	62.8	28.8	66.8	764.3	134.8	3.03
40 t manure + $N_{80}P_{30}$	8.10	0.266	67.25	684	4.26	34.7	151.3	55.8	26.8	61.8	731.8	141.3	2.82
60 t manure + $N_{50}P_{25}$	7.99	0.293	80.24	729	4.36	33.8	165.6	58.2	27.3	61.5	767.8	137.3	2.76
20 t manure	7.98	0.286	91.82	748	4.32	32.27	169.2	62.0	26.3	62.0	706.6	131.2	2.73
40 t manure	7.96	0.302	78.32	720	4.50	34.2	151.2	62.5	27.7	64.3	749.2	133.0	2.71
Unfertilized	7.95	0.230	49.98	663	4.04	33.3	153.5	64.3	27.8	64.0	742.6	126.6	2.88

Ni, Cr, Cd, has been noticed in clayey soils in the same concentrations as in the chernozem of Turda; in these types of soils, on one hand, sulphur and, on the other hand, the clay-humus compound have contributed to slow, but continuous accumulation of chemical elements.

2. The influence of fertilizers on wheat and maize yields

Researches conducted at the Agricultural Research and Development Station Turda, on a clayey chernozem soil, in long-term experiments, since 1967, highlight the importance of fertilization with manure in maintaining soil fertility, as well as in increasing wheat and maize yields. The results obtained in the trials fertilized with fermented manure are similar to those obtained in the trials fertilized with small quantities of mineral fertilizers (Table 2).

The highest maize yields were obtained in trials which received fermented manure combined with mineral fertilizers, and the most economical increases of yield were recorded for a manure dose of 20 t/ha. There are only slight differences in quantities between trials fertilized with 40 t or 60 t manure/ha and of those fertilized with 20 t/ha. The average increase of yields within the reference period has varied between 20.1 q/ha and 24.9 q/ha, i. e. 50-60% in comparison with the unfertilized plots.

The organo-mineral fertilization ensures both immediate and long-term needed nitrogen. Manure is a valuable fertilizer for wheat as well, especially on heavy, acid soils, with poor physical features. Wheat also utilizes well the subsequent effect of manure applied to maize crops; in this way, any organization difficulty related to manure incorporation on wheat crops is eliminated.

In wheat, fertilization with 80-120 kg N/ha + 80 kg P_2O_5/ha, on the background of maize fertilization with 20-60 t /ha, has ensured superior yields in comparison to control (Table 2). The obtained gains have varied between 17.1-20.3 q/ha, i.e. 53-62%. These results emphasize the positive contribution of mineral fertilization on the background with initial manure fertilization.

The high fluctuation in weather conditions is reflected by the ample variation of yields.

During the reference period, the rainfall showed a large range of variability, going from very favourable years to very droughty ones, totally unfavourable to wheat or maize, with strong influences on the obtained yields (Table 3). Between 1991-2001, the highest maize yield was obtained in 1992, when the quantity of rainfall reached a satisfactory level during July-August, which is the grain filling period. The smallest yield was recorded in 1995, when the quantity of rainfall from July and August was 71.0 mm (8.0 mm in July).

In wheat, the lowest yields were obtained in 1993, a very dry year with a long drought during Mai-June, when the total amount of rainfall was 63.8 mm as compared to 151.6 mm, the multiannual average. The highest yields and gains obtained by fertilization were recorded in 1995, a very good year for wheat, when the total amount of rainfall during May-June was 180.3 mm.

3. The influence of fertilizers on the chemical composition of the harvest

Table 2. The efficiency of manure in the first year of use on maize and the third year of use on wheat (1991-2001)

Variant of fertilization on maize, kg/ha	MAIZE				Variant of fertilization on wheat, kg/ha	WHEAT			
	q/ha	%	diff.	signif.		q/ha	%	diff.	signif.
N_{150} P_{60}	60.71	150	20.1	***	$N_{80}P_{80}$	49.1	153	17.1	***
20 t manure+NP_{50}	64.70	159	24.1	***	$N_{120}P_{80}$	51.5	160	19.5	***
40 t manure+N_{80} P_{30}	65.3	160	24.7	***	$N_{80}P_{80}$	50.3	157	18.3	***
60 t manure+N_{50} P_{25}	65.5	160	24.9	***	$N_{80}P_{80}$	51.3	160	19.3	***
20 t manure	63.2	156	22.6	***	$N_{120}P_{80}$	51.8	162	19.8	***
40 t manure	63.7	156	23.1	***	$N_{80}P_{80}$	52.3	163	20.3	***

Table 3. The production of maize and wheat according to weather condition

Variant	MAIZE						WHEAT					
	Minimum			Maximum			Minimum			Maximum		
	q/ha	diff.	%	q/ha	diff.	%	q/ha	diff.	%	q/ha	diff.	%
1	41.5	9.7	130	69.8	22.2	147	31.1	12.6	168	77.1	25.6	150
2	50.8	19.0	160	74.8	27.2	157	32.1	13.6	174	84.0	32.5	163
3	51.9	20.1	163	75.6	28.2	159	31.6	13.1	170	78.4	26.9	152
4	53.5	21.7	168	74.2	26.6	156	31.0	12.5	167	81.4	29.9	158
5	50.1	18.3	158	69.8	22.2	147	31.5	13.0	170	82.0	30.5	159
6	53.6	21.8	169	70.4	22.8	148	30.3	11.8	164	83.9	32.4	163
7	31.8	Check	100	47.6	Check	100	18.5	Check	100	51.5	Check	100

Table 4. The influence of organic and mineral fertilization on certain quality features of wheat and maize

Variant of fertilization on maize, kg/ha	Maize - first year of use				Variant of fertilization on wheat	Wheat - third year since organic fertilization						
						N%		P_2O_5%		K_2O%		
	N %	P_2O_5 %	K_2O %	Protein %		grain	plant	grain	plant	grain	plant	Protein (%)
$N_{150}P_{60}$	1.43	0.48	0.27	8.34	$N_{80}P_{80}$	1.96	0.53	1.04	0.16	0.45	1.02	11.42
20 t manure+$N_{120}P_{50}$	1.78	0.63	0.28	10.38	$N_{120}P_{80}$	2.19	0.60	1.05	0.17	0.46	1.12	12.76
40 t manure+$N_{80}P_{30}$	1.81	0.59	0.28	10.55	$N_{80}P_{80}$	2.15	0.56	1.05	0.17	0.46	1.15	12.53
60 t manure+$N_{50}P_{25}$	1.83	0.61	0.27	10.66	$N_{80}P_{80}$	2.12	0.55	1.06	0.18	0.47	1.13	12.35
20 t manure	1.63	0.57	0.27	9.50	$N_{120}P_{80}$	1.93	0.54	1.03	0.17	0.46	1.05	11.25
40 t manure	1.68	0.59	0.28	9.79	$N_{80}P_{80}$	1.95	0.56	1.04	0.18	0.46	1.09	11.36
Unfertilized	1.41	0.40	0.27	8.22	Unfertilized	1.84	0.51	0.91	0.15	0.45	0.98	10.72
DL5%=0.25	0.81	0.012	1.83			0.11	0.03	0.06	0.03	0.035		

The chemical analysis of the harvest of 1997, presented in table 4, emphasizes a strong connection between the doses of used fertilizers and the chemical composition of the harvest for the two tested crops. It is evident that there is a significant increase of the percentage of nitrogen and therefore of protein. The highest increases were recorded in trials which received organic and mineral fertilizers.

Thus, nitrogen percentage increased significantly from 1.41 in unfertilized plots to 1.83 in plots fertilized with 60 t manure + 50 kg N+ 25 kg P_2O_5/ha. In wheat, the nitrogen content in the grain varied from 1.84 to 2.12% in the same fertilized variant. With only organic fertilization on maize, the nitrogen content in the grain of both crops was lower, i.e. 1.63-1.68% for maize and 1.93-1.95% for wheat.

Under the influence of organic and mineral fertilization, the phosphorus content also increased significantly both in maize grains (from 0.40% to 0.63%) and in wheat straw and grains. The potassium content accumulated in grains and straw was not significantly influenced by fertilization.

CONCLUSIONS

Manure is a valuable fertilizer, with positive influence both on wheat and maize yields and on soil fertility.

On the clayey chernozem, under non-irrigated crops, manure must be directed mainly toward maize crops, as wheat efficiently utilizes its prolonged effect. For maize, the most economical fertilization is obtained with a dose of 20 t manure/ha, but the highest yields have been obtained in trials in which fermented manure has been used in combination with mineral fertilizers.

The stationary use of fertilizers also influenced the quality of wheat and maize crops, increasing the nitrogen and therefore the protein content.

The phosphorus content in maize grains and wheat straw and grain was suffered significantly

influenced by fertilizers, and the potassium content remained practically the same.

Systematic fertilization with manure contributed to the increase of the humus content as well as the total nitrogen, phosphorus and mobile potassium content.

In future, the organo-mineral fertilization will represent an essential element of a modern and durable agriculture. Under any circumstances, the main concern should be to preserve the soil and the environment, to use rationally one of the greatest richness of the planet, which is soil fertility. It is a fundamental duty of future generations.

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