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STUDY ON THE INFLUENCE OF ORGANIC MANURE ON SOIL FERTILITY

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Abstract

Fertility and soil balance cannot be maintained without the presence of organic matter and the addition of new quantities of plant residues or chemical and organic fertilizers, as plants extract significant amounts of nutrients from the soil each year. Therefore, the application of manure can be considered a good source for increasing the potential fertility of the soil. This study addresses on the fertilization with manure derived from cattle and sheep farming activities on the typical chernozem soil from the Romanian Plain. The effects of using these organic fertilizers are mainly observed in the behavior of nitrogen (N) and phosphorus (P) in the soil, as they are the main nutrients that influence agricultural crop yields. Potassium (K) has a secondary role, but along with pH and other macronutrients, it improves the physical and biological properties of the soil, as evidenced by the appearance and formation of a positive humus balance and an improvement in the NPK content of the soil. Following the application of manure over a period of more than five years, changes in the physical-chemical indicators are observed, such as the bulk density of soil which decreases from 1.28 g/cm^3 to 1.17 g/cm^3, or the humus that increases from 2.07 % to 2.57 %, after five years of manure action.

Key words**:** *fertilization, manure, soil, humus, typical chernozem, increase in production*

INTRODUCTION

Agriculture has a major impact on soil nutrients worldwide. In some regions, soil nutrients are depleted due to the low initial soil fertility or excessive nutrient removal through intensive land use compared to nutrient additions [14].
Soil organic matter is an essential component with multifunctional roles in soil quality and is linked to many physical and biological properties of the soil [19].
As a complex property of retaining, transforming, and providing mineral substances and water to plants, fertility is related to the soil's openness to the external energy flow. Kleinhempel advanced the idea that fertility is the variation of entropy over time as an inherent property of the soil [10].
The consumption of mineral substances from the soil (N, P, K, Ca, Mg, etc.) and organic matter with each harvest, needs to be replenished to the soil through the application of organic fertilizers (manure, compost) and the incorporation of plant residues (straw, corn stalks, sunflower, rapeseed, etc.), complemented by chemical fertilizers [20, 18].
The balanced application of organic fertilizers greatly influences the accumulation of organic matter in the soil and the microbial activities in the soil. The benefits of balanced fertilization using crop residues, organic manure, and green manure in maintaining soil organic matter levels are well known [9].

Manure is a byproduct of animal farming activities and is considered an organic fertilizer with high agrochemical and agronomic value. Studies conducted by researchers have shown that the application of manure led to changes in soil elements, with soil organic carbon reaching 17.7%, available nitrogen at 16.0%, available phosphorus at 66.2%, and available potassium at 19.1% [16], [12], [7] and [5].

The continuous application of organic manure alone or in combination with NP fertilizer for 10 years led to a decrease in soil pH from 8.1 to 7.69 due to the formation of organic acids during the decomposition of organic matter [1].

Other studies on poultry manure have shown that annual application of 10 tons of poultry manure significantly increased the available phosphorus and potassium content for plants, inhibited alkaline phosphatase activity, and resulted in the accumulation of a high level of available phosphorus for plants [11].

The object of study is the typical chernozem soil [8], used for the application of manure and the observation of changes in its properties compared to the same soil where this fertilizer is not applied.

MATERIALS AND METHODS

The soil used in this exeperiment is located in the Burnașului Plain, a subdivision of the Romanian Plain, situated in southern Romania, where an arid climate is encountered, with average annual precipitation of P = 400 - 450 mm and average annual temperatures above 12^{o}C.

The texture of this soil type is loamy-clayey, with a humus content ranging from 1.95% to 2.36%, available phosphorus content of 1.56 - 1.82 mg/100g soil, exchangeable potassium of 16.1-16.9 mg/100g soil, and a slightly alkaline reaction with a pH of 7.9 – 8.2, being included in the III class of quality with 72 points of bonitation out of a maximum of 100. [3]. The parent rock is represented by loess and loessoid deposits.

The manure applied to this type of soil comes from cattle and the soil is tested with a dose of 40 t/ha every two - five years for agricultural crops. The applied agronomic practices include autumn plowing to a depth of 18-20 cm with the incorporation of manure, then sowing after disc harrowing at a depth of 12 cm, and maintenance work during the growing season.

RESULTS AND DISCUSSIONS

The soil cover is one of the most important natural resources and the main means of production in agriculture, so it is crucial to exploit this resource rationally, as it is constantly subject to degradation due to the export of nutrients by plants.

This degradation of soils occurs due to the consumption and depletion of nutrients, degradation of soil structure, acidification, and suboptimal addition of organic and chemical fertilizers to the soil. Such adverse soil conditions can lead to poor soil quality and crop yields [15].

Therefore, long-term addition of organic matter, such as manure, improves crop yield, water retention capacity, total porosity, and reduces bulk density and surface crusting [17].

Manure is a byproduct of cattle and other animal farming, considered an organic fertilizer that provides significant contributions to the soil and falls into the category of environmentally friendly organic products [2].

The chemical composition of manure depends on the maintenance practices of animals, resulting in manure with bedding or without bedding, which significantly differs in terms of nutrient content and physico-mechanical properties.

Manure from animals with bedding has a lower nitrogen content by 33.3% in cattle (5.7 kg/t) compared to sheep where it is 9.4 kg/t. Bedded cattle manure contains 3.8 kg/t of N, while non-bedded cattle manure contains 2.9 kg/t of N, which is significantly lower than sheep manure.

The P_2O_5 content also decreases in non-bedded cattle manure where it is 2.9 kg/t, compared to bedded cattle manure where it is 4.1 kg/t. The K_2O content in manure decreases by approximately 48% when

bedding is used in animal housing compared to manure from non-bedded housing. In cattle manure, it decreases from 10.2 kg/t to 4.5 kg/t, while in sheep manure, there is a difference of 6.7 kg/t in K_2O content in manure (Table 1).

Table 1. Analysis of nutrient content in organic manure, kg/t

The type of manure	N (kg/t)	P_2O_5 (kg/t)	K_2O (kg/t)
Cattle manure with bedding	5.7	4.1	10.2
Cattle manure without bedding	3.8	2.9	4.5
Sheep manure with bedding	9.4	4.4	17.8
Sheep manure without bedding	9.1	3.7	11.1

Source: Own determination.

From the research, it was found that organic fertilization with manure contributed to the improvement of soil supply with humus, mobile phosphorus, and exchangeable potassium (Table 2).

After the first year of applying a quantity of 40 t/ha of manure, the soil's humus content increased only slightly from 2.07% to 2.10%. However, its effect was noticeable after three years of action when the humus content increased by 0.33% compared to the control group from the year 2017, and after five years of fertilization, it increased by 0.50%.

Table 2. Dynamics of humus content, mobile phosphorus (P), and exchangeable potasium (K) in the soil under the influence of organic manure

Fertilization type	Humus content (%)	Increase (%)	Mobile phosphorus (P) (mg/100g sol)	Increase (mg/100g sol)	exchangeable potassium (K) (mg/100g sol)	Increase (mg/100g sol)
The year 2017						
Unfertilized soil (control)	2.07	-	1.85	-	16.5	-
Manure (40 t/ha)	2.10	-	1.53	-	16.2	-
The year 2019						
Unfertilized soil (control)	1.95	- 0.13	1.96	0.11	16.8	0.3
Manure (40 t/ha)	2.40	0.33	2.54	1.04	20.2	3.7
The year 2021						
Unfertilized soil (control)	2.19	0.11	2.00	0.15	16.9	0.4
Manure (40 t/ha)	2.57	0.50	3.56	1.71	22.2	5.7

Source: Own determination.

Fertilization with manure at doses of 40 t/ha and at different intervals led to an increase in mobile phosphorus ranging from 0.11 to 1.71 mg/100g of soil over the five years of fertilization, compared to the initial content in 2017, which was 1.85 mg/100g mobile phosphorus (P) of soil. The mobile phosphorus content increased from 1.85 mg/100g of soil in the unfertilized soil to 3.56 mg/100g of soil after five years of fertilization with manure.

The values of exchangeable potassium (K) increased in the fifth year of application, in 2021, by 5.7 mg/100g of soil, rising from 16.5 mg/100g of soil in 2017 to 22.2 mg/100g of soil in 2021.

Fertilization with manure of the typical chernozem, contributes to the formation of structural elements with agronomic value. Applying manure at a rate of 40 t/ha leads to a reduction in the coarse fraction (>10 mm) while increasing the structural formations by over 10% in fractions with a diameter below 0.25 mm [13].

The content of fine clay, as well as physical clay, remains constant when fertilizing with manure. The loamy-sandy texture can be considered very favorable as it provides

normal conditions for the growth of cultivated plants. However, the low hydrostability of structural aggregates formed by soil work, weak resistance to secondary compaction, and high erosion risk are considered negative aspects of this loamy-sandy structure.

The highest increase in humus, phosphorus, and potassium compared to the unfertilized control, is observed after 5 years of manure application, with a 0.50% increase in humus, 1.71 mg/100g of soil increase in phosphorus, and 5.7 mg/100g of soil increase in potassium.

Table 3. The influence of manure on the physical indicators of the typical chernozem

Fertilization type	Bulk density (g/cm^3)	Total porosity (%)	Penetration resistance (PR) at depth 0–30 cm (kgf/cm^3)
Unfertilized soil (control)	1.28	52.4	23.2
Manure applied at 3 years (40 t/ha)	1.20	53.6	19.9
Manure applied at 5 years (40 t/ha)	1.17	55.4	13.5

Source: Own determination.

The increase in organic matter content in the variants fertilized with manure leads to a decrease in the bulk density of soil from 1.28 g/cm^3 to 1.17 g/cm^3 after 5 years of applying this fertilizer (Table 3). These changes have resulted in an increase in pore space of up to 55.4%.

The value of soil penetration resistance (PR) decreased by 9.7 kgF/cm^3, from values of 23.2 kgf/cm^3 to values of 13.5 kgf/cm^3, and the total soil porosity (TP) improved by 3 percentage points, increasing from 52.4% to 55.4% after five years.

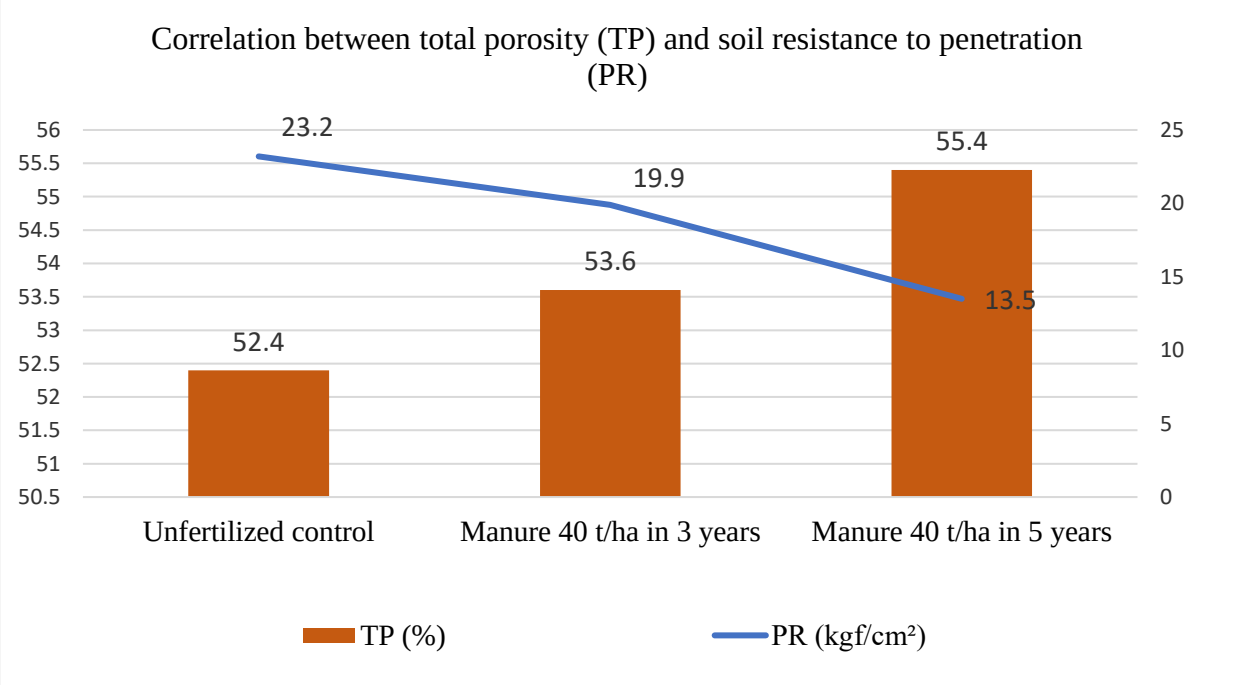

Fig. 1. Correlation between total porosity (%) and soil resistance to penetration (kgf/cm^3)
Source: Own determination.

The influence of manure fertilization has demonstrated that it has a high fertilizing effect on the soil, especially on its physical and chemical properties.

As observed in Figure 1, penetration resistance is inversely proportional to total porosity. At total porosity values of 52.4%, the penetration resistance increases to moderate values of 23.2 kgf/cm^3. As the total porosity increases to values of 55.4% after 5 years of manure application, the penetration resistance decreases by 41.8%, reaching

values of 13.5 kgf/cm^3, which are considered low in this zone. This indicates a considerable improvement in the physical properties of the soil [6].

Since organic materials in the soil have a low apparent density and high porosity, adding organic matter to the soil through the incorporation of manure improves the physical properties of the soil [4].

Table 4. Analysis of the influence of manure on production

Variant	**Productions without fertilization (kg/ha)**		
	Corn	**Wheat**	**Peas**
Unfertilized soil (control)	3,583.2	1,383.5	6,375.9
Fertilization type	**Increase in production (kg/ha)**		
Manure applied at 3 years (40 t/ha), increase in production	1,361.3	626.4	2,038.2
Manure applied at 5 years (40 t/ha), increase in production	1,220.9	543.6	1,901.7

Source: Own determination.

The average productions increase significantly, following the application of manure, for the corn crop it increases by 1,361.2 kg/ha, for wheat by 626.4 kg/ha and for peas it increases by 2,038.2 kg/ha when it is applied after 3 years (Table 4).

In the variants fertilized with manure with a dose of 40 t/ha at 3 and 5 years, significantly higher production increases were obtained.

Table 5. The increase in production under the conditions of application of 40 t/ha of manure

Fertilization type	**Increase in production (%)**		
	Corn	**Wheat**	**Peas**
Manure applied at 3 years (40 t/ha)	37.99	45.27	31.96
Manure applied at 5 years (40 t/ha)	34.07	39.29	29.82

Source: Own determination.

The biggest increase in production was recorded when fertilizing with 40 t/ha of manure once every two to three years, in the pea crop, the increase being 31.96%. In the wheat crop we have a significant increase of 45.27% and in the corn crop the production increase is 37.99% (Table 5).

CONCLUSIONS

Manure is the most important and widespread source of organic matter and nutrients for restoring soil fertility in chernozem soils and increasing agricultural crop productivity.

Applying manure for 5 years led to a positive balance of humus in the chernozem soil and an increase in the content of mobile forms of phosphorus and potassium. The humus content increased by 0.50% over the five years analyzed, the mobile phosphorus content increased by 1.71 mg/100 g of soil, and the exchangeable potassium content increased by more than 5.7 mg/100 g of soil.

The value of penetration resistance decreased by 48%, and total porosity significantly improved, reaching values of 55.4%, increasing by 3%.

It is recommended to apply manure on chernozem soils used for annual field crops at a rate of 40 t/ha, at least once every 2 years, but the greater effect is observed after at least 2 applications, after 3 years.

The increase in production after the application of manure 40 t/ha, is between 31.96% for wheat and 45.27% for wheat, which makes the best use of this fertilization.

REFERENCES

[1]Antil, R. S., Singh, M., 2007, Effects of organic manures and fertilizers on organic matter and nutrients

status of the soil. Archives of Agronomy and Soil Science, 53(5), 519-528.
[2]Bhatt, M. K., Labanya, R., Joshi, H. C., 2019, Influence of long-term chemical fertilizers and organic manures on soil fertility-A review. Universal Journal of Agricultural Research, 7(5), 177-188.
[3]Burcea, M., Oltenacu, N., 2019, The bonitation method for assessing the fertility of the Chernozem. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 19(3), 107-112.
[4]Celik, I., Ortas, I., Kilic, S., 2004, Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerert soil. Soil and Tillage Research, 78(1), 59-67.
[5]Christensen, B. T., 1988, Effects of animal manure and mineral fertilizer on the total carbon and nitrogen contents of soil size fractions. Biology and Fertility of Soils, 5(4), 304-307.
[6]Dumitru, M., Manea, A., Ciobanu, C., Dumitru, S., Vrinceanu, N., Calciu, I., Tanase, V., Preda, M., Risnoveanu, I., Mocanu, V., Eftene, M., 2011, Soil quality monitoring in Romania, the National Research and Development Institute for Pedology, Agrochemistry and Environmental Protection (Monitoringul stării de calitate a solurilor din românia institutul naţional de cercetare-dezvoltare pentru pedologie agrochimie şi protecţia mediului). In Romanina. ICPA Bucharest, Sitech Publishing House, Craiova.
[7]Faissal, A., Ouazzani, N., Parrado, J. R., Dary, M., Manyani, H., Morgado, B. R., Barragan, M.D., Mandi, L., 2017, Impact of fertilization by natural manure on the microbial quality of soil: molecular approach. Saudi Journal of Biological Sciences, 24(6), 1437-1443.
[8]Florea, N., Munteanu, I., 2012, Romanian System of Soil Classification (Sistemul Român de Clasificare a Solurilor SRTS), ICPA, Sitech Publishing House, Craiova.
[9]Kanchikerimath, M., Singh, D., 2001, Soil organic matter and biological properties after 26 years of maize–wheat–cowpea cropping as affected by manure and fertilization in a Cambisol in semiarid region of India. Agriculture, Ecosystems & Environment, 86(2), 155-162.
[10]Kleinhempel, D., 1970, A contribution to the theory of the humic substance state. Archives of Agronmy and Soil Science (O contribuție la teoria stării substanței humice. Arhivele agronomiei și științei solului). 14 (1), 3-14.
[11]Kobierski, M., Bartkowiak, A., Lemanowicz, J., Piekarczyk, M., 2017, Impact of poultry manure fertilization on chemical and biochemical properties of soils. Plant, Soil and Environment, 63(12), 558-563.
[12]Kulvinder, K., Kapoor, K.K., Gupta, A.P., 2005, Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions.Journal of Plant Nutrition and Soil Science 168.1 (2005): 117-122.
[13]Naveed, M., Moldrup, P., Vogel, H. J., Lamandé, M., Wildenschild, D., Tuller, M., de Jonge, L. W., 2014, Impact of long-term fertilization practice on soil structure evolution. Geoderma, 217, 181-189.
[14]Potter, P., Ramankutty, N., Bennett, E. M., Donner, S. D., 2010, Characterizing the spatial patterns of global fertilizer application and manure production. Earth interactions, 14(2), 1-22.
[15]Raupp, J., 2001, Manure fertilization for soil organic matter maintenance and its effects upon crops and the environment, evaluated in a long-term trial. Sustainable Management of Soil Organic Matter, 301-308). CABI Publishing.
[16]Saha, S., Prakash, V., Kundu, S., Kumar, N., Mina, B.L., 2008, Soil enzymatic activity as affected by long term application of farm yard manure and mineral fertilizer under a rainfed soybean–wheat system in N-W Himalaya. Eur. J. Soil Biol., 44 (2008), pp. 309-315.
[17]Schjonning P., Christensen, B.T., 1994, Physical and chemical properties of a sandy loam receiving animal manure, mineral fertilizer or no fertilizer for 90 years, Eur. J. Soil Sci., 45 (1994), pp. 257-268.
[18]Simionescu, V.M., Rusu, M., Bulica, I., 2016, Importance of systematic fertilization with mineral and organic fertilizers for preserving and increasing soil fertility. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 16(1), 487-492.
[19]Smith O.H., Petersen, G.W., Needelman, B.A., 2000, Environmental indicators of agroecosystems. Adv. Agron., 69 (2000), pp. 75-97.
[20]Toma, S., Gumovschi, A., 2002, Moldova's soils- a wealth that we are losing (Solurile Moldovei – o bogăţie pe care o pierdem). Agrochim Inform Bulletin, no. 3. Chișinău: Bons Offices, 4-8.