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-INFLUENCE OF ORGANIC FERTILIZER DERIVED FROM POULTRY MANURE ON YIELD COMPONENTS AND SEED TECHNOLOGICAL QUALITIES OF SPRING WHEAT

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Abstract

The aim of the study is to examine the effect of organic fertilizer on the basis of poultry manure at the doses of 10 t/ha, 20 t/ha and 30 t/ha on the yield and quality of spring wheat in the conditions of Akmola Region. Field tests were carried out on dark chestnut soil in Akmola Region in 2021. An analysis of the structural elements of the spring wheat yield was carried out in accordance with the method of state crop variety testing of cultivated plants by O. Fedin, a harvesting was carried out by the straight-combine method, the soil sampling was carried out by using the envelope method. The analysis of variance between variants was carried out in order to determine the effect of autumn fertilization on the basis of poultry manure fertilizer at the doses of 10 t/ha, 20 t/ha and 30 t/ha on structural elements of the spring wheat yield. The wheat yield was higher by 35% in the variant with the autumn fertilization at a dose of 10 t/ha and by 50% in the variants of 20 t/ha and 30 t/ha compared to the control. In accordance with the results of the wheat crop structural analysis, the use of organic fertilizer on the basis of poultry manure had a positive effect on the plant height, spike length and number of spikelets, as well as on the weight per 100 grains. Oon the basis of the obtained data we've concluded that the cost-effective recommended dose of autumn fertilization of organic fertilizer on the basis of poultry manure is 20 t/ha for spring wheat planting for the purpose of obtaining an optimal yield in the conditions of Akmola Region.

Key words: Organic farming, Ecologically safe products, Composted poultry manure, Wheat, Seeding.

Introduction

Organic agriculture completely excludes the use of synthetic fertilizers, pesticides and genetically modified organism (GMO) in favor of the maximum use of organic and microbial fertilizers to improve the soil fertility and increase the crop productivity. The organic farming system is able to have a secured effect on the agricultural landscape and the vegetation cover complexity, thereby maintaining the biodiversity of the area and accelerating the humus-forming processes in the soil (Norton *et al*., 2009). According to the law of the Republic of Kazakhstan "On production of organic products", which is currently valid, it is allowed to use soil-building substances and substances of animal and vegetable origin (manure, poultry manure and household food waste), obtained in the organic agriculture system and passed the stage of composting or anaerobic fermentation for the purpose of maintaining and increasing fertility and biological activity of the soil. Despite the acceptance of a new program of agro-industrial complex with a course to gradual decline at the area sown to wheat, cereals still occupy 80% of the sown area in Kazakhstan with an average wheat yield of 10-16 dt/ha (Gridneva *et al*., 2018; Mukhametzhanov & Zholaman, 2023). The yield of Kazakstani wheat varies depending on the cultivation region, the landscape structure of the fields and their moisture content (Khoroshev *et al*., 2018; Panfilova *et al*., 2020), as well as the choice of a straight variety adapted to environmental conditions (Malchikov *et al*., 2018; Panfilova *et al*., 2019). The problem with soil moisture content and monocultivation (cereals) of farming are not the only problems of low wheat yields, the key is also the fact of a gradual decline in soil fertility and decrease in the reserves of organic matter (Pashkov and Daybusinova, 2017; Karbivska *et al*., 2020).

At the same time, there is a problem of waste disposal from poultry enterprises in Kazakhstan, where a large poultry farm disposes about 100 tons of poultry manure daily. At this stage, due to a number of reasons, poultry waste is stored by poultry farms at nearby manure storehouse without appropriate processing. These manure masses are the sources of dangerous microorganisms, helminths and bad odor constitute a threat to the public health in the nearest human settlements, and also pollute local soil and water bodies during periods of snow melting and rain (Boustani *et al*., 2021). Outdoor storage of poultry manure without proper processing technology leads to losses of more than 40% of nitrogen (Amanullah *et al*., 2010; Karches & Buzás, 2013). Poultry manure composting is a measure designed to solve the problem of the valuable nitrogen loss taking into account the fact of low availability of nitrate nitrogen in the soils of Northern Kazakhstan, which indicates a high demand for cereal crops in nitrogen fertilizers (Ovtsinov *et al*., 2015). Moreover, poultry manure composting results in a more stable product with a high content of organic substance (NPK – Nitrogenium, Phosphorus, Kalium), as well as brings the compost to the necessary physical consistency in order to simplify its application in the fields (Vandecasteele *et al*., 2014).

Previously conducted studies in the world testify to the positive effect of the chicken manure use as a fertilizer on the structural elements of yield not only of wheat but also of other agricultural significant crops. The use of chicken manure makes it possible to increase the weight of 1000 soybean seeds, as well as the number and dry weight of tubercles, but does not affect the number of seeds in a pod compared to the control (Tagoe *et al*., 2008). The use of poultry manure for corn areas allows not only increasing the yield, but also improving such indicators as plant height, leaf area index and biomass (Boateng *et al*., 2006; Bazaliy *et al*., 2022). Therefore, of particular interest are the studies aimed at studying the fertilizer effect on the basis of composted poultry manure for wheat plantings and its structural elements in the conditions of Northern Kazakhstan. This article does not consider the option of complete refusal of traditional farming in Kazakhstan, since the transition to an organic farming system requires heavy financial costs in order to provide agricultural producers with the necessary amount of organic fertilizer and equipment. However, confident steps should be taken towards the production of ecologically safe products to maintain the health of the population and the ecosystem.

The task of the research is to examine the effect of organic fertilizer on the basis of poultry manure at the doses of 10 t/ha, 20 t/ha and 30 t/ha on the yield and quality of spring wheat in the conditions of Akmola Region.

Material and Methods

Field tests were carried out on dark chestnut soil in Akmola Region, Tselinograd District, Kazakhstan in 2021. The District climate is sharply continental with harsh dry winters and dry hot summers. The climate is characterized by intense winds. The average annual rainfall is 326 mm. In the experiment the autumn fertilization of organic fertilizer was used on the basis of poultry manure by the "Atlant TZP-39" unit at a dosage of 10, 20 and 30 tons per hectare, the control was without fertilization, where the covering was carried out by the John Deere 1830 unit to a depth of 8 cm. The plantings of wheat of the Karaganda 80 breed with a quantity of seed sown rate of 120 kg/ha (2.8 million germinable seeds) was carried out on May 22, 2021 by the John Deere 1830 seeder with an A-hoe blade to a depth of 6-7 cm. Chemical treatment of plantings against weeds, varmint and diseases was carried out as necessary. An analysis of the structural elements of the spring wheat yield was carried out in accordance with the Fedin's method (1985). A harvesting was carried out on September 24, 2021 by the straight-combine method with a Claas Tucano combine. The wheat yield was determined in the field conditions by a storage hopper with a weighing system.

A one-way analysis of variance between variants was carried out in order to determine the effect of autumn fertilization on the basis of poultry manure fertilizer at the doses of 10 t/ha, 20 t/ha and 30 t/ha on structural elements of the spring wheat yield. To study the technological qualities of wheat seeds, a BUCHI NIRFlex N-500 spectrometer was used in order to obtain accurate data in scientific research when determining the quality of crop production. Accounting of the soil biological activity was carried out by seeding technique of soil suspension cultivations on the solid medium (Netrusov *et al*., 2005; Tepper, 2005) followed by counting the number of CFU (colony-forming units). The soil sampling was carried out by using the envelope method to a depth of 0-20 cm with observance of sterility in the seeding-tillering phase and the wheat firm-ripe phase. The number of bacteria using nitrogen organic forms was taken into account on meat-and-peptone agar (MPA); bacteria and actinomycetes using nitrogen mineral sources on starch-and-ammonia agar (SAA); nitrogen-fixing microorganisms at Ashby. Aerobic cellulose-digesting microorganisms were detected on the Hutchinson's medium with subsequent differentiation into bacteria, fungi, and actinomycetes. The total microbial content was calculated by the number of grown colonies, the number of CFU in 1 ml was determined by the formula:

$$M = a \times 10^n / V,$$

where: a is a number of grown colonies; 10^n is cultivation; V is seeding dose (0.1 ml).

Results

Microbial activity and structural elements of yield: The traditional extensive farming of Kazakhstan, the climatic features and the region cereal orientation, the use of mineral fertilizers and synthetic plant protection measures, as well as soil erosion due to clearing, have led to a decrease in the once rich soil fertility of Northern Kazakhstan. In this regard, the use of organic fertilizers, including animal manure is a big step towards the development of sustainable agriculture. It should be noted that for the majority of agricultural producers, the preservation of soil fertility is not a priority, the only important thing for them is to obtain a consistently high yield of a good quality. Therefore, it remains important to study the possibility of using composted poultry manure as an organic fertilizer in different dosages in order to increase the yield and crops quality, as well as to stimulate microbial activity and soil-forming processes. Microbiological analysis of soil samples selected in the seeding-tillering and firm-ripe phases showed significant variability in the number of different micro-organisms groups between the variants (Table 1). Bacteria using organic and mineral forms of nitrogen, as well as actinomycetes, prevailed in the 20 t/ha fertilizer variant in the seeding-tillering phase of wheat and in the 30 t/ha fertilizer variant in the firm-ripe phase. While the number of nitrogen-fixing and cellulose-digesting micro-organisms prevailed in the variant of fertilizer applying at a dose of 10 t/ha in the seeding-tillering phase and in the variant of 20 t/ha in the firm-ripe phase.

Table 1. The Number of CFU isolated from soil to a depth of 0-20 cm for wheat plantings using different doses of compost on the basis of poultry manure.

Variant	Seeding-tillering phase					Firm-ripe phase				
	Gause	SAA	MPA	Ashby	Hutchinson	Gause	SAA	MPA	Ashby	Hutchinson
Control	$2.3*10^{5}$	$1*10^{6}$	$1.5*10^{6}$	$1.3*10^{7}$	$10.5*10^{4}$	$3.7*10^{5}$	$5*10^{6}$	-	$5*10^{5}$	$12.5*10^{4}$
10 t/ha	$3.4*10^{4}$	$3*10^{6}$	$1.15*10^{6}$	$5.5*10^{6}$	$15.5*10^{4}$	$2.9*10^{5}$	$1.5*10^{6}$	$2*10^{6}$	$1*10^{7}$	$1.1*10^{5}$
20 t/ha	$36.5*10^{4}$	$4*10^{6}$	$5.5*10^{6}$	$2.5*10^{7}$	$13*10^{5}$	$4.9*10^{5}$	$5.5*10^{6}$	$1*10^{6}$	$51.5*10^{6}$	$25.5*10^{4}$
30 t/ha	$4.7*10^{5}$	$1*10^{6}$	$3*10^{6}$	$1.5*10^{6}$	$6.5*10^{4}$	$5.6*10^{5}$	$9.5*10^{6}$	$6*10^{6}$	$3.5*10^{6}$	$14.5*10^{4}$

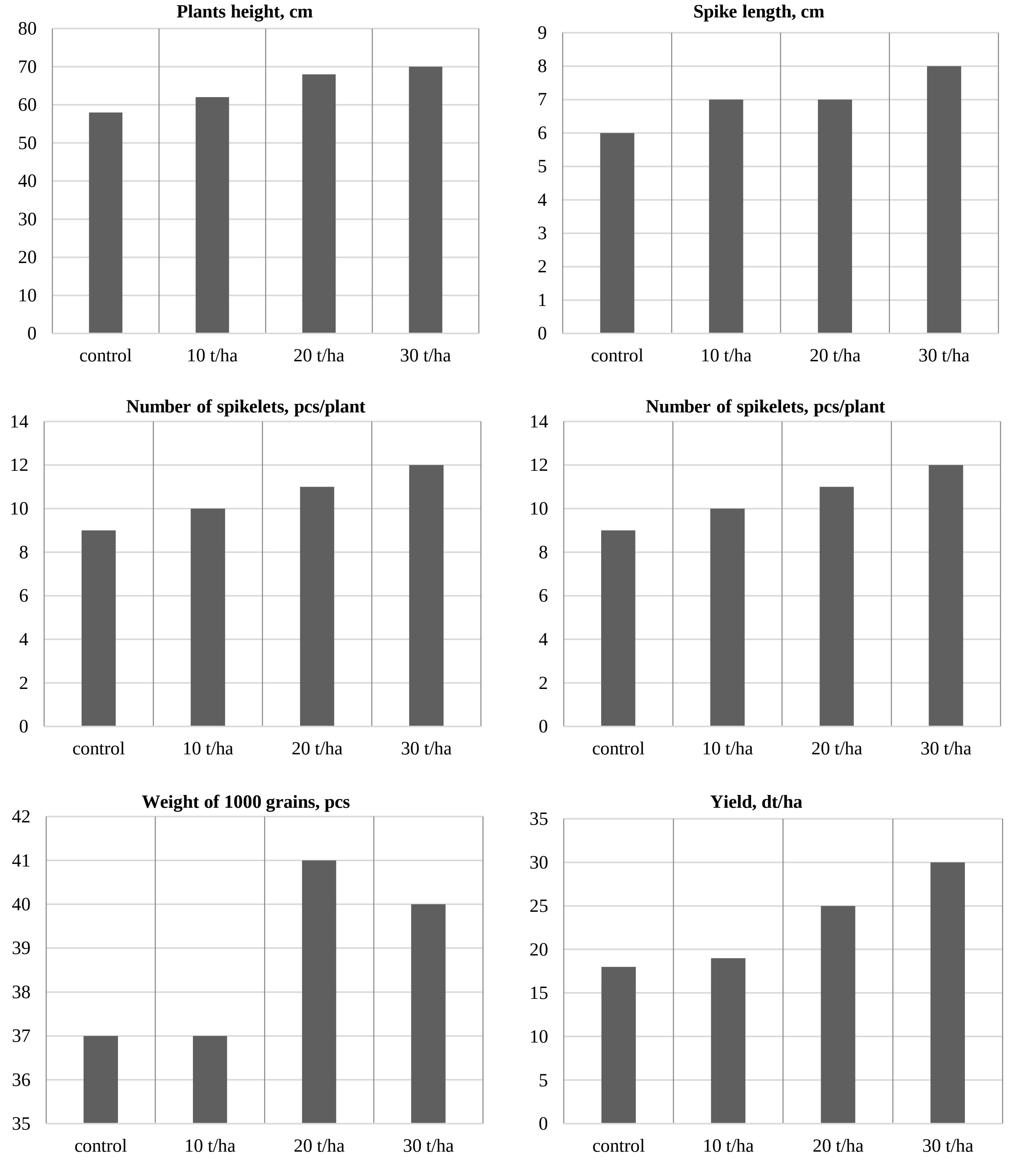

Fig. 1. The influence of organic fertilizer on the basis of poultry manure on the structural elements of wheat yield, 2021.

One-way analysis of variance did not show statistically significant differences between the average yield's values by variants (F (3.16) = 2.99, p = 0.062). In accordance with the obtained yield data, the use of organic fertilizer on the basis of the chicken manure allowed to achieve 3% of increase in wheat yield at a dose of 10 t/ha compared to the control. An increase in wheat yield of 34% was obtained in the variant with the fertilization at a dose of 20 t/ha. It should be noted that the autumn fertilization at a dose of 30 t/ha gave 55% increase in yield compared to the control (Fig. 1). The use of organic fertilizer on the basis of poultry manure had a statistically significant effect on the plant's height (F (3.12) = 12.65, p = 0.0005), spike length (F (3.12) = 12.22, p = 0.0006), number of spikelets (F (3.12) = 8.015, p = 0.0034) and the weight per 1000 grains (F (3.12) = 13.15, p = 0.0004). So wheat was 10% higher in the 10 t/ha variant, and approximately the same 30% height gain was in the 20 t/ha and 30 t/ha variants. The weight per 1000 grains did not differ from the control in the 10 t/ha variant and was 10% higher in the 20 t/ha and 30 t/ha fertilizer variants. In the variant with the use of 20 t/ha, 20% increase in the spike length and the number of spikelets was obtained, and in the variant of 30 t/ha, 30% increase for these structural elements was obtained. One-way analysis of variance did not show statistically significant differences between the average values of the number of grains in the spikelet by variants (F (3.12) = 1.126, p = 0.377).

Table 2. The influence of the organic fertilizer's doses on the basis of poultry manure on the technological qualities of durum wheat seeds.

Indicators	Variant			
	Control	10 t/ha	20 t/ha	30 t/ha
Moisture, %	8.74	7.27	9.54	7.54
Protein, %	18.83	18.12	20.31	20.96
Hagberg falling number, sec	135	69.7	465.8	134.9
Dough extensibility, cm	29.54	29.19	31.98	32.53

Technological qualities of seeds: Besides the yield, it is important to determine the technological qualities of wheat grains, since after all, it is the milling properties of seed that determine the quality of the finished product. Table 2 shows the analysis indicators of the technological qualities of durum wheat grains. In accordance with the obtained moisture data, a wheat seed is characterized as dry (>14%) both on the control and in the variants with the use of compost on the basis of poultry manure. The variants with the use of fertilizers at a dose of 20 t/ha and 30 t/ha showed an increased protein content in the grain by 7% and 11%, respectively, while in the 10 t/ha variant, the protein content was 4% lower compared to the control. In general, the protein content in the grain is considered high in all variants (≤16-17%). The Hagberg falling number that characterizes alpha-amylase activity showed rather fluctuating data between variants. Thus, the same values were obtained in the control and the variant with the fertilization of organic fertilizer at a dose of 30 t/ha, as well as the minimum and maximum values in the 10 and 20 t/ha variants, respectively. It should be noted that high natural amylase activity (low falling number) leads to the problems with excessively viscous and sticky dough.

The activity of soil microflora directly affects humus-forming processes and soil fertility. The quantity and quality of the soil microorganisms, which are in their turn determined by the type and amount of fertilization, have a direct impact on the growth and development of the plants. The long-term use of organic fertilizers, including poultry manure, allows increasing biological activity and microbial biomass compared to the long-term use of mineral fertilizers as nitrogen sources (Fauci & Dick, 1994). Soil microbes are able to metabolize the stable forms of soil nutrients (N, P, S) thus making them available for plant nutrition. It should be noted that the chances of isolating growth-stimulating microorganisms increase in soils that do not use mineral fertilizers or in soils with an organic farming system (Jacoby *et al.*, 2017). This fact indicates the positive impact of sustainable agriculture, including the use of organic waste on the condition of the soil and its inhabitants.

The study conducted in Northern Kazakhstan showed the increase in the soil biological activity, with a sustainable growth of microbiological activity by the end of the vegetation, on variants with the use of green manure and manure as fertilizers. Moreover, the use of these types of organic fertilizers had a significant beneficial effect on the positive balance of humus and the spring wheat yield (Ovtsinov *et al.*, 2015; Andryeyeva *et al.*, 2021). Poultry manure as a fertilizer contributes an increase in soil microbial biomass, soil respiration and soil enzyme activity, which is in its turn associated with easy decomposability and rapid mineralization of organic matter in poultry manure (Tejada *et al.*, 2006). It is known that the increase in wheat yield due to the use of chicken manure as a fertilizer is achieved by increasing the concentration of NPK in the soil (Limon-Ortega *et al.*, 2009). The increase of spike length, weight per 1000 grains, the number of grains in a spikelet, as well as the grain yield is consistent with the data obtained in a similar study with the use of the chicken manure as a fertilizer at a dose of 1 t/ha for wheat crops (Shahid *et al.*, 2015). Similar data on yield increase, around 34%, were obtained in the study with the use of the goose manure at a dose of 10 t/ha for spring wheat in a grain steam crop rotation (Sinyavskiy & Elikbaeva, 2019). In general, the use of the poultry manure as an organic fertilizer provides a guaranteed increase in yield by 1.2–1.5 times (Teuchezh, 2017; Hoover *et al.*, 2019). An increase in wheat yield from the poultry manure fertilization can be associated with an increase of the number spikelets, the number of grains in spikelets and also the weight of grains (Shahid *et al.*, 2015; Sheoran *et al.*, 2017).

Low soil nitrogen availability in organic farming can lead to reduced yields and low protein content in the grain. Composting often makes it possible to reduce nitrogen losses from the poultry manure, but its residual content is not sufficient to significantly increase crop yields. It should be noted that the use of poultry manure along with mineral fertilizers allows receiving a higher yield than their fertilization separately (Sinyavskiy & Elikbaeva, 2019; Tyliszczak *et al.*, 2019). This fact is due to the reason of that often-organic fertilizers are not able to fully provide the necessary amount of nitrogen in the soil required for a noticeable increase in plant growth (Ignatova *et al.*, 2015; Shahini *et al.*, 2022). For example, the use of chicken manure together with urea significantly increases the wheat yield and the number of spikelets per square meter (Limon-Ortega *et al*., 2008; Jiang *et al*., 2006). The results of studies conducted in the Kurgan Region showed a positive effect of the use of organic (poultry manure) and organomineral fertilizers on the quality of spring wheat grains, including the weight per 1000 grains and the gluten content (Sinyavskiy *et al*., 2019; Ndayegamiye & Cote, 1989).

In accordance with the previous studies, the introduction of a crop rotation of legume crops with cereals makes it possible to increase the content of available nitrogen in the soil, thereby increasing the yield and protein content of the latter (Vyn *et al*., 2000; Vrignon-Brenas *et al*., 2018). Perhaps, more research should be done regarding the use of composted poultry manure as a fertilizer for cereals with the introduction of crop rotation with legume crops as well (Zhengchao *et al*., 2013). In general, it can be noted that the autumn fertilization of poultry manure at the doses of 20 t/ha and 30 t/ha allowed to increase the protein content in the grain compared to the control, which is consistent with the previous study (Shahid *et al*., 2015; Dikinya & Mufwanzala, 2010). The use of poultry manure along with the mineral phosphate fertilizers and phosphate solubilizing bacteria makes it possible to increase the protein content in corn grains (Zafar *et al*., 2011).

Conclusions

Years of intensive land use with extensive use of synthetic fertilizers aimed only at increasing crop yields, has led to a serious exhaustion of soil fertility. Poultry manure as a valuable source of nutrients, is an environmentally friendly measure in order to stop further soil degradation and maintain soil fertility. An organic fertilizer based on composted poultry manure allows increasing the wheat yield and the quality of the resulting grain. The application of fertilizer based on poultry manure at a dose of 10 t/ha provided a slight increase in wheat yield compared to the control. The analysis of the dough extensibility showed high values, which can be due to the fact that durum wheat was used which is characterized by increased dough extensibility that is so important in the pasta manufacture. Scientific value of the work based in the finding of the cost-effective recommended dose of autumn fertilization of organic fertilizer on the basis of poultry manure.

Autumn fertilization of 20 t/ha and 30 t/ha compost allowed to increase the yield by 34% and 55%, respectively. In accordance with the results of the technological qualities of wheat grain analysis, the variant with the fertilization of organic fertilizer at a dose of 20 t/ha showed the best result. The prospects of further research consist in the studying the aftereffect of organic fertilizer and its impact on the yield not only of wheat, but also of other strategically important crops.

References

Amanullah, M., S. Sekar and P. Muthukrishnan. 2010. Prospects and potential of poultry manure. *Asian J. Plant Sci.*, 9(4): 172-182.

Andryeyeva, N., O. Nikishyna, B. Burkynskyi, N. Khumarova, O. Laiko and H. Tiutiunnyk. 2021. Methodology of analysis of the influence of the economic policy of the state on the environment. *Insights Reg. Develop.*, 3(2): 198-212. https://doi.org/10.9770/IRD.2021.3.2(3).

Bazaliy, V., Ye. Domaratskiy, V. Pichura, O. Kozlova and A. Jarosiewicz. 2022. Realization of the adaptive yield potential of the assortment of winter wheat in the Steppe zone under different growing conditions. *Ukrain. Black Sea Reg. Agrar. Sci.*, 26(4): 30-39. https://doi.org/10.56407/2313-092X/2022-26(4)-3.

Boateng, S., J. Zickermann and M. Kornahrens. 2006. Poultry manure effect on growth and yield of maize. *W. Afr. J. Appl. Ecol.*, 9(1): 1-11.

Boustani, N.M., M. Ferreira and R.P. Guiné. 2021. Food consumption knowledge and habits in a developing country: a case of Lebanon. *Insights Reg. Develop.*, 3(4): 62-79. http://doi.org/10.9770/IRD.2021.3.4(5).

Dikinya, O. and N. Mufwanzala. 2010. Chicken manure-enhanced soil fertility and productivity: Effects of application rates. *J. Soil Sci. Environ. Manag.*, 1(3): 46-54.

Fauci, M.F. and R.P. Dick. 1994. Soil microbial dynamics: Short- and long-term effects of inorganic and organic nitrogen. *Soil Sci. Soc. Am. J.*, 58(3): 801-806.

Fedin, M.A. 1985. *Methodology of state crop variety testing of cultivated plants.* Moscow: Publishing House of the Ministry of Agriculture of the USSR.

Gridneva, E.E., G. Sh. Kaliakparova and O.S. Guseva. 2018. Modern trends in the development of the wheat market in the Republic of Kazakhstan. *Prob. Agri. Market*, 2: 148-154.

Hoover, N.L., J.Y. Law, A.M. Long, R.S. Kanwar and M.L. Soupir. 2019. Long-term impact of poultry manure on crop yield, soil and water quality, and crop revenue. *J. Environ. Manag*., 252: 109582.

Ignatova, L., Y. Brazhnikova, R. Berzhanova and T. Mukasheva. 2015. The effect of application of micromycetes on plant growth, as well as soybean and barley yields. *Acta Biochim. Pol.*, 62(4): 669-675. https://doi.org/10.18388/abp.2015_1100

Jacoby, R., M. Peukert, A. Succurro, A. Koprivova and S. Kopriva. 2017. The role of soil microorganisms in plant mineral nutrition – current knowledge and future directions. *Front. Plant Sci.*, 8: 1617.

Jiang, D., H. Hengsdijk, T. Dai, W. de Boer, J. Qi and W. Cao. 2006. Long-term effects of manure and inorganic fertilizers on yield and soil fertility for a winter wheat-maize system in Jiangsu, China. *Pedosphere*, 16(1): 25-32.

Karbivska, U., V. Kurgak, V. Gamayunova, A. Butenko, L. Malynka, I. Kovalenko, V. Onychko, I. Masyk, A. Chyrva, E. Zakharchenko, O. Tkachenko and O. Pshychenko. 2020. Productivity and quality of diverse ripe pasture grass fodder depends on the method of soil cultivation. *Acta Agrobot.*, 73(3): 7334. https://doi.org/10.5586/AA.7334

Karches, T. and K. Buzás. 2013. Investigation of residence time distribution and local mean age of fluid to determine dead-zones in Flow Field. *Int. J. Comput. Methods Experim. Measur.*, 1(2): 132-141. https://doi.org/10.2495/CMEM-V1-N2-132-141

Khoroshev, A.V., K.A. Tkach and D.U. Murtazina. 2018. Influence of landscape pattern on productivity of grain crops in the steppe zone of Northern Kazakhstan. *Vest. Moskov. Univ.*, 5(3): 62-69.

Limon-Ortega, A., B. Govaerts and K. Sayre. 2008. Straw management, crop rotation, and nitrogen source effect on wheat grain yield and nitrogen use efficiency. *Eur. J. Agron.*, 29(1): 21-28.

Limon-Ortega, A., B. Govaerts and K. Sayre. 2009. Crop rotation, wheat straw management, and chicken manure effects on soil quality. *Agron. J.*, 101(3): 600-606.

Malchikov, P.N., M.A. Rozova, A.I. Morgunov, M.G. Myasnikova and Y.I. Zelensky. 2018. Yield performance and stability of modern breeding stock of spring durum wheat (*Triticum durum* Desf.) from Russia and Kazakhstan. *Vavilov J. Genet. Breed.*, 22(8): 939-950.

Mukhametzhanov, A. and R. Zholaman. 2023. Economic analysis of spring soft wheat seed production in North Kazakhstan region. *Scient. Hor.*, 26(3): 92-100.

Ndayegamiye, A. and D. Cote. 1989. Effect of long-term pig slurry and solid cattle manure application on soil chemical and biological properties. *Can. J. Soil Sci.*, 69(1): 39-47.

Netrusov, A.I., M.A. Egorova, L.M. Zakharchuk and N.N. Kolotilova. 2005. *Practicum on Microbiology: A textbook for university students.* Moscow: Akademiya.

Norton, L.R., A. Joys, R.C. Stuart and P.J. Johnson. 2009. Consequences of organic and non-organic farming practices for field, farm and landscape complexity. *Agr. Ecosyst. Environ.*, 129(1): 221-227.

Ovtsinov, V.I., N.A. Zhamanova and P.M. Stark. 2015. The evaluation of the local organic fertilizer effectiveness in spring wheat cultivation and soil fertility reproduction in Northern Kazakhstan. *Bull. Altai State Agrar. Univ.*, 11(133): 24-29.

Panfilova, A., A. Mohylnytska, V. Gamayunova, M. Fedorchuk, A. Drobitko and S. Tyshchenko. 2020. Modeling the impact of weather and climatic conditions and nutrition variants on the yield of spring barley varieties (*Hordeum vulgare* L.). *Agron. Res.*, 18(Special Issue 2): 1388-1403.

Panfilova, A., M. Korkhova, V. Gamayunova, M. Fedorchuk, A. Drobitko, N. Nikonchuk and O. Kovalenko. 2019. Formation of photosynthetic and grain yield of spring barley (*Hordeum vulgare* L.) depend on varietal characteristics and plant growth regulators. *Agron. Res.*, 17(2): 608-620.

Pashkov, S.V. and S.B. Baybusinova. 2017. Natural and agrogene conditionally of soils fertility in Northern Kazakhstan. *Transbaik. State Univ. J.*, 23(2): 16-27.

Shahid, M., M. Saleem, Z. Khan, M. Wahid and M. Sarwar. 2015. Improving wheat (*Triticum aestivum* L.) yield and quality by integration of urea with poultry manure. *Soil Environ.*, 34(2): 148-155.

Shahini, E., E. Skuraj, F. Sallaku and S. Shahini. 2022. Smart fertilizers as a solution for the biodiversity and food security during the War in Ukraine. *Scient. Hor.*, 25(6): 129-137.

Sheoran, S., D. Raj, R.S. Antil, V.S. Mor and D.S. Dahiya. 2017. Productivity, seed quality and nutrient use efficiency of wheat (*Triticum aestivum*) under organic, inorganic and integrated nutrient management practices after twenty years of fertilization. *Cereal Res. Commun.*, 45(2): 315-325.

Sinyavskiy, I.V. and S.A. Elikbaeva. 2019. Influence of combinations of organic and mineral fertilizers on yield and quality of spring wheat grain in the room of grain sparing. *Sci. J. Vestnik Kurgan State Agric. Acad.*, 2(30): 34-37.

Sinyavskiy, I.V., S.A. Elikbayeva and A.M. Plotnikov. 2019. Influence of the bird's dung and mineral fertilizers on productivity of wheat in the crop rotation link. In: *Actual Problems of Rational Use of Land Resources: Materials III All-Russian (national) Scientific and Practical conference* (pp. 139-143). Kurgan: Kurgan State Agricultural Academy named after T.S. Maltsev.

Tagoe, S., T. Horiuchi and T. Matsui. 2008. Effects of carbonized and dried chicken manures on the growth, yield, and N content of soybean. *Plant Soil*, 306(1): 211-220.

Tejada, M., M. Hernandez and C. Garcia. 2006. Application of two organic amendments on soil restoration: Effects on the soil biological properties. *J. Environ. Qual.*, 35(4): 1010-1017.

Tepper, E.Z. 2005. *Workshop on microbiology.* Moscow: Academy.

Teuchezh, A.A. 2017. The use of bird droppings as an organic fertilizer. *Polythem. Network Electr. Sci. J. Kuban State Agrar. Univ.*, 128: 913-930.

Tyliszczak, B., A. Drabczyk, S. Kudłacik-Kramarczyk, K. Rudnicka, J. Gatkowska, A. Sobczak-Kupiec and J. Jampilek. 2019. In vitro biosafety of pro-ecological chitosan-based hydrogels modified with natural substances. *J. Biomed. Mater. Res. - Part A*, 107(11): 2501-2511.

Vandecasteele, B., B. Reubens, K. Willekens and S. Neve. 2014. Composting for increasing the fertilizer value of chicken manure: effects of feedstock on P availability. *Waste Biomass Valori.*, 5(3): 491-503.

Vrignon-Brenas, S., F. Celette, A. Piquet and G. Corre-Hellou. 2018. Intercropping strategies of white clover with organic wheat to improve the trade-off between wheat yield, protein content and the provision of ecological services by white clover. *Field Crops Res.*, 224: 160-169.

Vyn, T.J., J.G. Faber, K.J. Janovicek and E.G. Beauchamp. 2000. Cover crop effects on nitrogen availability to corn following wheat. *Agron. J.*, 92(5): 915-924.

Zafar, M., N. Rahim, A. Shaheen, A. Khaliq, T. Arjamand, M. Jamil, Z. Rehman and T. Sultan. 2011. Effect of combining poultry manure, inorganic phosphorus fertilizers and phosphate solublizing bacteria on growth, yield, protein content and P uptake in maize. *Adv. Agric. Bot*., 3(1): 46-58.

Zhengchao, Z., G. Zhuoting S. Zhouping and Z. Fuping. 2013. Effects of long-term repeated mineral and organic fertilizer applications on soil organic carbon and total nitrogen in a semi-arid cropland. *Eur. J. Agron.*, 45: 20-26.

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