A QUALITATIVE AND ECONOMIC EVALUATION OF THE SPREADING OF DIFFERENT ORGANIC FERTILIZERS

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Abstract
Recently, the use of granular fertilizers in agriculture has been expanding rapidly due to their favorable properties in improving the environment and increasing operational efficiency. Therefore, a qualitative and economic evaluation of the precise application of granular and non-granular organic fertilizers has been performed in this work. The evaluation of the uneven application of organic fertilizers was performed by spreading cattle manure, manure granules, and lime in the spreading spreader "Rollforce" 5517. The economic evaluation was performed for mechanized technological operations of loading, transportation, and distribution of organic fertilizers, estimating the price of used aggregates and consumed fuel, the cost of individual technological operations, and other indirect costs. Studies have shown that manure is easier to spread over a wider area than pellets and lime, as manure particles are much larger and heavier. The lowest costs (180 Eur ha^{-1}) for the purchase of organic fertilizers are incurred using manure, but in the evaluation of mechanized technological operations, the lowest costs (2.32 Eur ha^{-1} and 6.65 Eur ha^{-1}) are obtained for fertilization with meat and bone meal pellets, and manure pellets.

Key words: *cattle manure; granulated fertilizers; lime fertilizers; costs; spreading.*

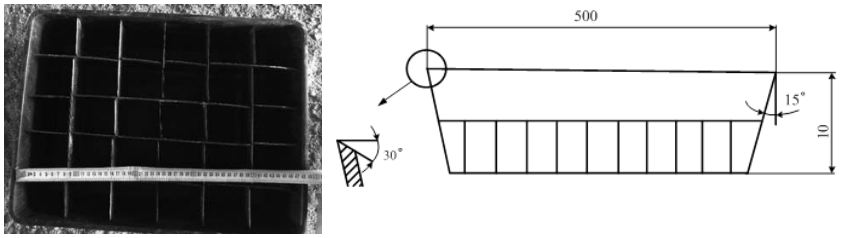
INTRODUCTION

To obtain an optimal yield, it is very important to provide growing plants with the necessary nutrients (*Schmitt & Vries, 2020; Sikora et al., 2020*). *Stewart et al.* (2005) states that crop fertilization increases crop production by 30-50%. The scientific literature states that there are many crops and plants with different growing habits as well as different nutrient needs. Fertilizers containing measured nutrient mixtures, which give plants access to potential nutrients, accelerate growth and provide higher yields than usual, help to meet these needs (*Hazra, 2016*). The main means of building up good quality humus are fertilization with organic fertilizers such as manure, compost, peat, straw (*Čiuberkis, 2005; Pranckietienė & Dromantienė, 2017; Jonikaitė, 2018*). Organic fertilizers are also defined as those derived exclusively from the remains of decayed or decaying plants or animals (*Khandaker et al., 2017*). The use of organic fertilizers not only saves on mineral fertilizers but also contributes to the preservation of the environment (*Jonikaitė, 2018).*
Manure has been used around the world for centuries as the optimal fertilizer for farming (*Chew et al., 2019*). Recently, the production of granular organic fertilizers manufacturing popularity, the main purpose of which is to convert organic substances with a high moisture content (manure, manure mixtures, meat, bone waste, or other organic substances) into convenient pellets. The granules are usually made in such a way that they can be spread with mineral fertilizer spreaders, preferably 4 or 6 mm (*Staugaitis et al., 2016*). This technology can be applied to manure processing to facilitate the export of manure nutrients to the market (*Sharara et al., 2018*). The main advantage of granular organic fertilizers is that they contain 50-75% organic matter. It is a very good tool for restoring the amount of humus in the soil (*Staugaitis et al., 2016*).
The efficiency of fertilizers is determined by many factors, but the focus is on fertilization rates and forms of fertilizer and the timing of fertilizer application, considering into account the stages of plant development. However, another important factor is the quality of the fertilizer application. Poor quality spreading of even the best fertilizers can have a negative impact on economic performance, increase environmental pollution and reduce plant quality (*Zinkevičius, 2004; Ştefan et al., 2019; Sikora et al.,*

2020). Equal the application of organic fertilizers is a complex process, as the consistency and size, and shape of fragments are not homogeneous, so the movement of fertilizers on the surface of the spreading (metal) and in the air is uneven (*Ştefan et al., 2019*). The dynamics of the spread of fertilizer particles are influenced by the fixed and changing technical specifications of the spreader. The point of descent of a particle on the soil depends on the trajectory of the particle itself, which is ejected by the rotating disk (*Pocius et al., 2014*).
To find the best technological solution for the application of various organic fertilizers, it is very important to carry out experimental studies of the properties of fertilizers and their application under real conditions in the field. It is equally important to carry out an economic assessment that would justify the cost-effectiveness of the use of different organic fertilizers. The aim is to perform a qualitative and economic assessment of the precise application of granular and non-granular organic fertilizers.

MATERIALS AND METHODS

Experimental research methods and parameters for the application of granular organic fertilizers to soil were selected and determined according to the relevant standards ISO 5690 and ASAE S314.2. The assessment of the uneven the transverse application of organic fertilizers was performed by spreading cattle manure, manure pellets, and lime in the spreading spreader "Rollforce" 5517. The unevenness of the fertilizer application is assessed by the coefficient of variation of the distribution of the fertilizer mass determined by collecting the spreading fertilizer over the entire working width of the fertilizer machine. For this purpose, in a line perpendicular to the direction of movement of the fertilizer implement, special boxes with dimensions of 500x400x10 mm are placed on the field surface over the entire working width of the fertilizer (Fig. 1). For spreading lime and granular fertilizer, cardboard partitions are placed in the trays so that the fertilizer does not bounce off the bottom of the tray and is evenly collected in the box.



a) b)

Fig. 1 Experimental research boxes, used to determine the irregularities in the transverse application of the fertilizer: (a) general top view; (b) box scheme from the side

For one measurement, special boxes for collecting fertilizers are arranged in one row with a gap of at least one meter between them. The row of boxes is arranged so that the direction of movement of the machine coincides with the prevailing wind direction. 3 replicates were performed for each experiment. An example of the arrangement of the boxes is given in Fig. 2.

Fig. 2 Arrangement of boxes to determine the evenness of organic fertilizers

Fertilizers were spread while driving at a speed of 12 km h^{-1}. All fertilizers were spread with the same fertilization rate, 200 kg ha^{-1}.

The economic evaluation was performed for mechanized technological operations of loading, transportation, and spreading of organic fertilizers, estimating the price of used aggregates and consumed fuel, the cost of individual technological operations, and other indirect costs. Expenses affecting the change of economic costs in technological operations, calculated according to the rates of mechanized work services prepared by the Lithuanian Institute of Agrarian Economics (*LIAE, 2018*). Nitrogen N, phosphorus P_2O_5 and potassium K_2O fertilizer prices were selected according to the literature (*Kazlauskas et al., 2021*), accordingly N – 0,90 Eur kg^{-1}, P_2O5 – 0,8 Eur kg^{-1} ir K_2O – 0,5 Eur kg^{-1}.

Arithmetic means of the data, their standard deviations and confidence intervals at the probability level of 0.95 were determined.

RESULTS AND DISCUSSION

Experimental studies have shown that the lowest amount of lime fertilizer entered the boxes furthest from the spreading discs of the fertilizer machine. Box 6, meanwhile, has a maximum amount of fertilizer. It should be noted that this box was placed in the center between the tractor and the fertilizer wheels during the studies (Fig. 3a.). Studies on the uniformity of manure spreading with a manure spreader showed that the amount of manure in the test boxes ranged from 491 g to 982 g (Fig. 3a). The results of the study were evaluated by calculating a Gaussian coefficient that is less than 0, suggesting that the uniformity of distribution is greater than that of lime. This is because the manure particles are much larger and heavier, making it easier to spread them over a wider area during spreading.

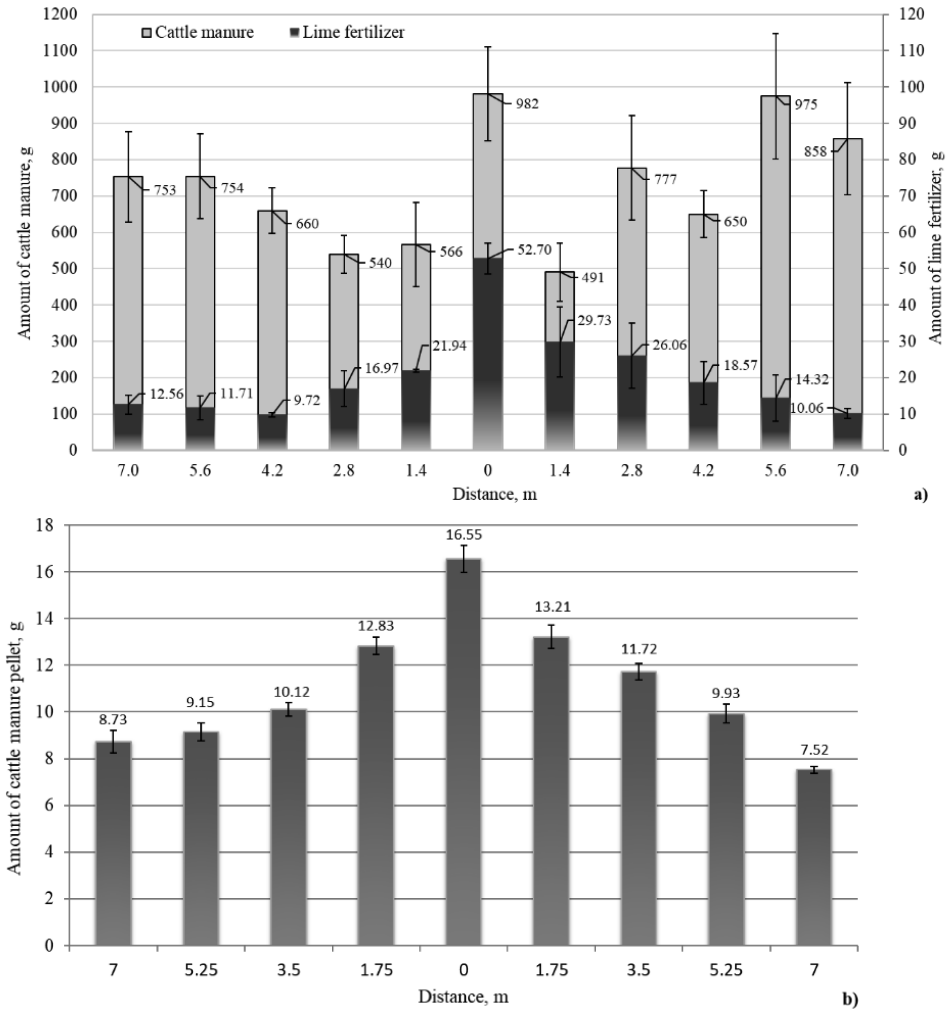


Fig. 3 Quality of organic fertilizer spreading: a – cattle manure and lime fertilizer; b – cattle manure pellet

As can be seen in Fig. 3b., the amount of organic granular fertilizer in the test boxes varied from 7.52 g to 16.55 g. The box in the center, which was in the middle of the fertilizer, had the highest amount of granular fertilizer falling between the tractor and the manure spreader wheels, reaching 16.55 g. The spreading of granular fertilizers was not uniform. In order to improve the spreading uniformity, it is necessary to increase the number of cross conveyor belts and the corps must not be fully no unloaded in order to ensure a smooth and even supply of pellets.
Analyzing the value of one tonne of organic fertilizer by individual elements, it was found that manure pellets and meat and bone meal pellets have significantly higher NPK levels than manure, so the rate of manure pellets or meat and bone meal pellets can be many times less that to provide similar economic benefits to the soil. However, in assessing the cost of organic fertilizers, it has been found that the cheapest organic fertilizer is manure (Tab. 1), as it is used for livestock production, and manure pellets or meat and bone meal pellets still have to go through a certain technological process before they become pellets form. As a result, their price per tonne is several times higher.

Tab. 1 Costs of organic fertilizers spreading

Organic fertilizers quantity	Costs on organic fertilizers, Eur ha^{-1}	Loading, Eur ha^{-1}	Transportation, Eur ha^{-1}	Spreading, Eur ha^{-1}	All costs, Eur ha^{-1}
Manure (16 t ha^{-1})	180	4.64	22.24	26.3	233.18
Manure pellet (2 t ha^{-1})	400	0.58	2.78	3.29	406.65
Meat and bone meal pellet (0.7 t ha^{-1})	273	0.20	0.97	1.15	275.32

An analysis of the costs of loading, transporting, and spreading different types of organic fertilizers has shown that the highest costs per hectare are incurred when manure is applied, 53.18 Eur ha^{-1} is spent. This is because is not enough for manure one spreader to in the spreading of one hectare. Depending on the capacity of the manure spread, you may need to drive several times. Distance also has a significant effect. In our case, the distance to the field was 7.5 km. The further away the field is fertilized from the livestock complex, the higher the transport costs. Fertilization with manure pellets with one load of spreader can fertilize several hectares and fertilization with meat and bone meal pellets - a dozen hectares. And this, of course, significantly reduces costs.
Organic fertilizer pellets have several other advantages over manure that are not always easy to evaluate money. Dry organic fertilizer pellets are much easier, cleaner, and safer to transport than wet manure (*Jotautienė et al., 2021*). The high temperature of pellet production allows the removal of all harmful pathogens or microorganisms, so safe and nutritious fertilizers reach the soil and plants. The granulation process also reduces unpleasant odors, which is very important during the transport and fertilization of fields (*Klyosov & Orekhovskaya, 2021*). Other authors state that the yield of spring wheat is significantly higher when using organic granular fertilizers compared to non-granular fertilizers (*Apaeva et al., 2021*).

CONCLUSIONS

The spreading of the pellets was influenced by the pulsating supply of pellets by the conveyor towards the spreading discs. To improve the uniformity of the spreading of the pellet's fertilizer by the spreader, it is necessary to increase the number of cross conveyor belts and to always have a not fully discharged corps to ensure a smooth and even supply of pellets. The effect on the uniformity of manure spreading is that the manure particles are much larger and heavier, which makes it easier to spread over a wider area during spreading, which is the opposite compared to lime fertilizers.
Fertilization costs for loading, transport, and spreading are several to dozen times higher than for manure pellets (8 times) and meat and bone pellets (23 times). Assessing the total costs, including the price of fertilizers, fertilization with manure results in only 42.14 Eur ha^{-1} lower costs compared to fertilization with meat and bone meal pellets, but significantly lower (173.47 Eur ha^{-1}) compared to fertilization with manure pellets. However, granular fertilizers are more easily compatible with modern agricultural machinery used for precision farming.

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