

Methods and Results of Experimental Studies on The Indicators of Combined Fertilizers

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Abstract: This article presents a fertilizer device of a combined unit that distributes organic fertilizers over the surface of a field in the form of a strip and forms a pile above it. The device studied the diameter of the auger of fertilizer blades, the number of revolutions, the installation angle of the blades on the shaft, as well as the influence of the installation angle of the blades on the shaft. The results of experimental studies to determine the uneven distribution of fertilizer application rates according to the movement of the unit are determined.

Keywords: Electric Motor, Pulley, Belt, Organic Fertilizer (Manure), Device, Auger, Unit, Humus, Soil, Auger Rotation Speed

Introduction

We see that on land irrigated for a long time, the amount of humus and a number of nutrients in the soil has decreased. Therefore, to improve the physical and mechanical properties of the soil, increase the productivity of cotton, grain and other crops while the cost of mineral fertilizers increases, it is important to use relatively cheap organic fertilizers [1], [2].

In global agriculture, organic fertilizers are widely used to improve soil fertility and obtain quality products from agricultural crops. Currently, many methods and technologies for applying organic fertilizers to the development zone of plant roots are being developed. As a result of the research and surveys carried out, a combined unit was developed that distributes organic fertilizers over the surface of the field in the form of a strip and forms a dust-like mass above it. Theoretical studies were carried out based on the parameters of the developed device for aggregate fertilization and the desired results were obtained. with practical ones, as well as to determine the energy and quality indicators of the device. To conduct experimental studies, the pushers of the device were removed, the support wheels were raised, and instead of the cardan transmission, an electric motor was bolted to the frame of the device [3].

The electric motor was connected to the gear reducer by a belt transmission. A film was placed under the device for complete collection of manure falling out of the fertiliser ejection chute of the device (Fig. 1). Pulleys of different diameters were used to ensure different speeds of the thumbscrew rotation



Figure 1. Laboratory copy of the device

1- frame; 2- hopper; 3- support wheel; 4- electric motor; 5- electric measuring device; 6-rolling chute; 7- belt transmission pulley;8- support stand; 9- slurry.

Methodology

The methodology for evaluating the performance and operational stability of the combined fertilizer device was established through structured laboratory experimental studies designed to distribute organic manure over a field surface. To isolate and precisely control testing conditions, the device's pushers were removed, its support wheels were elevated, and the traditional cardan transmission was replaced with an electric motor bolted directly to the frame and connected to a gear reducer via a belt transmission. A collection film was positioned beneath the ejection chute to capture the discharged cattle manure entirely. The laboratory plot was configured to simulate the simultaneous treatment of four crop rows. Systematic single-factor experiments were conducted by loading exactly 100 kg of weighed cattle manure into the hopper sections, initiating the device, and recording the elapsed time until complete discharge to determine the fertilizer transmission rate [4]. The primary variables investigated included evaluating blade lengths from 100 to 130 mm to test auger diameters of 260, 280, 300, and 320 mm; checking rotational speeds at 40, 50, 60, and 70 rpm using different pulley diameters; and varying the blade installation angles on the shaft between 35 and 65 degrees. Each distinct experimental setup was repeated four times, and the collected manure was weighed on a scale. The resulting empirical data underwent statistical processing to calculate the application rate per unit area and assess its distribution irregularity — measured via the coefficient of variation — against baseline theoretical expectations [5].

Results

Experimental studies were conducted in order to compare the results of the conducted theoretical studies.

The laboratory plot was also designed to treat 4 rows, all rows were fertilised and the prescribed experiments were carried out.

Laboratory experiments were conducted to study the influence of auger diameter D_b on the fertilizer rationing process and its non-uniformity. For this purpose, blades of different lengths of 100, 110, 120 and 130 mm and auger diameter of 260, 280, 300 and 320 mm were prepared respectively Figure 2.

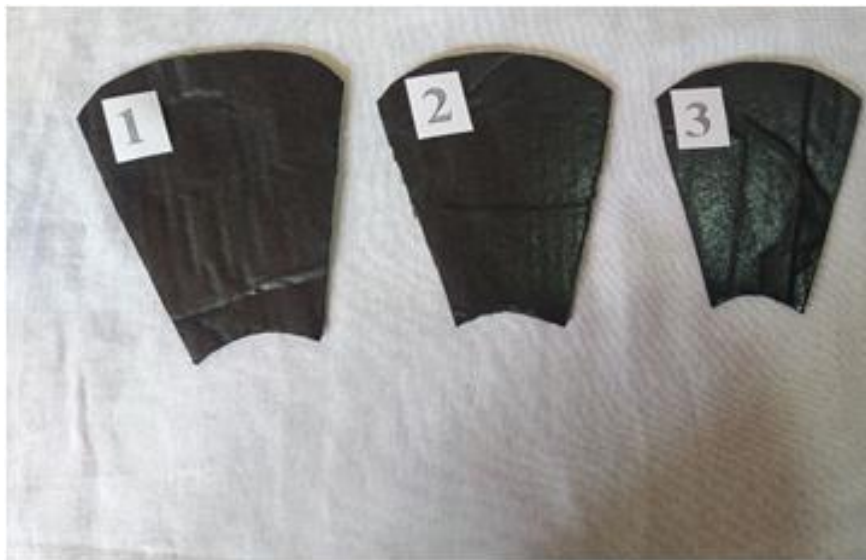


Figure 2. Auger blades of different sizes

Other parameters, including auger speed 60 rpm, number of blades in each screw 15 pcs, angle of blade installation on the shaft 45°.

A total of 100 kg of cattle manure was weighed into each hopper section, the device was started and the time elapsed until the manure was finished was measured. The amount of manure from each fertiliser was measured on the scale [6]. Experiments were conducted in 4 repetitions for each variant. The data obtained from the experiments were processed statistically. The fertilisation rate and its irregularity (coefficient of variation) were taken as evaluation criteria.

Using known data and expressions, the rate of fertiliser application per unit area N was determined by the following ratio.

$$N = 36qz, \text{ kg/ga}, \quad (1)$$

where z is the number of screws, pcs.

The results obtained during the experiments are presented in Table 1. The experimental data were compared with the results obtained in the theoretical part of the study.

Table 1. Influence of auger diameter on fertiliser application rate

Diameter of propeller blade $Dsh, \text{ mm}$	Fertiliser transmission rate $q, \text{ g/s}$			Fertilisation rate $N, \text{ kg/ga}$
	$qo'r$	$\pm\sigma$	$V, \%$	
260	216,32	0,19	15,42	4830,9
280	242,10	0,16	8,85	4498,4
300	278,86	0,15	7,88	5181,7
320	308,42,15	0,20	17,23	5730,6

To calculate expression 1: speed 6.5 km/h; assumed coverage width 2.4 m

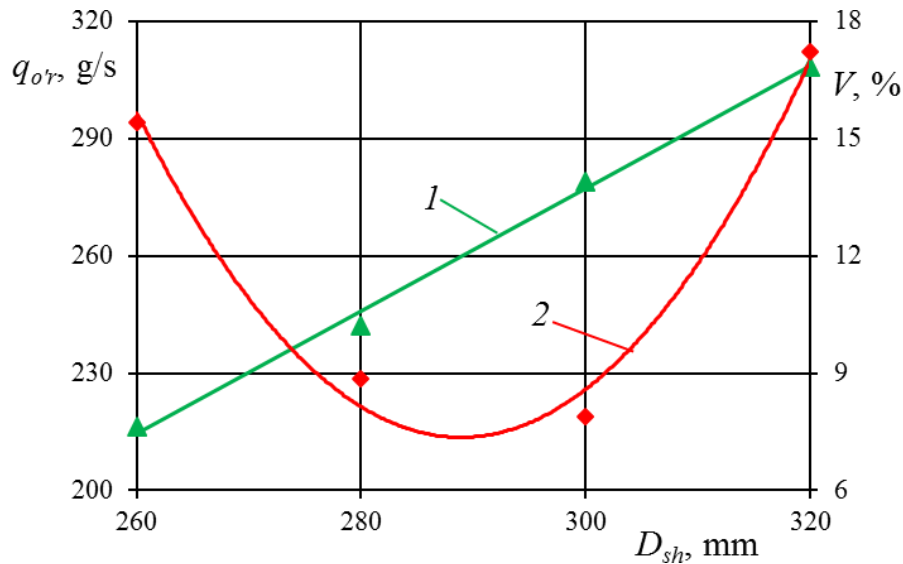


Figure 3. Graph of change in fertiliser application rate and its standard deviation depending on auger blade diameter

From the analysis of the graphs it follows that it is necessary to increase the auger diameter from 260 mm to 320 mm, and the fertiliser rate increases proportionally, i.e. according to the straight line rule. Because as the diameter of the auger blade increases, the working surface of the blade, i.e. the working volume, also increases.

It was found that the unevenness of fertiliser application, i.e. the diameter of the paddle auger increased from 260 mm to 290 mm, significantly decreased from 25.5% to 10.8% and increased from 290 mm to 320 mm (from 10.8% to 21.3%) [7], [8].

This situation can be explained as follows: when the auger diameter is small, the working surface of the auger corresponds to it. However, manure pellets have a certain size, regardless of the size of the bird. Due to the small working surface of the mouldboard, the manure pieces cannot be completely placed on it, as a result the movement of manure in the housing is low. As the working surface increases, this process improves and manure transfer from the hole to the boom stabilises in the auger diameter range of 280-300 mm, indicating a reduction in the unevenness of the application rate. Further increase in the working surface of the parrot increased the unevenness of the rate, but the level of unevenness of the fertiliser rate met the initial requirements, i.e. became less than 25%.

In single-factor experiments to study the effect of the number of auger revolutions on the rate of fertiliser application, the auger diameter was 300 mm, the angle of auger installation on the shaft was 45°. The number of auger rotations was 40, 50, 60 and 70 rpm with an interval of 10 rpm. The experiments were carried out in 4 repetitions [9]. The fertilisation rate and its irregularity (coefficient of variation) were taken as evaluation criteria as indicated above.

The results obtained are presented in Table 2 and Fig. 4 in the form of graphs.

Table 2. Influence of auger blade speed on fertiliser application rate

Number of propeller revolutions m , rpm	Fertilisation rate q , g/s			Fertilisation rate N , kg/ga
	q_{ort}	$\pm\sigma$	V , %	
40	236,32	0,20	15,42	4390,97
50	278,14	0,18	8,85	5167,8
60	324,86	0,17	9,88	6035,89
70	368,42	0,24	17,23	6845,24

To calculate expression 1: speed 6.5 km/h; The pavement width was assumed to be 2.4 m.

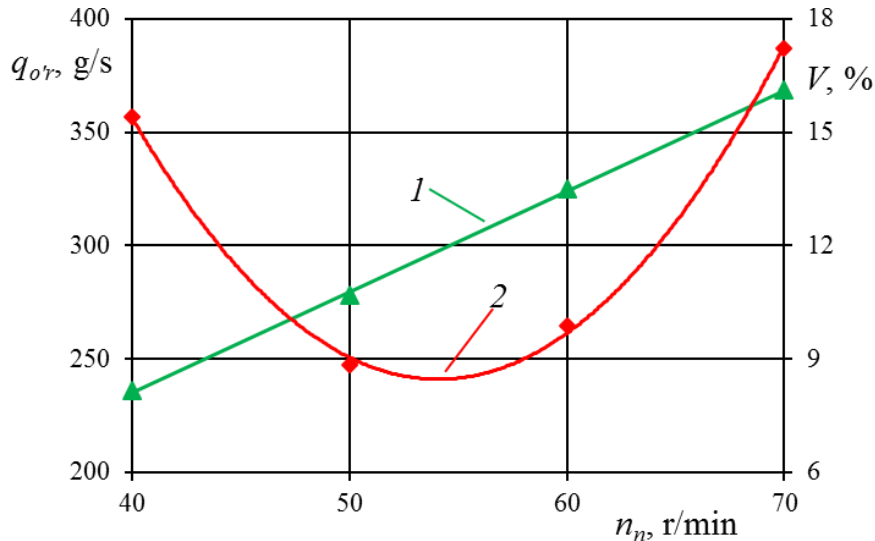


Figure 4. Graph of change in fertiliser application rate and its standard deviation depending on the number of rotations of the paddle auger

From the analysis of the graphs we can see that the number of revolutions of the auger blade increases from 40 rpm to 70 rpm, and the application speed increases proportionally, i.e. according to the law of straight line. Because as the number of auger revolutions increases, the number of simultaneous movements of the auger in the housing also increases.

The irregularity of fertiliser application rate initially changed from 14.64 % to 9.56 % (according to the coefficient of variation). The correlation graph in Figure 4 has a concave parabola pattern, and the rate non-uniformity is relatively high at low (40 rpm) and high (70 rpm) speeds. However, the unevenness of fertiliser application rate in the studied range of 50-62 revolutions per minute quite meets the initial requirements [10], [11]. Consequently, the number of auger revolutions in this range provides stability of fertiliser application rate. According to the results of experiments can be adjusted the rate of fertiliser application by changing the number of revolutions of the paddle auger and it can be concluded that the unevenness of the rate of fertiliser application will be within the initial requirements.

One of the factors affecting the quality indicators of the technological process is the angle of blade installation on the shaft. According to the results obtained in theoretical studies, the blades were set on the shaft at angles from 35° to 65° with an interval of 10 degrees [12]. The experiments were conducted at each set angle and repeated 4 times. During the experiment, the parameters of a screw with a diameter of 300 mm and a speed of 60 rpm were kept constant.

The obtained results are included in Table 3 and presented in Fig.5.

Table 3. Results

Angle of blade installation on the shaft γ , degree.	Fertilisation rate q , g/s			Fertilisation rate N , kg/ga
	q_{ort}	$\pm\sigma$	V , %	
35	216,65	0,22	13,62	4025,35
45	278,56	0,16	9,66	5175,65
55	273,67	0,26	8,1	4954,73
65	240,12	0,24	15,25	4461,43

To calculate expression 1: speed 6.5 km/h; assumed coverage width 2.4 m.

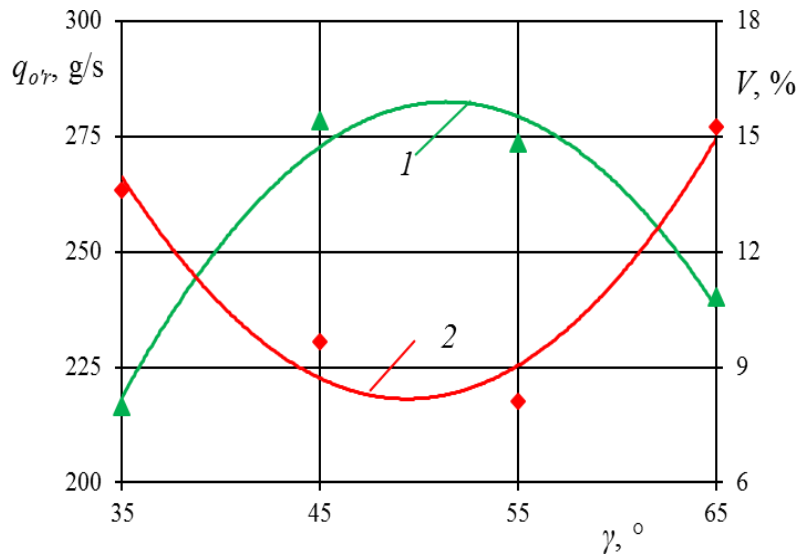


Figure 5. Graph of change in fertiliser application rate and its standard deviation depending on the blade angle on the shaft

In experiments with the paddle auger set at an angle of 35° , the amount of fertiliser removed from the casing by each wing was 216 grams. This is a fertiliser application rate of 4025 kg/ha. Increasing the angle of installation will also increase the amount of fertiliser removed from the casing [13]. When the parrack was set at an angle of 45° it was able to push the highest amount of fertiliser out of the hull and this value was 278 grams and the fertiliser application rate was 5175 kg/ha. Increasing the parrack angle also resulted in a decrease in the rate of manure removal from the shell and consequently the fertiliser application rate. Because the percentage of fertiliser carried out by the parrack from the sheath decreases.

From the analysis of the graph, it can be seen that the amount of fertiliser carried out of the shell in one period of time is related to the angle of its installation on the shaft according to the law of bubble parabola. Unevenness of fertiliser application rate is related to the angle of blade installation on the shaft according to the law of concave parabola [14], [15]. At an angle of installation of a knife on a shaft within $45\text{-}55^\circ$ the unevenness of a rate of fertiliser application satisfies the specified requirement. Thus, from single-factor experiments the parameters of the device on the blade screw are established, that is, the diameter of the screw 280-300 mm, the number of revolutions 50-62 rpm, the angle of installation of the blade on the shaft $45\text{-}55^\circ$.

Conclusions

1. According to the results of the conducted experimental researches the following parameters of the device laying manure in the form of a strip in four rows and forming heaps on it are determined: diameter of the paddle auger - 290 mm, number of revolutions - 60 rpm (adjustable) and angle of the blade installation on the shaft - 50° .
2. At certain values of the parameters of the auger blade of the device the amount of manure poured from one rod is 267 g/s (fertiliser rate - 4961 kg/ha) and the unevenness of its distribution on the rows - 8.4. %.
3. The device of the proposed design works stably and reliably in cattle manure with humidity not more than 60%, not containing stones and similar solid materials. The coefficient of variation of change in the rate of fertiliser application in time depending on the distance travelled by the device averaged 15.8%.
4. The power required to rotate the bladed augers of the device is equal to 2038 kW when operating without load (salt) and 3011 kW when operating with load (fertilising process). Thus, the power consumed by the device for the fertilising process is equal to 0.973 kW.

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