



Research Results of a Combined Machine that Increases Productivity in Grain Farming

By Qurbanov Huseyn Nuraddin

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Uneven fertilization significantly affects the characteristics of the crop and causes environmental pollution. The inhomogeneity of the field in terms of nutrients resulting from fertilization is often the main cause of uneven cropping. Cereal plants also cause yield loss, which in some years can reach about 25-60%. Experience in the operation of modern technical means has shown that at present, there is a need to provide an equal amount of fertilizer on the slopes to under the soil, fully meeting the agro-technical requirements.

Keywords: slope, plow, mineral fertilizer, combined plough, speed.

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Abstract- Fertile and nutritious soil is the main condition for increasing the productivity of cereal crops in agriculture. By adding mineral fertilizers to the soil, nutrients are added to the nutrients in the soil and enrich it by increasing its fertility. Even distribution of fertilizers in the field is one of the main conditions that increase its efficiency. It is not possible to increase the productivity infinitely by increasing the fertilizer rate.

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As can be seen, the development of a new technical proposal for fertilizing and plowing the slopes in equal amounts on the slopes, improving the technological and design parameters, taking into account the physical and mechanical properties of fertilizers, is very important.

Taking into account the above-mentioned issues, a combined plough was developed in our laboratory. Combined plough carries out pre-sowing technological operation in the cultivation of cereals, providing a smooth equal amount of mineral fertilizers to under the soil on the slopes.

Thus, in the article, the optimal values of the constructive dimensions of the smooth spreading working part, which evenly distribute mineral fertilizers, were selected. Laboratory and field were tests of equal distribution conducted and the results were recorded in tables.

Keywords: slope, plow, mineral fertilizer, combined plough, speed.

I. INTRODUCTION

The use of the sensitivity functions of agricultural plants gives the opportunity to program productivity, requirements for machines and technologies, and the means of application of solid mineral fertilizers in the agricultural system (Pyataev M.V. 2014). The technological process of supplying different types of solid mineral fertilizers with structural machines consists of several technological operations that determine its direction (Mitchell D.1975). In order to prepare the technological process of introduction of solid mineral fertilizers, it is necessary to know the

methods of application of fertilizers, their physical and mechanical properties, and to have machine complexes that ensure the fulfillment of agrotechnical and ecological requirements during cultivation (OST. 70.71 - 2000). Machines with a centrifugal working body apply powder and granular fertilizers over a large variable working width (Simakin A. I. 1988, Sedashkin, A. et.al. 2013). The main drawback of these machines is the uneven distribution of fertilizers, especially when working on slopes. These traditional disadvantages of the work of machines with centrifugal working bodies are the main reason for the intensive search for other constructive solutions. Therefore, machines with centrifugal working bodies are improved both in our country and abroad mainly in order to improve the uniformity of sowing and increase productivity. One of the main agrotechnical indicators of the operation of mineral fertilizing machines is the provision of even distribution of mineral fertilizers in the field (Abbasov İ.D. 2011, Alakbarov J.Q. et.al. 2001).

Due to the soil climate in the republic, for a number of reasons, it is advisable to use additional sowing of fertilizers in excess of the basic norm. First of all, this allows to refuse the production and release of a large number of technical means (Merzlikin A.S., et.al. 1995). As already mentioned, it is necessary to accurately determine the fertilizer rate for the planting stock of fertilizer plants. Compliance with this condition also requires the high quality of fertilizers: nutrients, humidity, granulometric result and the strength of granules, which affects more distribution of sowing on the field (Alakbarov F. 2016).

This is due to the fact that, for the first time, machines equipped with working bodies of the disc spreader type are larger than the design width of the working width of the machine itself (Sendryakov I.F., et. al. 1976., Klyatis L.M., et.al., 1979). Therefore, it is necessary to mark the field or equip the machines with markers to ensure the desired working width. It causes environmental pollution. The inhomogeneity of the field of nutrients created during fertilization is the main reason for the unevenness of many crops(Mitchell D. 1974, Nasonov V.A. 1984). Cereal plants also cause yield loss, some plants can reach 25-60%. According to the literature, depending on the structural characteristics of the sown and the quality of the fertilizers sown, the applied fertilizer can be unevenly distributed between



40-60% of the norm, which leads to nutrient deficiency. (Adamchuk B.V. et.al. 2004, Ostanin A. I., et.al., 1971)

An increase in the distribution rate of uneven strength fertilizers to 70-80%, a decrease in the yield of cereals by 11-15 s/ha was observed. The researchers of foreign scientists can also find that the yield in the areas paid for by fertilizers, the applied application of uneven fertilizers, the yield is on average 15% higher. Therefore, it is advisable to study the impact of local and foreign materials and the quality of fertilizer payment on the entire field, and the application of uneven fertilization machines of the field is created (Bagirov B. et. al. 2018).

II. MATERIAL AND METHODS

Research studies were conducted through literature, patent and internet searches, as well as advanced advanced research. When checking the newly developed combined plough, the established standards were used: (Afanashev R.A., 2006)

1. General purpose boilers, methods of field tests - GOST-2911
2. Forestry and agricultural machines and tractors. Test admission rules GOST 28305-89, (STSE 6546-88).
3. Test of K/T technique - Ost 70.4.2.-80
4. OST 70.2.16-72 in the evaluation of the main operational-technological inspections

The main indicators of the goal determined in the process of farm trials are:

1. Ensuring the equality of distribution of fertilizers on the working area, %;
2. Ensuring the equality of distribution of the fertilizer application rate along the length of the machine passage, %.

The purpose of the technological process and the evaluation of the quality indicator include the following:

1. Deviation of the actual application norm from the set norm;
2. Determining the unevenness of the application;
3. Determining the unevenness of the fertilizers along and across the field;
4. Determination of the working speed of the machine for uniform spreading of fertilizers;
5. Determining the productivity of the machine for uniform spreading of fertilizers.

Fertilizer application rate (Q) in kilograms per hectare is calculated by the following formula: (Adamchuk VV., 2003)

$$Q = \frac{10 q}{LB}; \quad (3.7.1)$$

Here:

q - the mass of fertilizers sown during the repetition of the experiment, gr;

L - length of the calculation area, m;

B – the width of the combined plough, m

The accuracy of the actual fertilizer application rate from the normalized determination as a percentage of the application working width (ΔQ) is checked by the following formulas:

$$\Delta Q = \frac{Q_y - Q_f}{Q_f} \cdot 10^2; \quad (3.7.2)$$

$$Q = Q_{y1} \frac{V_y B_y \gamma_y}{V_f B_f \gamma_f}; \quad (3.7.3)$$

Here:

Q_y - is the norm of fertilizer application, the actual worker of the application reduces the best, kg / ha⁻¹;

Q_f - the actual rate of fertilizers in the working width of the application at the beginning of the application period, kg / ha⁻¹;

Q_{y1} - set fertilizer rate, kg/ha;.

The testing program of the solid mineral fertilizer dispensing machine includes:

1. Technical expertise;
2. Evaluation of the purpose and technical characteristics of the car;
3. To evaluate the performance of the process;
4. Assessment of the quality of the technological process.

III. RESULTS

The structural model shown in Fig. 1. can be used to estimate the cost impact of uneven fertilization. However, research conducted in the republic and abroad has determined that the application of fertilizers in the scattering of modern machines causes not only fertilizer loss, but also environmental pollution. The actual anthropogenic characteristics of the soil in the fields depend on the uneven application of fertilizers by machines with spreading working bodies, which often varies up to 40 ... 60% in farm conditions. At the same time, the use of high rates of fertilizers leads to an increase in the risks associated with a decrease in productivity as a result of low-quality fertilization.

The high static strength of granular fertilizers at least 2.0 MPa ensures preservation of the granulometric content of fertilizers during application of fertilizers with modern machines.

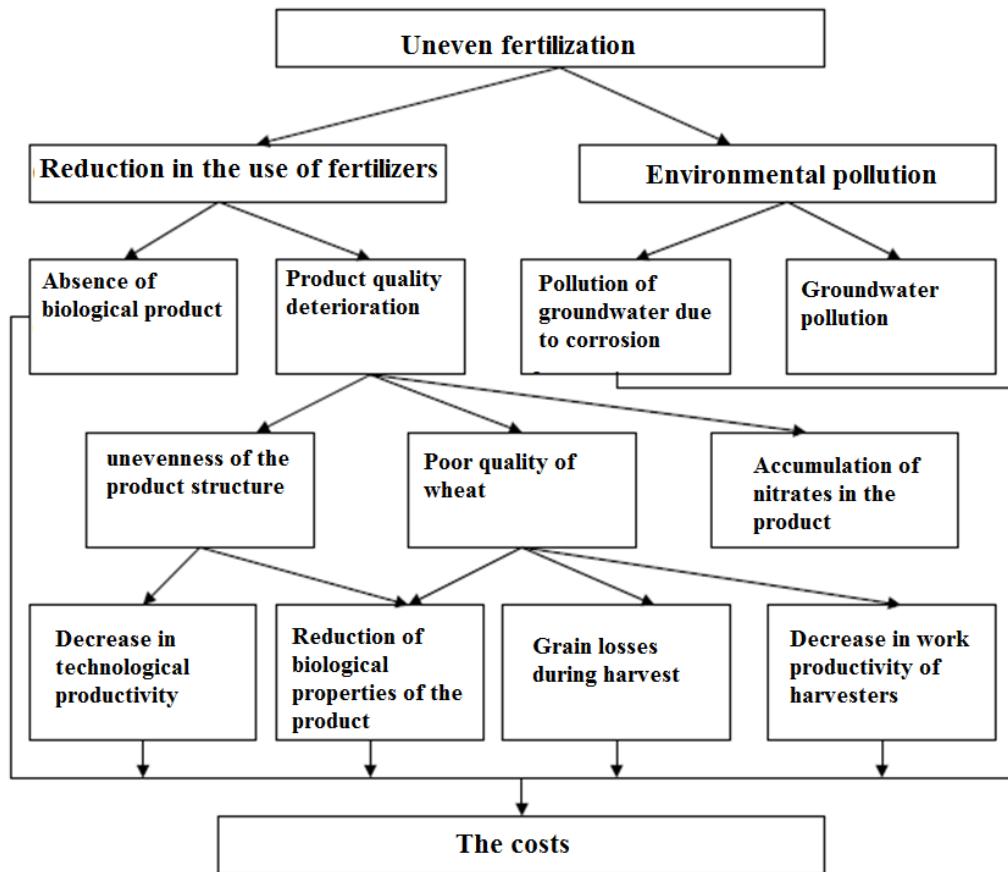


Fig. 1: Structural Model of Uneven Fertilization Management

According to the modern strategy, all decisions related to soil-plant impact are based on the average parameters of the cultivated area. If the illegality of the application exceeds the agrotechnical requirements, the content will be as follows (Pyataev M.V., 2010):

1. Exponential increase in the price of irreplaceable energy;
2. Increase in environmental pollution;
3. High variability of productivity and product quality.

All the above-mentioned indicators of the properties of fertilizers and technologies of application of fertilizers in the cultivation of plants were obtained while developing the agrotechnical requirements of new fertilizer spreading machines.

As can be seen in the picture Fig. 2, two ATP-2 fertilizer spreaders were installed on the plough. Movement of the devices is provided by the support wheel of the plough. The rate of fertilizer application is regulated by the change of stars. The scheme of technological process of the combined plough is shown in Fig. 2. The combined plough consists of two ATP-2 fertilizer spreaders (3) mounted on a Turkish-made SP-12 4-body plough (1). Fertilizers (3) receive movement from the plough support wheel (7) by means of chain transmissions (2). The support wheel is equipped with

rebar to prevent slipping. Fertilizers, moving from the support wheel, spread the fertilizer under the plow through four fertilizer pipes (5). A smooth spreader (8) is attached to the outlet of the pipes to ensure even distribution of fertilizers. The use of a combined plough before plowing completely reduces the operation of fertilizer application by fertilizer machines, its cost and labor costs, while ensuring high efficiency of fertilizer use, ie the submission of fertilizer to the ground prevents its loss, ensures even distribution, etc. In addition, it saves a lot of time and allows you to perform operations in a short time (Qurbanov H.N., 2023).

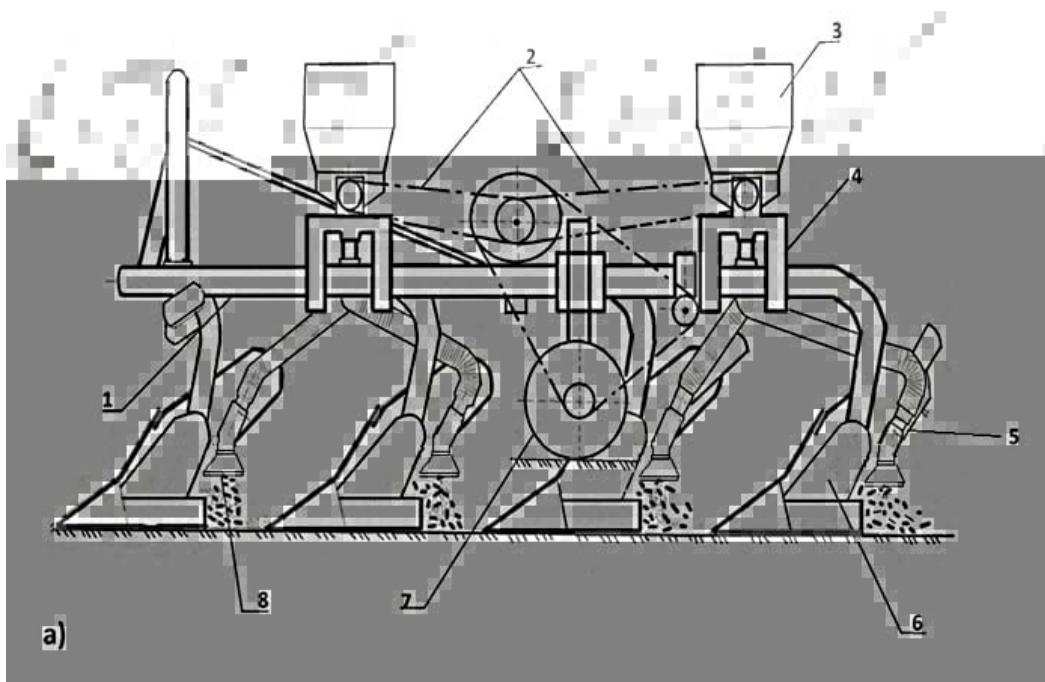


Fig. 2: Combined Plough. (a) Side View

1- plough frame, 2-chain transmission, 3-fertilizer, 4-fertilizer connecting frame to plough, 5-fertilizer transfer pipe, 6-plough body 7-moving support wheel, 8-smooth spreader,

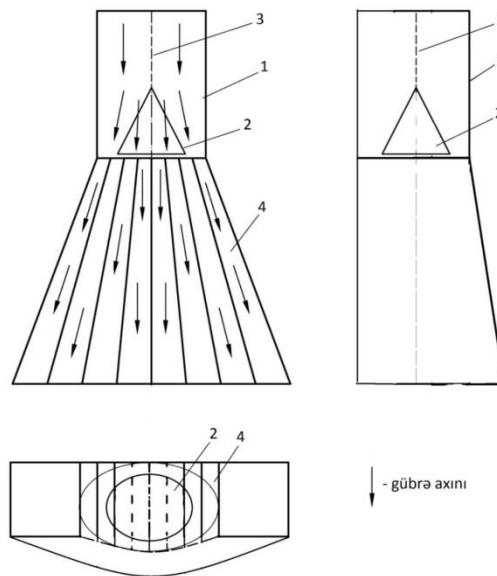


Fig. 3: Smooth Scatterer

1 - main face, 2 - cone with pendulum, 3 - chain, 4 - partitions

The experimental studies of the laboratory products of the technological process of sowing of solid mineral fertilizers show that the technological process of the fertilizer sowing norm is observed during the removal of granular fertilizer with a physical weight of more than 300 kg/ha. In addition, in addition, uneven distribution of fertilizer parts falling from the flow pipe in the soil is observed, which is around 40%. Experimental studies were carried out in the laboratory on the basis of a

suitable device for 4 angle slope checks of the newly made smooth scattering part(Qurbanov H.N., 2022).

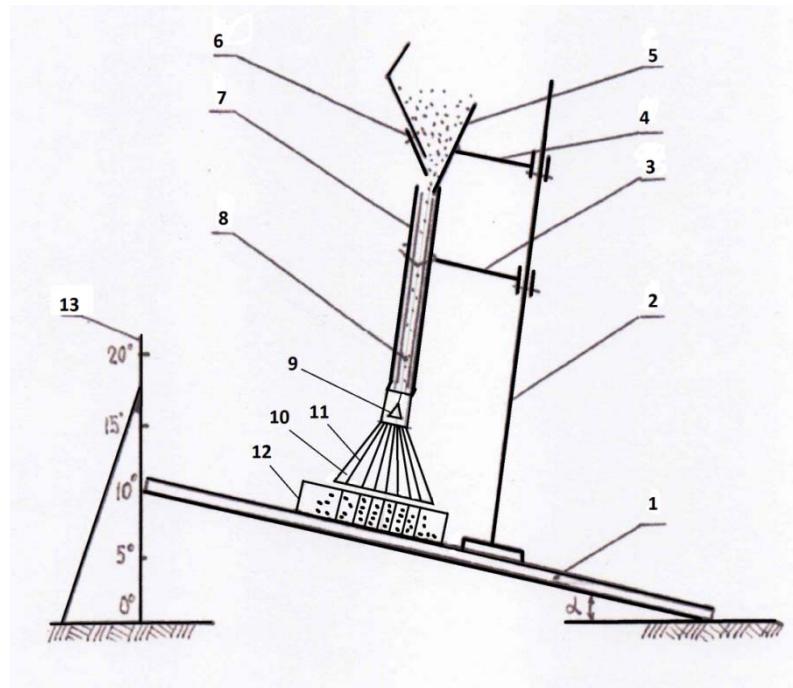


Fig. 4: Device for Determining the Scattering Equation of a Smooth Disperser

1- main support; 2- tripod; 3; 4 - holder; 5 - fertilizer box; 6 - valve regulating the fertilizer rate; 7 - cover of the fertilizer pipe; 8 - fertilizer pipe; 9 - pendulum cone; 10 - fertilizer distributor; 11 - partition; 12 - partition container for pouring fertilizer; 13 - regulating the inclination along the vertical support

In the laboratory, the main 3 types of fertilizers were selected (urea, double superphosphate, potassium chloride) and the spreading percentages of

the poured fertilizer were additionally determined in 8 partitioned containers.



Fig. 5: Laboratory Tests

Conducting a field trial. A sloping site in the Goy-Gol area was chosen for the implementation of the experimental research. Before starting the research, 3 types of fertilizers were taken, moisture was measured with a KE-108 measuring device, 9% in urea; it was 8% in double superphosphate and 8% in potassium chloride.

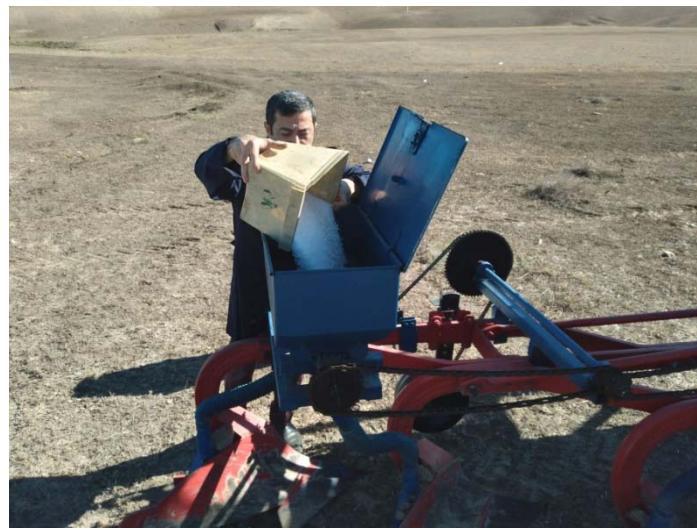


Fig. 6: A Field Test

The inclination of the slope was measured with an "Eklimeter" brand device, with an inclination of 5°, 10°, 15°, and the research area was selected. Soil moisture was measured with a KE-108. device and was 18%

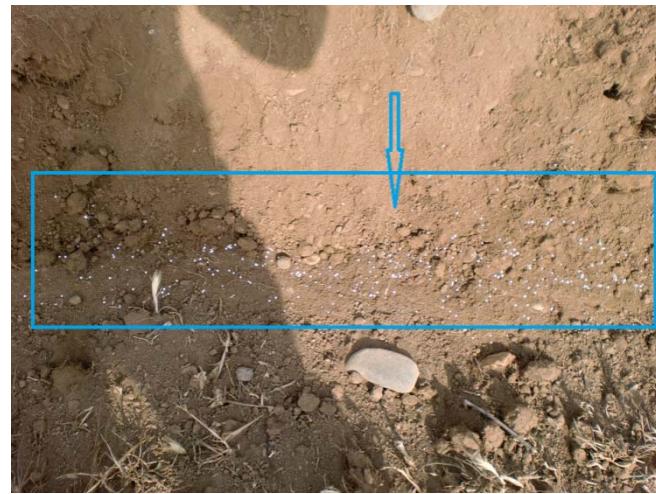


Fig. 7: The Device Measuring the Angle of Inclination of the "Eklimeter" Brand

By filling two hoppers with the capacity of the combined plough, the slope width speed and aggregate movement condition were detected, 4 tests and 5 repeated operations were performed. for three types of fertilizers



Fig. 8: Field Testing of the Combined Plough



Şəkil 9: The State of Application of Urea Fertilizer to the Soil

IV. DISCUSSION

Reliability of distribution according to the technological scheme can be achieved under the condition that the selection of structural dimensions of the smooth spreading part allows optimal fertilizer distribution (Serzhanov I. M. 2013).

Optimization of the main structural parameters of the smooth scattering working body. The dimension parameters of the pendulum cone, which is the working body of the smooth scatterer, are taken as the basis of the cone ($\text{tg } \gamma$) angle, cone height (h), cone diameter

(d), distance between the cone and the wall (Z), and the charge distance from the cone to the partitions ($h1$) (Sivukhin D.V. 2005, Stromberg A. G., et. al. 2009). The main parameters of the subject on dispersion width (D) were calculated and are given in Table-1. Based on mathematical calculations, the parameters of the working subject were selected as dispersion width (D). According to the conditions of the one-factor experiment, the distance between the cone and the wall (Z) and the charge distance from the cone to the partitions ($h1$) were taken with fixed numerical values by obtaining mathematical dependencies.

Table 1: Optimizing Cone Size Parameters

Nº	distribution angle, $\text{tg } \gamma$	h, height, sm	d, diameter, sm	cone-to-wall clearance distance (Z), sm	h_1 , distribution distance from the cone to the partitions, sm	D, spread width, sm
1.	20	3	2.18	1	25	20.38
2.	21	3	2.30	1	25	21.49
3.	22	3.5	2.83	1	25	23.03
4.	23	3.5	2.97	1	25	24.19
5.	24	4	3.56	1	25	25.82
6.	25	4	3.73	1	25	26.87
7.	26	4.5	4.39	1	25	28.77
8.	27	4.5	4.59	1	25	30.06
9.	28	5	5.32	1	25	31.90
10.	29	5	5.54	1	25	33.26
11.	30	5.5	6.35	1	25	35.20
12.	31	5.5	6.61	1	25	36.65
13.	32	6	7.49	1	25	38.74
14.	33	6	7.79	1	25	40.26
15.	34	6.5	8.77	1	25	42.49
16.	35	6.5	9.10	1	25	44.11
17.	36	7	10.17	1	25	46.50
18.	37	7	10.55	1	25	48.23
19.	38	7.5	11.72	1	25	50.78
20.	39	7.5	12.15	1	25	52.64
21.	40	8	13.44	1	25	55.38

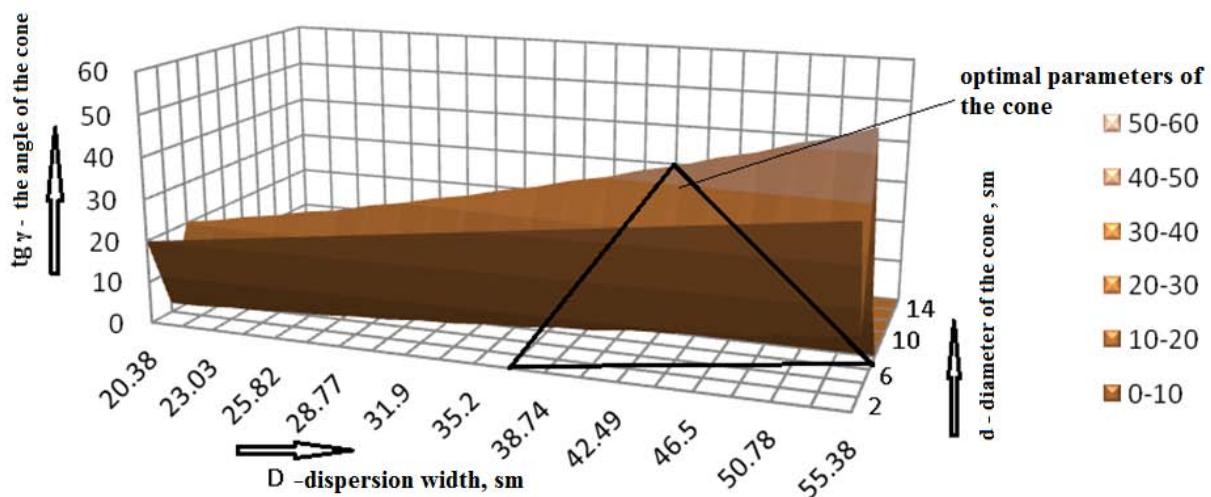


Fig. 10: Optimization Graph of Cone Parameters

Due to the fact that the working width of the cranberry in the plough trunk is 35 cm, the required spreading width $D=35.2$ cm, the angle of the cone $\text{tg } \gamma=30$ degrees, cone height $h = 5.5$ cm, and cone diameter $d = 6.35$ cm are taken from Table 4.8. The clearance distance between the cone and the wall $Z = 1$ cm and the charge distance from the cone $h_1 = 25$ cm are taken as fixed values.

In order to verify the reliability of the control studies, to improve the proposed design of the machine and to justify its operating modes, field studies are determined, which ensures the spreading of fertilizers in the field.

Table 2: Technical Parameters of the Combined Plough

Indicator	Numerical indicator
Productivity, ha/hour	0.7...0.9
Working width, m	1,4
Number of working bodies, PCS	4
Weight, kg	700
Overall dimensions, mm	
Length	3120
Width	1700
Height	1300
Working depth, cm	20...22
Working speed, km/h	3.9...6
One working width, mm	350
Number of bunkers, PCS	2
Bunker capacity, dm ³	45
Norm of mineral fertilizer applied per 1 ha, kg	65...328
Type of attachment to the tractor	hanging
Aggregates with 30 kN class tractors	1

Table 3: Indicators of Even Distribution of Fertilizer in the Inclined Conditions of the Spreader

Name of Indicators	Inclination angle			
	0°	5°	10°	15°
Urea fertilizer				
Equal distribution, %	96.08	94.65	92.17	88.81
In the 1 st period of the fertilizer shaft, gram	82.57	81.32	79.22	76.32
Doublesuperphosphatefertilizer				
Equal distribution, %	97.63	96.85	94.34	92.82
In the 1 st period of the fertilizer shaft, gram	129.26	128.23	124.91	122.89
Potassiumchloridefertilizer				
Equal distribution, %	96.95	96.62	94.72	93.72
In the 1 st period of the fertilizer shaft, gram	118.74	118.34	116.02	114.79

When the fertilizers were spread evenly in the laboratory, urea was 92.37%, double superphosphate was 94.96%, and potassium chloride was 95.42%.

Table 4: Equal Spreading of Fertilizers in the Sloping Conditions of the Slope

Indicators	Slope			
	0°	5°	10°	15°
AMAZONE ZA M -1500				
Amount of fertilizer thrown from the left disc, kg	12.3	13.93	15	19.93
Amount of fertilizer thrown from the right disc, kg	12.3	11.86	10.33	9.33
Equal distribution, %	100	85.14	68.87	46.81

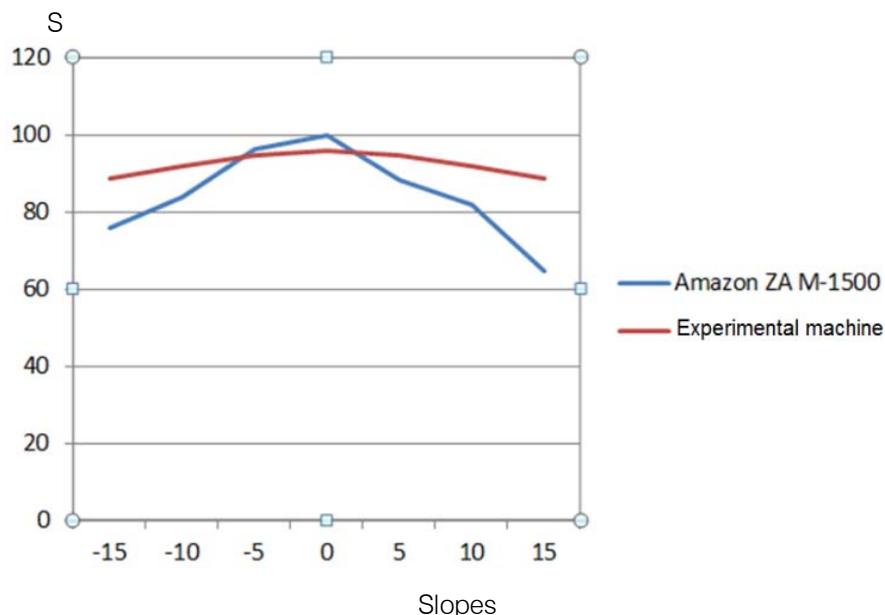


Fig. 11: Distribution Graph of Mineral Fertilizers in the Soil with the Amazone ZA M-1500 Machine and the Experimental Machine

The results of the research work, the table IV and the fig.11 clearly show that the Amazon ZA M-1500 machine distributes fertilizers unevenly in the field.

The regression equation is obtained for a smooth uniform scattering (Melnikov S.V., 1980).

For urea fertilizer

$$Y = 93.9 - 0.75 X_1 - 1.59 X_2 + 0.1 X_1 X_2$$

For double superphosphate fertilizer

$$Y = 95.04 - 0.57 X_1 - 1.84 X_2 - 0.18 X_1 X_2$$

For potassium chloride fertilizer

$$Y = 95.50 - 0.33 X_1 - 1.28 X_2 - 0.17 X_1 X_2$$

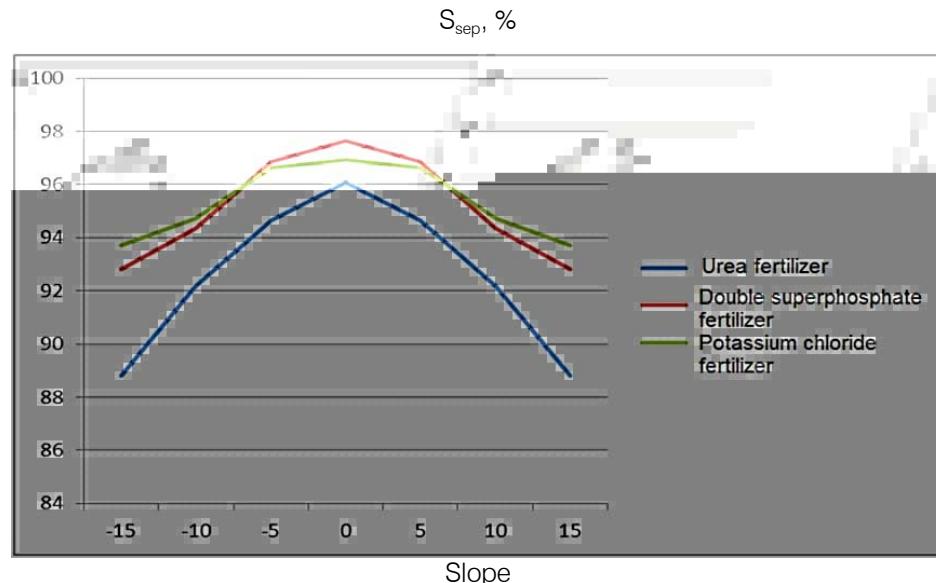


Fig. 12: Percentage of Even Distribution of Fertilizer on Slopes

Experiment planning plays a key role in the efficient and speeding up of research work.

The planning of the experiment is to experiment on the factors that seriously affect the function by reducing the number of factors without taking into

account the low values of the factors that affect the function by identifying multifactor dependencies. For this purpose, the regression equation of the multi-factor function of scattering productivity is drawn up using the grapho-analytical method.

The general expression of the regression equation

$$\Sigma W_{sep} = 20.38v + 4.34 Q + 47.65 \frac{1}{B} + \dots + \dots;$$

$$\Sigma W_{sep} = 20.38 v + 4.34 Q + 47.65 \frac{1}{B} + 20.38 * 4.34 v Q + 20.38 v^2 + 4.34 Q^2$$

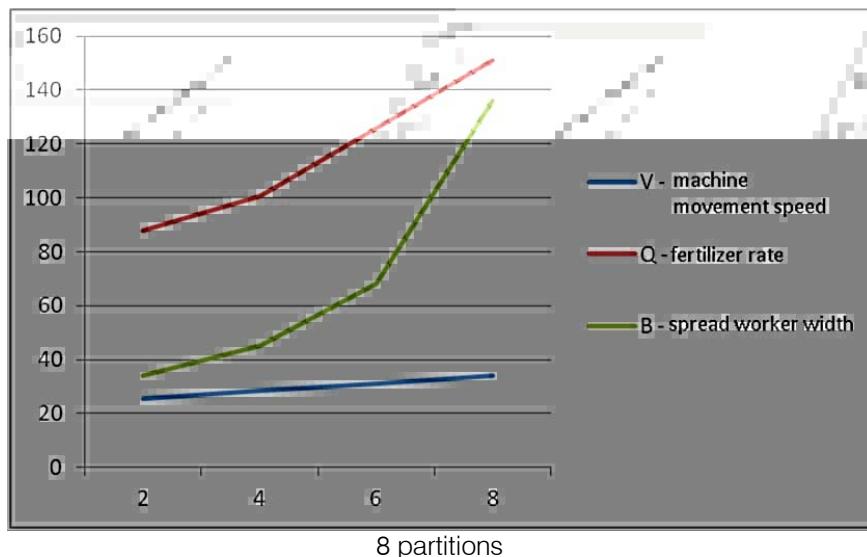


Fig. 13: The Main Factors that Affect the Productivity of Scattering

From the graph in Fig. 13, it is clear that W_{sep} - the 1st factor that most affects the sowing productivity Q - fertilizer rate, 2nd factor B- spread worker width,3- the

less influential factor V is the speed of movement of the machine.

Table 5: Economic Comparison Table

s/s	The name of indicators	Unit of measurement	Mechanization options			
			SP -12 plough	Amazone ZA M -1500	Single time operations Total	Experimental Combined plough
1.	Productivity	ha/h	0.72	5.12	0.72	0.72
2.	Duration of technological operation	h	450	450	450	450
3.	Capital investment	dollars	8.17	20.05	28.22	14.88
4.	Depreciation expense	dollars	398.22	3.4	401.62	399.18
5.	Current repair and maintenance costs	dollars/ha	16.40	6.48	22.88	17.89
6.	Fuel and lubricant costs	dollars/ha	12.23	1.72	13.95	12.23
7.	Operating costs	dollars	1346.9	931.91	2278.80	1348.74
8.	Costs incurred	dollars	1348.94	936.92	2285.86	1352.45
9.	Economic efficiency	dollars	-	-	-	933.40
10.	Economic efficiency in grain growing	ha/dollars	-	-	-	123.53
11.	Economic efficiency during the growing season in grain growing	kg/ha	-	-	-	600
11.	Economic efficiency during the growing season in grain growing	dollars	-	-	-	40023.53
12.	Overall economic benefit	t	-	-	-	194.4
12.	Overall economic benefit	dollars	-	-	-	40956.93

Table 5 shows a comparative analysis of technological operations (Merzlikin A. S., et. al. 1999). Thus, the smooth and even distribution of mineral fertilizers in the field with the use of combined plough increases the productivity in grain growing from a minimum of 26 s/ha to 32 s/ha. If we calculate that a kilogram of wheat costs about 21 cents, 600 kg per hectare allows us to get an economic benefit of 123.5 dollars/ha, and during the season - 3200 hectares of land with an economic benefit of 40 003 dollars.

V. CONCLUSION

1. Plowing and fertilizing work on the slopes was performed in one go by using the combined plough. Fertilizing evenly under the soil prevents environmental pollution and increases the efficiency of fertilizer use.
2. As a result of economic testing of the combined plough, the working speed was 3.9 ... 6 km/h, the working width was 1.51 m, the cultivation depth was 20... 25 cm, the fertilizer application rate was 65 ... 328 kg/ha.
3. Uniform distribution of urea fertilizer under the soil was 92.0%, double superphosphate - 94.0%, potassium chloride - 93.0%.
4. Field and farm experiments have shown that with the reduction of uneven dispersion of mineral fertilizers with experimentally combined plough provides 20% of minimum green mass productivity and grain growth of 600 kg/ha.
5. As a result of the application of the combined plough, labor costs are reduced by 14.65% and operating costs by 18.3% compared to the usual method.
6. The annual economic benefit of one device is US \$933.4 due to the difference in costs incurred.

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