E3S Web of Conferences **398**, 01017 (2023) https://doi.org/10.1051/e3sconf/202339801017
ABR 2023

Efficiency of winter wheat crops harrowing with simultaneous application of solid mineral fertilizers

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Abstract. Proper care of plants during the growing season is the main factor in obtaining high yields. To produce a high-quality product, it is necessary to carry out soil cultivation, plant protection and fertilizing in time. However, the above operations increase the cost of the products received. We propose the development of a multifunctional unit with which it is possible to combine two technological operations, harrowing with simultaneous application of mineral fertilizers. This technical solution will reduce labor costs, increase productivity, and reduce the number of technical means used.

1 Material and methods of research

In crop production, according to the technology of winter wheat cultivation, mineral fertilizers are introduced, as well as spring harrowing of crops to embed fertilizers in the soil and destroy the soil crust.

The application of mineral fertilizers plays a very important role in the cultivation of winter wheat, as they nourish plants, thereby giving growth and resistance to diseases. In turn, top dressing must be carried out within the established agrotechnical deadlines, if this is not done, then the plant may not have enough nutrients, and it will be weak.

Spring harrowing of crops also plays an important role, since after the winter transition period to spring, a soil crust forms on the soil surface, which prevents the flow of oxygen and moisture to the plant. To do this, it is necessary to use machines for surface tillage, and more specifically, harrows, for example, such as "zigzag", spring or rotary. In turn, harrows may not fulfill agrotechnical requirements for soil destruction on structural aggregates of the required size, or for damage to plants, which rotary hoes do well and they should be preferred [1, 7].

2 Results of research

As often in technologies, measures are planned for the introduction of mineral fertilizers on winter wheat crops and their harrowing, but in most farms only fertilizing is performed without embedding fertilizers in the soil, which negatively affects the environment, since

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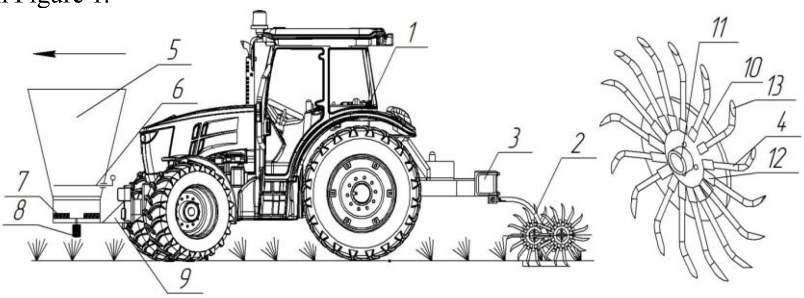
fertilizers that have not penetrated to the plant evaporate into the atmosphere. We propose to combine two separately performed operations into one by creating a fundamentally new multifunctional unit that combines the application of mineral fertilizers and their simultaneous embedding in the soil [1, 5, 7, 9].

The proposed unit includes a mineral fertilizer spreader, which is placed on the front hitch of a tractor driven by a hydraulic motor to change the rotation speed of the spreading disks, and restrictive flaps are also installed on the spreader to change the width of the grip. A rotary hoe is installed on the rear hitch to destroy the soil crust and seal mineral fertilizers, a needle disk is used as a working organ on the hoe, and the needle (tooth) of the working organ is made so that the angle of entry into the soil is exactly 90 degrees [2, 3, 4]. This is done so that the hole formed by the needle is minimal for better sealing of fertilizers and the least evaporation of them into the atmosphere. Also, due to the load distribution on the front and rear of the tractor, the center of gravity is leveled and the resistance to overturning of the tractor is increased. The scheme of the proposed multifunctional unit is shown in Figure 1.



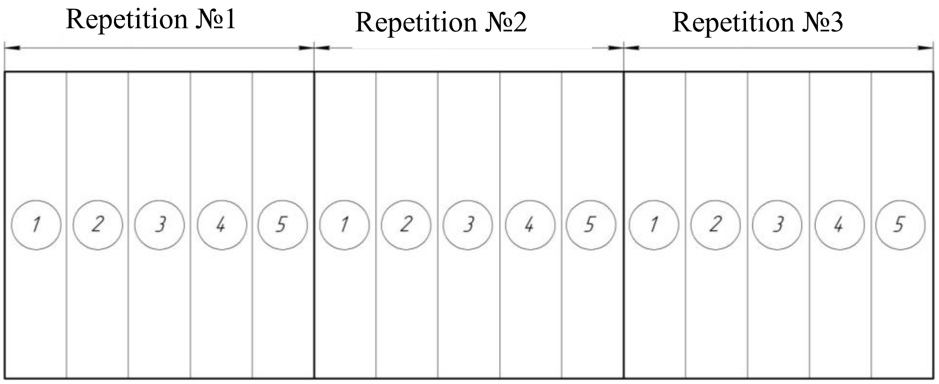
1 – tractor, 2 – rotary harrow, 3 – frame, 4 – tooth, 5 – hopper, 6 – flap, 7 – spreading disc, 8 – drive, 9 – attachment points, 10 – disc, 11 – hub, 12 – sleeve, 13 – tooth section

Fig. 1. Diagram of a multifunctional unit (MFA) for harrowing crops with simultaneous fertilizing

The process of the MFA is as follows: when moving through the field due to the drive from the hydraulic motor, the spreading disks are rotated and capturing fertilizers with their blades, they are scattered over the surface due to centrifugal force, then a rotary hoe moves, which penetrates into the soil with the needles of the working organ, thereby destroying the soil crust, giving oxygen and moisture to plants, as well as planting fertilizers in the soil [6, 7, 8]. A multifunctional unit for harrowing winter wheat crops with simultaneous fertilizing is shown in Figure 2.

Fig. 2. Multifunctional unit (MFA) for harrowing crops with simultaneous fertilizing

After creating a multifunctional unit, we conducted experiments in the fields of the experimental field of Kuban State Agrarian University with bringing it to yield. To conduct a small-scale farming experiment, the method of B.A. Dospekhov was used, after which a plot was selected that was sown with winter wheat of the Zarya variety. The type of soil, leached chernozem, the predecessor was corn for feed, tillage was carried out by disking the soil in two tracks to a depth of 10 to 12 cm. Spring fertilizing was carried out with mineral fertilizers with a dose of 35.5 kg d.v. The depth of seed embedding is from 4 to 5 cm, the phase of plant development is tillering. The scheme of conducting a small-scale experiment is shown in Figure 3.



1 – active location of the tooth of the working organ of the hoe; 2 – passive location of the tooth of the working organ of the hoe; 3 – light tooth harrow; 4 – control area (without loosening); 5 – seeder "Klyon-1.5".

Fig. 3. The scheme of conducting a small-scale experiment for harrowing crops with simultaneous fertilizing

The experiment was carried out in three-fold repetition according to the scheme shown in Figure 3, using the experimental sample shown in Figure 2. At the same time, in these sections, the unit moved at three different speeds of 5, 10 and 15 km / h, as well as in sections 1 and 2, disks with different diameters and the number of needles were used, which are shown in Figure 4.

n=12 pcs n=14 pcs n=16 pcs
Diameter of each disk D = 500, 525, 550 mm

Fig. 4. Working bodies of the rotary hoe

After harrowing with simultaneous application of mineral fertilizers, we took soil samples to determine the structural and aggregate composition of the soil (Figure 5), according to GOST 20915-2011, and the size of fractions with a diameter of more than 3 cm, no more than 15%. The structural and aggregate composition was determined using a set of sieves; the dried soil was sifted and each fraction was weighed on laboratory scales, then data processing was performed, soil moisture and hardness were also determined (Figure 6).

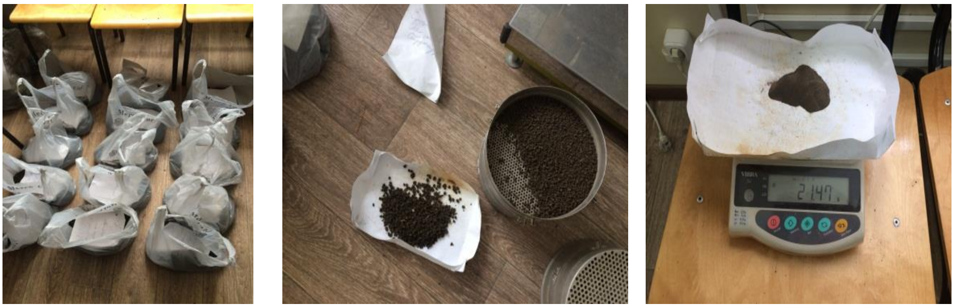


Figure 5. Determination of structural and aggregate composition

Fig. 6. Determination of soil moisture and hardness

During the growth of the crop, the degree of development of the plant and its height were determined every month, for this purpose a measuring element in the form of a ruler was used. The degree of plant development is shown in Figure 7.

Fig. 7. Degree of plant development

Having brought the winter wheat to ripeness and humidity of no more than 15%, we took samples of the crop from the site that was intended for the small-scale experiment Figure 8.

Fig. 8. Selection of sheaves

To determine the yield of winter wheat, we made a number of measurements of the stem and ear, as well as its threshing. After that, the amount of ground and crumbled grain was weighed and processed mathematically (Figure 9).

Fig. 9. Determination of winter wheat yield

3 Conclusion

The advantages of the unit we offer are obvious, since the combination of two technological operations reduces costs, increases the profitability of production, and also releases one tractor.

After the experiment, we processed the data according to which the optimal parameters of the working body of the rotary hoe and the speed of movement of the unit, the diameter of the disk 518 mm, the number of needles 14, the speed of movement of the unit 6.43 km/h were determined. Also, mathematically processing the uniformity of tillage and structural and aggregate composition, we can conclude that the working body with an active tooth arrangement has the best effect on the yield of winter wheat crops.

References

1. Serguntsov, A. Harrowing of sowings with synchronous additional fertilizing / A. Serguntsov, N. Malashikhin // MATEC Web of Conferences : 2018 International Conference on Modern Trends in Manufacturing Technologies and Equipment,

ICMTMTE 2018, Sevastopol, 10–14 September, 2018. Vol. 224. – Sevastopol: EDP Sciences, 2018. – P. 05016. – DOI 10.1051/matecconf/201822405016.

2. Zhuk, A. F. Investigation of the type and justification of parameters of combined working bodies for pre-sowing processing [Text]: PhD thesis. – Moscow, 1978. – 238 p.
3. Zheligovsky, V. A. Elements of the theory of tillage machines and mechanical technology of agricultural materials [Text] / V. A. Zheligovsky. – Tbilisi : Publishing House of the Georgian Aagricultural Institute, 1960. – 146 p.
4. Serguntsov, A. Operational parameters and modes of rotary working body for harrowing crops / A. Serguntsov, N. Malashikhin, V. Serguntsova // E3S Web of Conferences, Sevastopol, 09–13 September 2019. Vol. 126. – Sevastopol: EDP Sciences, 2019. – P. 00023. – DOI 10.1051/e3sconf/201912600023.
5. Konovalov V. Analytical study of the design parameters of the grinding unit of disk harrows / Konovalov V., Konovalov S., Igumnova V. // In the collection of articles: IOP Conference Series: Earth and Environmental Science. 12th International Scientific Conference on Agricultural Machinery Industry, INTERAGROMASH 2019. 2019. C. 012086.
6. Ziyazetdinov, R. F. Investigation of the processes of operation of aggregates with needle disks in the processing of agricultural crops [Text]: Abstract of the PhD thesis, 1966. – 26 p.
7. Serguntsov, A. Optimization of parameters and operating modes of the rotary working body for harrowing agricultural crops / A. Serguntsov, V. Serguntsova // E3S Web of Conferences, Sevastopol, 07–11 September 2020. – Sevastopol, 2020. – P. 01021. – DOI 10.1051/e3sconf/202019301021.
8. The system of agriculture of Krasnodar Territory on an agro-landscape basis. – Krasnodar, 2015. – 352 p.
9. Tereshchenko, I. S. The effectiveness of the needle harrow-hoe [Text] / I. S. Tereshchenko, V.A. Zykov // Mechanization and electrification of the social rural household. - 1975. – No.5. – pp. 9-11.