Experimental studies of the efficiency of incorporating green manure crops with a combined unit

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Abstract. In recent years, many agricultural producers have begun to take care of environmental aspects and are gradually switching to the use of organic farming elements in the cultivation of agricultural crops, which include green fertilizers - siderates. Many experts recommend cutting the green mass of green manure crops with a mower and embedding it in the surface layer of the soil as mulch. However, not all termination methods are equally effective. In particular, when passing through a field with a rotary harrow's green manure, the disc knives have to simultaneously perform two functions: chop and embed the vegetative mass of plants, which negatively affects the depth of processing. Therefore, the goal of our research is to develop a combined unit for mowing, crushing and embedding green mass of green manure crops into the soil. To achieve this, it is proposed to attach a plant chopper to the front of the tractor, which will mow and chop the plants, and two disc batteries installed on the rear hitch of the tractor will close the chopped organic mass. To determine the efficiency of using the proposed combined unit in different regions of the Republic of Tatarstan on different soils, comparative field tests were carried out, which consisted in determining the completeness of incorporation of green mass. The value of this indicator without using the mower on the front hitch was 65%, and with mowing and chopping - 95%, this is 1.5 times more than in the variant with the compared unit, which should have a favorable effect on the decomposition of the embedded organic matter.

1. Introduction

In recent years, the use of elements of agricultural biologization has been expanding in agriculture, including the use of green fertilizers or green manure, enriching the soil with organic matter [1-2]. In addition, among them can also be called the creation on the soil surface of a mulching cover of plant residues, which is necessary to protect it from wind erosion, to reduce the leaching of nutrients from the plow horizon into deeper layers, etc. [3-4]. Therefore, some researchers recommend cutting green manure crops with a flat cutter and leaving them on the soil surface [5-6]. It is known that about four
hundred species of cultivated plants can act as siderates [7-8]. Basically, legumes (peas, annual lupine, etc.) and cruciferous (mustard, spring and winter rape, etc.) crops, as well as cereals (oats, rye, barley, timothy, etc.) are used for these purposes. Depending on the physical and mechanical composition of the soil and the type of crops, the green mass of green manure can be embedded in the soil with special combined aggregates [9-11].

Moreover, not all termination methods are equally effective. For example, using a reversible plow increases energy consumption. In addition, this method is not suitable for the technology of cultivation of crops with minimal tillage. In most cases, disc harrows are used to incorporate green manure. However, in this case, sufficient completeness of embedding is not always ensured, and the organic mass remaining on the soil surface does not have time to completely mineralize before sowing the next crop. According to experts, plant residues should be efficiently crushed and evenly distributed - both over the entire area of the field and along the depth of the arable layer, which ensures their fastest decomposition and does not create hindrances and barriers to the subsequent growth and development of plants [12].

The purpose of the research is to substantiate the most rational method for embedding green mass of green manure crops and an agricultural unit for its implementation.

2. Materials and methods
Employees of the Kazan State Agrarian University and the Tatar Institute for the Retraining of Agribusiness Personnel have developed and manufactured a set of combined machines for mowing tops and vegetables, which can also be used for green manure [13-15]. In the case of using a conventional disc harrow for this purpose, which is installed at the rear of the tractor, its front battery crushes the green manure, and the rear one embeds them in the soil. If a plant chopper with flexible working elements is mounted on the front hitch of the tractor, it will mow and chop the green manure, and both batteries of the disc harrow attached to the energetic mean close up the chopped organic mass (figure 1).

The studies were carried out in the fields of the Krasnaya Zarya agricultural complex in the Vysokogorsk region, the Zemlyaki farm in the Nizhnekamsk region, Sviyaga LLC in the Apastovsky region, and Duslyk LLC in the Nurlatsky region of the Republic of Tatarstan. The thickness of the arable layer is 25 ... 27 cm. The humus content (according to Tyurin) in the Vysokogorsk region was 3.46%, in the Nizhnekamsk region - 3.1%, in the Nurlatsky region - 6.07%, in the Apastovsky region - 5.21%. Mobile phosphorus (according to Kirsanov) - 147.2, respectively; 145.5; 145.9; 165.9 mg/kg, potassium - 155.2; 135.2; 148.1; 159.0 mg / kg soil. The predecessor is spring barley.

During the research, the results of the operation of two units were compared:

- Tractor MTZ-1221 with a disc harrow BDT-3 on the rear hitch;
- Tractor MTZ-1221 with rotary mower BIR-4 on the front hitch and disc harrow BDT-3 on the back.
The principle of operation of the unit is as follows. The torque from the power take-off shaft is transmitted to the flexible working elements of the chopper rotor, which are pulled into a string under the action of centrifugal forces. The working element crushes the plant by impact and scatters it over the working width of the tillage implement attached to the rear of the tractor. The spreading width is adjusted by installing deflectors (not shown) to the side of the rotary working element. Further, the crushed mass of green manure crops is embedded in the soil by the working bodies of the rotary harrow.

Before testing, areas of 50 m² (length 13.33 m and width 3 m) were allocated. The vegetative mass from an area of 1 m² was weighed three times on an electronic balance. Further, also in three repetitions, the green manure was sealed with both aggregates, after passing through which the green mass remaining on the surface was collected from the test site and weighed. According to the ratio of the mass of the embedded green manure to its mass before testing, the effectiveness of the studied variant was assessed.

As siderates in the experiment, we sowed yellow sweet clover, blue lupine and white mustard, the yield of green mass of which was practically the same. In yellow sweet clover, it reached 40000 kg per hectare, in blue lupine and white mustard it was lower - 37500 and 38000 kg per hectare, respectively.

When carrying out field experiments, the speed of movement of the energy device varied from 2 to 4 m/s with a step of 0.5 m/s, and the depth of tillage from 7 to 15 cm with a step of 2 cm. The speed of movement was set before entering the experimental plot by measuring travel time of a fixed path in triplicate. The tillage depth was adjusted on a special concrete area outside the field.

3. Results and discussion

The combined unit in the investigated version effectively performed the process of embedding the crushed mass of green manure, as evidenced by the results of experimental studies (Fig. 2). The smallest completeness of incorporation of green mass was noted at a depth of travel of the working bodies of the disks of the harrow of 7 cm and the speed of the forward motion of the combined unit of 2 m/s - 61%. The highest value of this indicator was at a processing depth of 13 cm and a unit speed of 3.5 m/s - 95%. A further increase in the studied parameters led to a deterioration in the quality of the technological operation. This is due to the fact that the machine loses its ability to withstand a given working depth when the rotary harrow discs are too deeply buried and starts to leave flaws in the form of a crushed mass not embedded in the soil. The same can be said for the speed of the combined unit. With its small values, it is possible to grind green manure plants into smaller fractions, however, due to the design features, the disks are not able to thoroughly mix the soil layer with the vegetative mass of green manures.

In similar tests without installing the rotary mower BIR-4 on the front hitch of the tractor, the best result of the unit as part of the MTZ-1221 + BDT-3 was also achieved at a travel speed of 3.5 m/s and the depth of the harrow discs by 13 cm (figure 3).

In general, according to the results of experiments on the fields of the agricultural enterprises "Krasnaya Zarya", "Zemlyaki", "Duslyk", "Sviyaga", the completeness of embedding green mass of green manure on the vine was on average 65%, and with preliminary mowing and grinding it was within 95%.

The test results in various farms differ from those presented by no more than 5%, which indicates the applicability of the proposed combined unit in all climatic zones.

4. Conclusion

The combined unit as a part of the MTZ-1221 tractor, on the front hitch of which the BIR-4 mower-shredder is installed, and the BDT-3 harrow is attached to the rear, allows the technological process of grinding and embedding green manure crops to be stably carried out with a travel depth of 13 cm of working bodies and a speed of movement of the unit 3.5 m/s in all climatic zones of the republic. At the same time, the completeness of embedding green manure into the soil reaches 95%, which is on average 1.5 times more than when using only BDT-3 without a mower.
Figure 2. Dependence of the completeness of incorporation of green mass of green manure crops on the speed of movement of the BIR-4 + MTZ-1221 + BDT-3 unit and the depth of burial of the rotary harrow disks (average for four farms).

Figure 3. Dependence of the completeness of incorporation of green mass of green manure crops on the speed of movement of the MTZ-1221 + BDT-3 unit and the depth of burial of the rotary harrow disks (average for four farms).

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