Combined units for mowing and sealing of siderates

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Abstract. Many agricultural producers have switched to organic farming methods, i.e. the use of green fertilizers - green manure. Many experts recommend cutting siderate cultures with a subsurface plow and leaving it on the surface of the soil as mulch. But not all termination methods are effective. The purpose of this work is to develop a technology for cultivating green manure crops for fertilization, to substantiate the most rational method for planting green manure crops and an agricultural unit for its implementation. It is proposed to hang a plant chopper on the front of the tractor, which will perform the function of mowing and chopping green manure, and both batteries of the discator, mounted on the rear part of the tractor, will close up the chopped stalks of green manure. To determine the effectiveness of using the proposed approach, comparative field trials were carried out, consisting in determining the completeness of incorporation of green mass in green manure crops. According to the results of the experiments, it was found that the completeness of incorporation of green mass of green manures without mowing was 65%, and with mowing and grinding - 96%, which is 1.5 times more than the compared approach.

1. Introduction

In recent years, many agricultural producers have switched to organic farming methods, i.e. the use of green fertilizers is green manure. These plants enrich the soil with nitrogen and also protect against pests [1-3]. One of the basic rules of organic farming is to create a deciduous cover, which is necessary to protect the soil from wind erosion, reduces the leaching of nutrients into the deep layers and keeps them in the arable horizon, i.e. performs the role of live mulch [4-6]. As you know, about four hundred cultivated plants act as siderates. Legumes (peas, annual lupine, etc.) are mainly used. From cereals, oats, rye, barley, timothy, and others are grown as siderates. Cruciferous (mustard, spring and winter rapeseed, etc.) are also used. Siderates must be mowed to form seeds in the phase of
butanization or the beginning of flowering. Many experts recommend cutting sidereal cultures with a plane cutter and leaving it on the surface of the soil as mulch. It protects it from overheating and waterlogging, creates favorable conditions for the life of worms. During the decomposition period under the influence of microorganisms, it releases mineral elements for the nutrition of cultivated plants [7-9]. Therefore, in many cases, depending on the physical and mechanical composition of the soil and the type of crops, the cut green mass of green manure can be embedded in the soil with special combined aggregates [10-12].

But not all termination methods are effective. When planting green manures with reversible plows, energy costs increase, and this method is also not suitable for cultivation technologies for agricultural crops that use minimal tillage. Therefore, in most cases, disc harrows are used. But this method does not provide a sufficient completeness of embedding and the green manure remaining on the soil surface does not rot before the start of the next crop cultivation.

The purpose of this work is to develop a technology for cultivating green manure crops for fertilization, to substantiate the most rational method for planting green manure crops and an agricultural unit for its implementation.

2. Materials and methods
We have developed and manufactured a set of combined machines for mowing tops and vegetables (figure 1), which can also be used for crushing green manure and simultaneously embedding them in the soil [13-15].

![Figure 1. Combined unit for grinding plants and incorporating them into the soil as part of the MTW-1221 (Minsk Tractor Works) tractor and the RT-4 (Rotary topper) topper, presented at the international exhibition ‘Field Days in Tatarstan’ (Laishevsky District, Republic of Tatarstan, Russia).](image)

In accordance with the currently used technology, a disc harrow, mounted on the rear of the tractor, chops the green manure plants with the front battery, and embeds them into the soil with the rear battery. We propose to attach a plant chopper with flexible working elements to the front of the tractor, which will perform the function of mowing and chopping green manures, and both batteries of the discator, mounted on the rear of the tractor, will close the chopped stalks of green manure.

The experiments were carried out on the fields of the ‘Krasnaya Zarya’ agricultural complex in the Vysokogorsky district of the Republic of Tatarstan. The soil is gray forest, medium loamy composition. The thickness of the arable layer is 25...27 cm. The content of humus according to
Tyurin is 3.42...3.52%, mobile phosphorus – 132...151 mg/kg and exchange potassium 149...161 mg/kg of soil. The predecessor is spring barley.

Table 1. Basic input data and agricultural indicators.

| Sideratecultures     | Fieldlength, meters | Fieldwidth, meters | Area, hectares | Seedinigrate, kg/hectare | Plantdensity, m² | Plant height during harvest, cm | The yield of green mass, kg/hectare |
|----------------------|---------------------|--------------------|----------------|--------------------------|------------------|-------------------------------|-----------------------------------|
| Yellowclover         | 100                 | 30                 | 0.3            | 27                       | 280              | 75...80                        | 40,000                            |
| Lupineblue           | 100                 | 30                 | 0.3            | 25                       | 210              | 80...85                        | 37,500                            |
| Whitemustard         | 100                 | 30                 | 0.3            | 28                       | 230              | 82...87                        | 38,000                            |

As can be seen from table 1, the conditions were the same for three crops and, accordingly, the yield of green mass was almost the same.

The results of the operation of two units will be compared: an MTW-1221 tractor with a HDH-3 (heavy disc harrow) disc harrow attached to it and an MTW-1221 tractor with a RT-4 rotary mower attached to it in front and a HDH-3 disc harrow in the back.

The experimental technique is as follows. Plots with an area of 50 m² (length 13.33 m and width 3 m) are marked before testing. The green mass is weighed using an electronic balance from an area of 1 m² in several replicates and the mass of the green mass on the test area is determined. Further, also in three repetitions, the green manure is sealed with both units. After the passage of the unit, the green mass of green manure is collected from the test area, which remains on the soil surface not sealed, and weighed. According to the ratio of the mass of embedded green manure to the mass of green manure before testing, the effectiveness of using the proposed method of mowing and embedding is evaluated.

3. Results and discussion

When cultivating sideral crops, it is necessary to select the most suitable agricultural unit for each technological process.

Autumn plowing of the fallow is carried out by K-700A (Kirovets) energy-saturated tractors and MSP-8-35 (mounted share plow) plows.

Early spring moisture closure is performed as the soil is ripened with the HSTMH-1.0 (high speed tooth middle harrow) tooth harrows in the TH-16A (tow hitch) coupling diagonally across the field. Before cultivation, the field is leveled by the levelers MSH-5.6 (mounted seedbed harrow).

Pre-sowing tillage is carried out by HSFC-4G (high speed fallow cultivator) cultivators with tooth harrows in order to create a loose soil layer that provides favorable conditions for seed germination and plant growth.

To achieve a level field, partial compaction of a loosened soil layer and additional crumbling of large lumps, soil is rolled before sowing with 3RSR-6 (Ring-spur roller) rollers.

Sowing is carried out in the early and short time by the GS-5.4 (grain seeder) seeder. After sowing, rollers 3RSR-6 are rolled. A time gap between soil preparation, sowing and rolling should not be allowed. On the 4-5th day after sowing, pre-emergence is carried out, and in the tillering phase - post-emergence harrowing with light seed harrows STH-0.6A (seeding tine harrow) [9-11].

Based on the foregoing, it is possible to draw up a technological map for the cultivation of green crops, presented in table 2.

The effectiveness of green fertilizer mainly depends on the age of the plants. Young plants that are rich in nitrogen quickly decompose in the soil. Therefore, it is recommended to mow and at the same time close up the green fertilizer during the budding period before flowering.

For this, a combined unit is proposed, composed of a MTW-1221 row crop tractor, on the front of which a RT-4 plant cable chopper is mounted, and a WGCFC-2 (wide-grip cultivator-flat cutter) plane cutter is attached at the back (figure 2).
Table 2. Route map for the cultivation of green crops.

| Name of works                  | The timing | The tractor          | agricultural machine | Quantity | Quan tity | Agrotec hnical requirements, cm | Note |
|--------------------------------|------------|----------------------|----------------------|----------|----------|---------------------------------|------|
| Plowing winter                 | Fall       | K-700A               | MSP-8-35             | 1        | 22…25   | -                               |      |
| Harrowing chillies (closing moisture) | April – May | MTW-1221             | TH-16A+32            | 1+32     | -        | -                               |      |
| Soil leveling                  | April – May | DT-75M (diesel tractor) | HSTMH-1.0            | 1        | -        | -                               |      |
| Soil preparation for sowing    | May        | MTW-1221             | HSFC-4G +4           | 1        | 6…8     | -                               |      |
| Rolling soil before sowing     | May        | MTW-82               | 3RSR-6               | 3        | -        | -                               |      |
| Seed transport                 | May        | Gazelle              | RT-4 + WGCFC-2      | 1        | -        | -                               | Donnik |
| Sowing sidereal crops          | May        | MTW-1221             | GS-5.4 + STH-0.6A    | 1        | 2…3     | -                               |      |
| Rolling crops                  | May        | DT-75M               | TH-11A +3×3RSR-6    | 3        | -        | -                               |      |
| Before and after sprouting     | May, June  | DT-75M               | HC-21 (hydraulic coupler) + 12xSTH-0.6A | 12 | -        | -                               |      |
| harrowing crops                |            |                      |                      |          |          |                                 |      |
| Grinding and seeding siderates | July       | MTW-1221             | RT-4 + WGCFC-2      | 1        | -        | -                               | Donnik |
|                                | MTW-1221   | RT-4 + MSP-3-35     |                      | 1        | -        | -                               | Lupine |
|                                | MTW-1221   | RT-4 + HDH-3        |                      | 1        | -        | -                               | Mustard |

Figure 2. Combined unit for surface incorporation of siderates RT-4+MTW-1221+WGCFC-2.

The presented unit simultaneously performs the process of mowing and grinding green plants and incorporating them into the soil. Due to the fact that the RT-4 cable chopper is hung on the front linkage of the tractor, the drive from the power take-off shaft is transmitted through the cardan drive system to the front of the power tool.

The principle of operation of a rotary grinder with flexible working elements is as follows. A tractor with an aggregate mounted on it moves across the field. Flexible cable elements mounted on a disk rotor are driven by a vertical shaft connected to a bevel gear, which in turn receives a drive from the aforementioned cardan drive system. During rotation, flexible working elements are pulled into the
Green manure must be mowed and crushed in the period before seed formation in the budding phase and the crushed mass should be left on the soil surface; it is necessary to treat the soil with plane cutters while maintaining stubble to a depth of 25...30 mm. This helps to increase soil fertility and increase the collection of agricultural products from the fields.

Some green manure crops, when hard stems were formed, decompose more slowly, because microorganisms that decompose coarse stems lack nitrogen for life, and they compensate for this deficiency by absorbing nitrogen from the soil. Therefore, when planting mature plant mass, it is advisable to use a combined unit composed of an MTW-1221 tractor in front of which a cable shredder of plant stems RT-4 is hung, and a HDH-3 disc harrow is attached at the back (figure 3).

![Figure 3. Combined unit for incorporating green fertilizers RT-4+MTW-1221+HDH-3.](image)

The combined unit in the presented combination effectively performs the process of planting the crushed mass of green manure crops, and also contributes to a significant cleansing of the field from weeds and the normalization of the ecological situation in the agricultural sector.

In choosing a crop for green fertilizer, it is necessary to clarify the vegetative periods of plants, its productivity of the accumulation of green mass, their placement in the crop rotation and the timing of mowing. So, due to late mowing, seeds appear in plants and they clog the field surface. If it is too late to mow siderates with a powerful root system, it becomes more difficult to process such soil and therefore it is necessary to use a combined unit composed of an MTW-1221 tractor in front of which a RT-4 chopper is mounted, and a MSP-3-35 plow behind (figure 4).

![Figure 4. The combined unit for plowing green fertilizers RT-4+MTW-1221+MSP-3-35.](image)

The main tillage is necessary to completely close up the powerful root system of plants, as well as to give the soil a certain structure, create favorable conditions for the accumulation and preservation of moisture, the destruction of weeds, changes in the state of the field surface, etc. The productivity of agricultural crops and the cost of production to a large extent depend on the quality of the process.
Regardless of the cultivated green manure, the incorporation of green mass into the soil must be carried out after crushing by the chopper. To confirm the above, field trials of the proposed combined unit at the ‘Krasnaya Zarya’ agricultural production complex were carried out in two versions - without and with simultaneous mowing and grinding. According to the results of the experiments, it turned out that the completeness of embedding green mass of green manure without mowing was 65%, and with mowing and grinding 96%, which is also confirmed by the photograph from the experimental plot (figure 5).

![Figure 5](image)

**Figure 5.** Plot of green manure in the field of the agricultural enterprise ‘Krasnaya Zarya’ in the Vyskogorsky district of the Republic of Tatarstan: on the left - after the passage of the MTW-1221+HDH-3 aggregate without mowing and embedding siderates; on the right – after the passage of the RT-4+MTW-1221+HDH-3 aggregate with simultaneous mowing and embedding of siderates.

The same studies were conducted in such regions of the Republic of Tatarstan as Nizhnekamsk, Apastovsky, Nurlatsky. The test results differ from those presented by no more than 5%, which indicates the applicability of the proposed technology in all climatic zones of the republic.

4. **Conclusions**

The presented combined units allow performing the technological process of grinding and embedding siderate culture in all climatic zones of the republic according to the adopted crop rotation of the region, as well as increasing the completeness of embedding siderate culture in the soil by 1.5 times, which favorably affects the decomposition of the planted green mass.

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