Relevance for Using Machines Appropriate to Strip Tillage

V V Myalo \(^a\), E V Demshuk \(^b\), D E Kuzmin \(^c\), A S Soyunov \(^d\), U K Sabiev \(^e\)

Federal State Budgetary Educational Institution of Higher Education "Omsk State Agrarian University named after P.A. Stolypin" 644008, Omsk, ul. Institutskaya Square, E-mail: \(^a\) vv.myalo@omgau.org, \(^b\) ev.demshuk@omgau.org, \(^c\) de.kuzmin35.06.04@omgau.org, \(^d\) as.soyunov@omgau.org, \(^e\) uk.sabiev@omgau.org

Abstract. To increase the quantity and quality of any product type, it is necessary to upgrade machines, improve production processes, and minimize costs. The treated surface density, the amount of removed and transferred material should be minimal, but sufficient to create optimal conditions for the subsequent operations implementation of the technological chain, which requires the production processes adaptation to specific conditions. Therefore, the technology optimization and the machines working bodies improvement is a relevant area for research.

1. Introduction

Agricultural production process modernization and improvement is quite relevant taking into consideration the current increase in fuel prices and other production cost growth. Soil preparation is considered to be the most energy-intensive technological process for growing crops. The following block diagram represents tillage technology (Figure 1):

![Figure 1 - Tillage technology](image)

The tillage technologies are divided according to the soil impact degree:
- conservation technology - the technology by which soil conservation tillage is performed;
- traditional farming - where there is a maximum impact on the soil, since it is based on a plow;
- minimal farming - when there is minimal impact on the soil, and its preparation is carried out directly during sowing.

Processing method choice depends on the soil type, the ratio between crops in crop rotation, climatic conditions, infectious pressure of pathogens living in the soil, the prevailing form of organic fertilizer, wind and water erosion danger. The degree and depth of soil compaction propagation, the compaction depth and the area share of wheel tracks, the moisture content and carrying soil capacity, the quantity, distribution and crop residues properties, as well as the weed type and density should be taken into account.

Conservation technology can be divided into 3 tillage technologies (Figure 1):
- technology of the mulching processing, when plant residues accumulate on the field surface. The latter, in turn, protects the soil from wind and water erosion, and also contributes to the moisture...
retention in the soil during hot summer days, when the soil warming in the upper layer can reach temperatures of 50°C and above.

- ridge processing technology allows to delay melt water flow, which carries out the fertile particle removal from the soil surface. Also ridges contribute to the rapid soil warming in areas with insufficient sunny day number.
- no-till technology - a technology that minimizes the impact on the soil while sowing or planting a crop. In the period between the change of predecessors, the soil is not processed.

According to the definition of the company Conservation Technologie Integration Center (CTIC), which is the center for the introduction of preservative technology, various groups of technologies classification for growing crops is presented in the following form.

2. Results and Discussion

Traditional farming is a plow technology, an intensive tillage technology. The minimum treatment - 15 ... 30% of the soil surface remains covered with crop residues, the fight against the erosion formation is carried out. Technology ridge tillage (Ridge-Till) - ridges are created on the field surface, crop residues remain between the ridges. The technology of mulch tillage (Mulch-Till) - the soil surface before sowing is treated with fully deep-rippers, cultivators or disc harrows. No-Till and Strip-Till: tillage methods where the soil remains untreated between the harvest and the sowing company. In the strip tillage technology process, narrow bands are processed in the autumn period, which allows you to simultaneously apply mineral fertilizers [1].

The band method is designed to reduce the level of tillage, but at the same time it contributes to maintaining the conditions necessary for plant growth. According to A. McGuire, the band tillage technology is promising, due to the fact that when cutting strips, the untreated surface will be about 70-80% of the field total area [2]. Strip-Till strip farming technology is suitable for many regions of Central Russia. The following can be distinguished from this soil-climatic zone features: a thin fertile soil layer, an abundance of weeds with a broad botanical composition, low fertility with a low content of organic matter, swimming soils, a short growing season compared with Western Europe. Scientists have noted a number of benefits from the technology Strip-Till use: reduced labor time and the technological operations number, strip loosening allows you to get higher yields when used properly [3, 4, 5].

![Figure 2. Strip-till strip tillage process flow diagram](image)

Figure 2. Strip-till strip tillage process flow diagram a - spherical disks loosening; b - chiselling; c - treated strip closing; g - treated strip horizontal section.

When processing the soil using the Strip-till technology, vertical volumetric loosening is reduced to three mandatory operations:
- soil loosening at a depth hd with its excavation and sowing strip formation of width b (Figure 2, a);
- open furrow chiselling by the working body with a chisel of width bchis to depth hch (Figure 2, b) provided that the strain width bch does not exceed the strip width b processed by the discs (bch ≤ b);
- processed strip closing by disk working bodies with subsequent rolling (Figure 2, c).
Work on this technology also has negative consequences in the form of soil layers mixing, abrasion of cleaners and closing rows organs microparticles and working surfaces. That contradicts the resource-saving technologies basics, obliging to carefully treat the soil, to preserve it [6].

In the Volgograd region territory, the strip tillage technology has been used since 2012 on sunflower and maize. It is southern low-power black soil climatic zone, with an average annual rainfall of 360...470 mm. The yield increase, when using this treatment, was about 19%, while the high rates of oil content remained [7]. The strip tillage allowed to increase the moisture absorption rate by 3...5 times, to improve the surface soil layers aggregates stability by 30%, to increase the soil organic matter by 0.1-0.15% per year.

In the Republic of Bashkortostan strip cultivation in the cultivation of maize and sunflower has been used since 2011. Geographically, the Republic of Bashkortostan is located in the Southern Urals and in the Ural Region, the climatic conditions within the republic are differentiated due to the presence of the Ural Mountains. Due to the saving technologies use in the farms of the SEC “Krasnaya Bashkiriya” Abzelilovsky, GUSP “Tavakan” Kugarchinskiy, MTS “Zirgansky” Mezeuzovsky districts of the Republic of Bashkortostan, they experienced a significant increase in the soil fertility yield and reproduction [8, 9].

Saving agriculture technologies were introduced in the Belgorod region, where the climate is temperate continental with snowfalls and thaws in winter and hot, often with droughts and hot dry winds, in summer. The advantages of the Strip-Till tillage technology over the No-Till direct sowing technology were obtained: better plants root system development, earlier sowing start possibility [10].

In Germany, the Strip-Till tillage technology has been applied for the past 10 years. This technology advantages compared with the traditional treatment, are as follows: soil natural fertility is preserved; the possibility of growing row crops on slopes from 3 to 5 degrees, with the mandatory cultivation of intermediate crops; soil erosion is being fought; crop yield increases by 10...20%; reduced costs of mineral fertilizers, due to their precise introduction; reduced fuel and lubricant costs; reduced labor costs.

After market and relevant literature studying, we can conclude that initially machine development for the strip technology was carried out in a simpler way. The machines for ordinary tillage that existed at that time were refined and adapted to the strip technology. Initially, such machines were used only for row crops (corn, soybean, sunflower, etc.) [8]. The gun frames were borrowed, and the corresponding working bodies were already installed on them. Further modernization was aimed at accuracy improving of the soil topography copying, as well as characteristics improving of the technological process. At the same time, methods were developed for moving along individual working body depth. If we classify existing machines by this parameter, we can distinguish three types:

Type I: Cutting and loosening working bodies are rigidly fixed to the frame. The frame itself over the entire working width is recessed due to the adjustment of the support wheels. Clearing, combing and grinding working bodies, due to their design peculiarities, are able to repeat the soil relief. Car models produced by Unverferth, Carrotech, Schlage, JohnDeere and BlueJet are widely used in agriculture.

Type II: A subframe is mounted on each machine section, on which individual working bodies are mounted. Due to this, this type gains advantages over the first type due to more accurate soil relief copying by each separate machine section. Necessary working bodies can also be installed and adjusted on this subframe (Figure 3). Manufacturers of this design machines: Strip-Cat, Orthman, B & H manufacturer, BighamBrothers, Hiniker, Carter, Yetter, Kongskilde, and Sunflower / Agco. This model is the most popular presented on the market.

Type III: Based on its own system, Kuhn / Krause has developed a machine that, like in type I, has a cutting tool fixed to the machine frame. The working body, which purpose is loosening (for the equipment of this company type, Krause is the rack) is attached to the machine frame with a parallelogram (like type II), and the grinding working body leads the tool in depth (Figure 4). Such a functional principle is a distinctive model feature of the third type. Accordingly, the grinding working bodies should be made of wear-resistant materials. The exclusion from the grinding working body section will directly lead to a change in the loosening working body depth, which will complicate the regulating process such processing.

Tools for band tillage, common in the Russian Federation: Orthman (1tRIPr), KRAUSE (Gladiator), as well as their domestic counterpart of DorAgroMash Orlik are quite expensive, which affects the final products price.
The tools presented do not allow for the mineral fertilizer application, which draws another operation, respectively, and fuel and lubricants cost, time, and affects the production unit cost. From the domestic widespread development of technical tools for the sexual tillage we can distinguish the Orlik tool from DorAgroMash company. It is presented in several variations and has a lower cost compared to foreign counterparts.

Table 1. Production technology impact on direct technical costs (sunflower)

| Technology                        | Fuel costs, % | Agricultural machinery amortization, % | Tractor amortization, % | Operator's salary, % |
|----------------------------------|---------------|---------------------------------------|-------------------------|----------------------|
| Chizel, mechanics                 | 100           | 100                                   | 100                     | 100                  |
| Chizel, plant protection products | 88.6          | 103                                   | 94.2                    | 83.2                 |
| Strip-till                       | 64.5          | 75.5                                  | 78                      | 63                   |

Based on the data in Table 1, it can be concluded that, in terms of technical costs, Strip-till technology is more profitable and more promising than other tillage types. Technical costs are affected by machines number reducing when using Strip-till technology, as well as improving productivity in tillage.
With regard to the territory of the Omsk region, which has 3 soil zones (Figure 6):

- forest-steppe zone occupies the largest part of the Omsk region territory (about 51%). Black soil-meadow, meadow-black soil and meadow soils, as well as alkaline soil complexes predominate in the forest-steppe zone soil cover. The average humus content varies within 4...5%. For agricultural needs in this zone, 3 744 000 hectares of land have been developed, of which 56% is arable land.

- The forest zone is the most limited by the agricultural land area (600 thousand hectares). This zone is lower than all in relation to the ocean level, and is also swamped, and as a result is over-humidified; groundwater occurs at a depth of 3 meters. The land fund is mostly represented by podzolic, marsh and meadow soils, which are mostly acidic, thin, with a low humus supply (up to 3%), phosphorus and nitrogen.

- The steppe zone covers only about 9% of the Omsk Region territory, but it is the most agriculturally developed. Treated land in individual farms reach up to 95%. In the land fund of the steppe zone, ordinary and southern black soil, as well as carbonate and solonets, predominate. The humus amount is within 4...9%.

Strip tillage in the rapeseed cultivation can be divided into two branches: a separate principle and a combined principle. A prominent representative of the first is the band tillage technology from AMAZONE. This principle can be represented as follows: band tillage with the possibility of mineral fertilizers, the direct seeds application is carried out by a separate operation. The second principle is adhered to by HORSCH, which allows for complex work, i.e. in one working cycle, the technician performs soil treatment, fertilizers application and seeds sowing. These principles advantages are presented in table 2.
Figure 6. Omsk region climatic condition map

Table 2. The main advantages of band tillage separate and combined principles

| Separate principle                                      | Combined principle                                      |
|---------------------------------------------------------|---------------------------------------------------------|
| Choosing the optimal time for making seeds              | Labor saving                                            |
| Sowing rate does not depend on tillage speed            | Lower energy consumption                                 |
| Tillage can be carried out around the clock, during daytime sowing | No need to use RTK-GPS steering system                   |
| Heavy soils (clay > 10%) can lower moisture before sowing | Weather conditions influence elimination between tillage and sowing |

The band tillage use in the rapeseed cultivation in the soil and climatic conditions of the Omsk region territory can be divided into two branches: a separate principle and a combined principle.

3. Conclusion

In the Omsk Region, agrochemical soil condition monitoring is constantly carried out. Due to the humus content in the soil, acidity, the soil availability with phosphorus and potassium, pollution with heavy metals, as well as chemical elements, are taken into account. Thus, according to the regional agrochemical service data, practically 87% of arable land needs phosphorus-containing substances in combination with fertilizers additionally. The potassium content in the soils of the region is significantly higher than the phosphorus content in percentage terms. In the steppe zone and the southern forest-steppe, 98% of the land has a high and very high potassium supply. The minimum potassium content in the northern zone, and it is 87%. The annual humus loss as a result of agriculture reaches 0.4 t / ha. To date, there has been a decrease in the gross humus reserves in arable soils to 10...15% from the land development start, especially in the south of the region. Therefore, tillage with a strip method with the possibility of mineral fertilizer application is relevant.

The Strip-till technology use will reduce the fuel materials cost up to 35.5% compared to the classic chisel, and 24% relative to the minimum technology. Such a change in costs is due to the reduction in the number of technological operations of mechanical tillage.
According to the site "selhozportal.rf" the area of arable land in the Omsk region in 2018 is 286 thousand hectares. Tilled crops occupy about 40% of the area, no more than 20% of enterprises work on saving technologies. Such conservatism when choosing a cultivation technology is primarily related to the fact that the Omsk region is in the zone of “risky farming”. The slightest mistake in technology application leads to significant losses during the harvest. Thanks to the rational band tillage use in tilled crops production can be achieved: increase yields, reduce fuel and lubricants and mineral fertilizers cost. To this end, it is necessary to develop tools that will allow strip tillage with simultaneous mineral fertilizers application, taking into account the agroclimatic features of the machine application area.

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