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Energy-saving tillage with a combined unit with universal working bodies

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Abstract. The need for minimal tillage is due to the reduction of energy and labor costs for the operation. In modern technologies for the cultivation of agricultural crops, processing accounts for up to 25% of labor and 40% of energy costs. The purpose of the study: the development of a combined tillage unit with a universal working body that increases the quality of minimum tillage, the stability of the unit movement with an increase in functionality.

1. Introduction

Increasing the efficiency of production of competitive agricultural products is inextricably linked with the provision of the agro-industrial complex with highly efficient machine technologies and energy-rich technology of a new generation [1].

One of the main factors of high and stable productivity of agricultural plants and sustainability of agriculture is the optimization of nutrient, water and air regimes of the soil, taking into account the biological characteristics of crop cultivation and soil and climatic conditions.

Favorable physical properties are the basis for the necessary conditions for the realization of potential soil fertility for obtaining high yields of agricultural crops. An important role in this is assigned to the method, depth and intensity of soil cultivation, which determine the rate of mineralization and the availability of nutrients.

Soil density, as one of the fundamental indicators of fertility, in variants with different intensities is determined by the method and depth of loosening (Figure 1). The most loose soil layer in the range from 0 to 30 cm is observed after plowing with a reversible plow to a depth of 20-22 cm (1,39 g/cm³) [2].



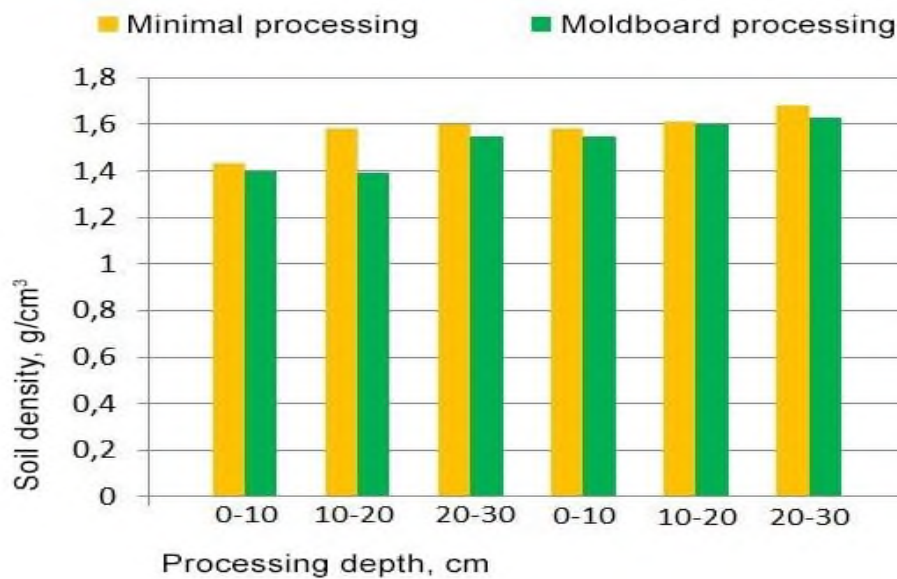


Figure 1. Dependence of soil density on the depth of cultivation for two growing seasons.

For radical improvement of the physical properties of soils for zones of insufficient moisture, methods are being developed that promote the accumulation and preservation of moisture. In the zone of excessive moisture, agrotechnical and reclamation measures, on the contrary, should be aimed at reducing the moisture content in the soil and increasing its aeration.

The development of the root system slows down significantly when the soil air contains less than 15 volume percent oxygen. The porosity of aeration, as an indicator of the rate of gas exchange between the soil and the atmosphere, depends mainly on the density of its composition and moisture content. Throughout the growing season, the porosity of aeration should not fall below optimal values [3].

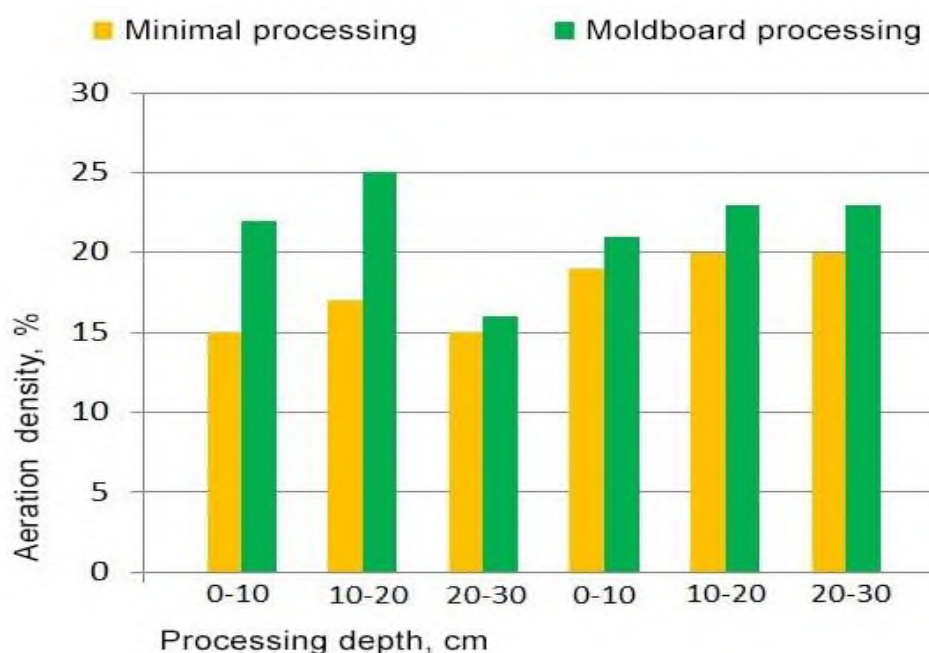


Figure 2. Dependence of the porosity of aeration on the depth of treatment for two growing seasons.

The use of intensive tillage in crop rotations with a predominance of annual plowing activates the microbiological processes of humus decomposition. Chernozem soils during moldboard tillage lose 0.8-1.2% of humus over 30 years, which negatively affects the balance of organic matter and leads to significant losses of nutrients and energy. Accelerated decomposition of humus contributes to the development of erosion processes, especially on slope lands. For this reason, minimal tillage is considered as the most important condition for maintaining potential and increasing effective fertility, protecting soil from erosion by improving the humus balance and reducing the loss of nutrients. At the same time, it significantly reduces the energy costs of processing and the time for completing field work.

The most important conditions for the effective use of minimum processing are:

- high technological level of crop cultivation,
- high-quality performance of mechanized field work in optimal terms,
- provision of the enterprise with effective plant protection products and fertilizers.
- The main areas of minimum tillage include:
- reduction of the number and depth of the main, pre-sowing and inter-row treatments on highly fertile soils and favorable agrophysical properties, subject to the use (if necessary) of herbicides;
- replacement of deep main treatments for some crops, with minimal ones, due to the use of wide-cut flat-cutting, disc and other tools, especially for winter and spring crops;
- combination of several technological operations and techniques in one working process due to the use of combined tillage and sowing units.

Purpose of the study – development of a combined tillage unit with a universal working body that increases the quality of minimum tillage, stability of the unit's movement with an increase in functionality.

2. Materials and methods

As the analysis of the search for material of various designs of soil-cultivating equipment, both foreign and domestic, has shown, the production indicators of soil-cultivating machines remain low, due to the short service life of the working bodies, overloading of the working units and parts, which requires the search for solutions that ensure the quality of soil cultivation and high working capacity [4,5,6,7].

The design of the multifunctional tillage unit under consideration allows in one pass to carry out the soil slitting in the vertical plane to a depth twice the depth of cultivation, moldboard loosening of the soil with pruning of weeds, additional crushing and harrowing of the soil to a width equal to the width of the cultivator.

Our Center has developed more than one design of tillage equipment, including those with automated regulation of the depth of tillage and combined devices [8,9,10,11].

Currently, the work is going on to improve the design of the multifunctional tillage unit (Figure 3), which consists of three sections in the form of a frame structure, the main one is located in the center and two folding ones are fixed to it on the sides. The side sections contain three frames. On the front frames of the side sections, four slotters and cultivator shares are installed. The middle frame consists of two tines on which the cultivator's legs are fixed. The rear frames contain one leg each. The paws are installed with the possibility of overlapping the front paws by 2 ... 4 cm. The rear frames of the side sections contain a needle grinder and a tooth harrow, the total width of which is equal to the width of three paws with overlapping.

The main section is located in the middle and contains a bar, transport and support wheels, and hydraulic cylinders for servicing the side sections. The front frame of the main section is designed in the same way as the frames of the side sections. The second frame is with one post and paw. The rear frame is made with four tines, a needle grinder and a tine harrow. The needle chopper and harrow work the soil to a depth equal to the cultivation depth.

Figure 4 shows a universal working body of the tillage unit, which consists of a cultivator paw and its holder, two wings with a fused blade located on the outer surface along the edge of the wings. On the joint line of the paw wings, a through slot is made for a saber-shaped working body (a ripper with a slotter), made with the curvature of the cutting edge in the direction of movement, and an indent from the toe of the paw. The length of the slot is half the length of the paw wing and the width is 2-3 mm. The working body is installed in the slot with the possibility of its removal, the height of its upper part - the ripper - 70-80 mm, and the height of the lower part - the slotter - 110-120 mm.

The width of the slotter from the rear of it is at least 3-4 mm greater than the width of the ripper, forming a support protrusion. At the junction of the upper and lower parts of the working body, there are rigidly fixed two support plates that follow the paw wings, with a width equal to the length of the slot and a length not exceeding half the width of the paw wing.

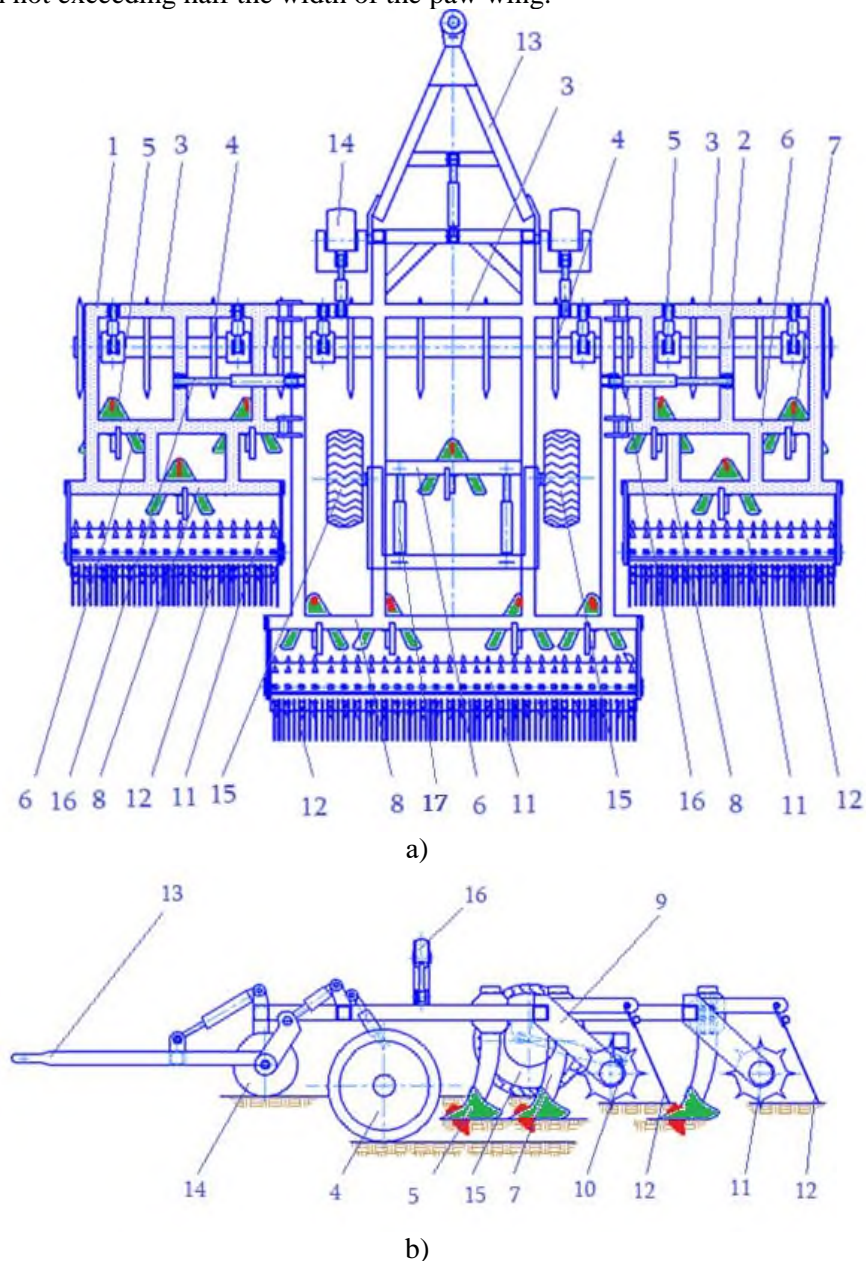


Figure 3. The scheme of the unit with a universal working body in two projections a - view from above; b - view from the side; 1 and 2 - the first and third sections in the form of three frames; 3 - front

frames; 4 - slotter; 5 - paw; 6 - middle frame; 7 - rack; 8 - frame; 9 - shaft; 10 - needle chopper; 11 - tooth harrow; 13 - gnum; 14 - supporting wheels; 15 - transport wheels; 16.17 - hydraulic cylinders.

Before starting work, the saber-shaped working body with the lower part with the support protrusion of the slotter is inserted into the through slot until the plates stop on the paw wings.

During the operation of the unit, disc-shaped slotters cut the soil in a vertical plane; needle grinders crush the soil to a depth equal to the working depth of the cultivator paw. The cultivation is completed by a tine harrow, which levels the soil.

The cultivator's paw cuts the soil layer with wing blades with 13° - 16° sharpening on the thin frontal part of the wings, which ensures complete undercutting of weed roots. The working body, inserted into the slot, with the upper part - with a ripper, cuts the soil in a vertical plane with simultaneous loosening.

The lower part of the working body - the slotter, conducts the slotting at a depth of 110-120 mm, while improving the water-air balance in the soil.

In the process of work, the working body, with the help of plates fixed on it, rests on the paw wings and under the influence of soil pressure remains in the working position, despite the fact that it is not fixed on the paw of the cultivator. The presence of the support protrusion of the slotter in the rear butt part, abutting along the line of the joint of the wings from below, does not allow the slotter to protrude from the soil, which contributes to its stable operation. The working body is dismantled by simply pulling it out of the slot of the share.

Installation of the paw wings at an angle of inclination of 2 ... 40 in relation to the horizontal surface in the direction of movement of the unit, allows not only to cut the soil in the horizontal plane, but also to shift it with a separation.

The presence of a ripper and a crevice tool allows you to combine cultivation with cutting weeds with simultaneous loosening and crevice of the soil. As a result, in one pass of the unit with the cultivator paw, the top layer is processed without turning the layer, weeds are destroyed, the soil is loosened and crevices, which increase the quality of processing and improve the water-air balance in the soil.

The proposed design of a universal tillage device allows one working body to simultaneously cultivate with loosening and siping, thereby achieving its versatility.

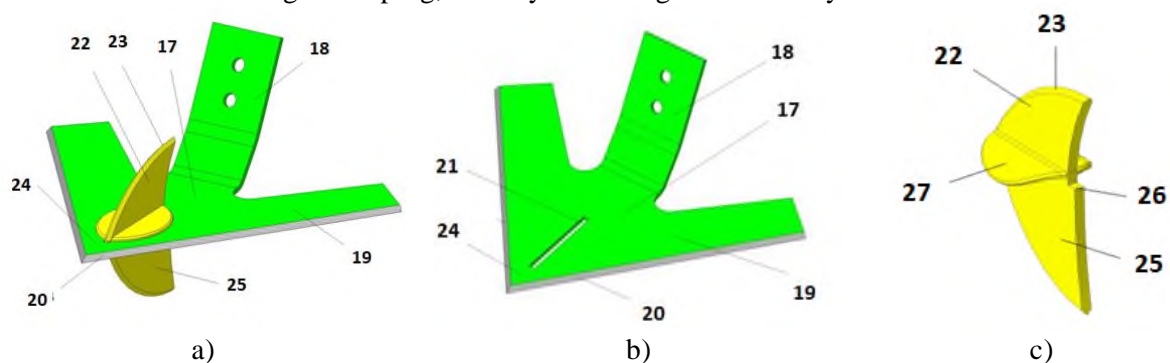


Figure 4. Universal working body. a) is a complete view; b) the paw of the cultivator; c) a cultivator with a slot; 18 - holder; 19 - wing; 20 - blade; 21 - slot; 22 - a cultivator; 23 - the curvature of the cultivator; 24 - toe paws; 25 - slotter; 26 - ledge; 27 - base plates.

3. Conclusions

Disk slotters in the unit, located along the width of the cultivator paw, help it to cut the seam without tearing, which generally reduces the traction resistance of the unit. The work of the cracker at great depths improves the water-air balance in the soil.

Implementation of the device with folding side sections facilitates changing the working width in a simple way.

The use of the proposed unit with a universal working body helps to improve the quality of minimum tillage, to increase the service life by reducing the loads on the working bodies due to equipping cultivator paws with slot cutters, to improve the processes occurring in the soil and reduce fuel consumption by up to 15%.

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