UDC 631.3
DOI: 10.37128/2520-6168-2023-3-12

DEVELOPMENT OF MACHINE UNIT FOR RESOURCE-SAVING TECHNOLOGIES OF SOIL PROCESSING

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Water and wind erosion are possible on crop rotation fields. By using various agrotechnical techniques, it is possible to minimize soil erosion. One of these techniques is the creation of shafts about 10 m wide and 80-100 cm high at a certain distance. Effective agrotechnical anti-erosion techniques are slitting, special porous and comb plowing, organization of soil-protective crop rotations, strip placement of winter and spring crops, grain and row crops, creation of buffer strips of grasses, liming of washed lands and drains.

In the steppes or areas where the topography of arable land has a slope, it is recommended to use various technologies of minimal tillage to counteract wind and water erosion. Surface treatment of the land ensures the accumulation of plant residues in the surface layer of the soil. This increases the amount of organic matter in the upper layers, which, in turn, improves the strength of the aggregates and the resistance of the soil to the action of raindrops and wind gusts. When plowing sloping fields, contour plowing is a useful method of reducing the risk of erosion. It uses the topography of the field to absorb water, preventing it from running down the rows.

Crop residue remaining on the surface is also a factor in which minimal tillage protects the land from erosion. In general, both plants and their remains on the surface effectively slow down the speed of movement of both water on the surface of the soil and air above it. From a physical point of view, plant cover growing on the surface, as well as plant residues, effectively protects the ground, for example, from the impact of raindrops.

If we talk about traditional crops, it should be noted that perennial grasses provide the best protection, and cereals can moderately resist erosion. When growing row crops, such as sugar beet or corn, most of the land remains uncovered, meaning that these crops provide less protection. The worst option from the point of view of erosion is steam without growing any crops and without preserving the harvest residues on the surface.

Analysis of existing machines for soil protection against wind and water erosion was carried out. The proposed design of the machine for plowless tillage.

Key words: *soil mulching, erosion, cultivation, plant residues, crop rotation.*

Fig. 5. Ref. 8.

1. Problem formulation

The forest-steppe zone of Ukraine is divided into two subzones - the western forest-steppe and the eastern forest-steppe. The regions of Volyn, Rivne, Lviv, Ivano-Frankivsk, Chernivtsi, Ternopil, and Khmelnytsky regions are included in the subzone of the Western Forest Steppe. The Eastern Forest Steppe includes the districts of Vinnytsia, Zhytomyr, Kyiv, Cherkasy, Odesa, and Chernihiv. Sumy, Kharkiv, Kirovohrad, and Poltava regions. These areas are often affected by wind and water erosion of the soil (especially in areas not protected by forest belts and slopes).

The causes of accelerated erosion are:

1. Uncontrolled deforestation. The forest protects the soil from erosion the most effectively, because the root system of the trees forms a thin plexus, which, interweaving the soil, enables it to retain thaw and rainwater. ·

2. Destruction of meadows. Herbaceous plants have a well-developed root system, which forms turf on the surface of the soil, which performs soil-protective functions.

3. Excessive livestock grazing is dangerous because: vegetation cover is significantly reduced, because plants are destroyed faster than the normal cycle of pasture recovery is completed, cattle during grazing knock out the soil with their limbs, as a result of which its structure is disturbed.

4. Improper farming: · lack of crop rotation, improper plowing of slopes (longitudinal plowing of slopes, even low ones, which causes soil particles to be washed away) Soil erosion is an irreversible process, everything that is removed from the soil by water or wind is forever lost for agriculture.

2. Analysis of recent research and publications

Soil erosion is the process of soil destruction and wear under the influence of wind, water flows, and mechanical actions of agricultural machines.

On sloping sites, water erosion can be very serious when rain falls on bare soil devoid of plant cover or plant debris. Clay particles are washed away by rain, carrying bound phosphorus with them, and collect in lowlands or are lost outside the field.

Wind erosion occurs when the air flow interacts with the open surface of the soil, causing its particles to move. Moving particles destroy soil aggregates and attract the destruction products to the air flow, which often carries them over long distances (Fig. 1).

To protect arable land from wind erosion, a complex of anti-erosion agrotechnical measures is used, which includes a system of no-till soil treatment with preservation of stubble and harvest residues on the surface of the fields, soil-protective crop rotations. In addition, the number of passes of agricultural machines on the fields is reduced. [1].

On dry, bare soils, wind erosion can cause damage when airborne sand particles are deposited on crop sprouts.

The fight against water erosion, which occurs on slopes, includes a system of organizational and agrotechnical measures that ensure water retention. These include: timely tillage, plowing with soil deepeners or cut-out bodies, plowing with the simultaneous formation of bridges and ridges in the furrows, formation of holes and intermittent furrows, moulting and snow retention. (Fig. 1).

Fig. 1. Wind and water soil erosion

Heavy rain or intense snowmelt can wash away soil from arable land. Along with water, soil particles, plant nutrients and organic material are carried into streams, lakes and seas. Sloping fields suffer the most from this. The steeper the slope, the stronger the erosion, because the rate of water runoff increases.

Doubling the rate of water runoff causes erosion to increase fourfold. Water erosion can dramatically increase phosphorus leaching because much of the soil phosphorus is bound to the surface of clay particles.

Plowing on slopes is necessary so that the furrows run across the slope, along the horizon. The plow unit must be on the same level at each pass, without rising or falling on the slope. Compared to longitudinal plowing of a field across a slope with a steepness of more than 3° per hectare, it reduces soil erosion by 2 times and increases the moisture reserve in a layer 1 m thick by 150...200 tons, and the yield of grain crops by 0.2... 0.3 t. Reversible PON-2-30 and PKCH-4-35 shuttle plows should be used for plowing slopes. [2-3].

3. The purpose and tasks of research

The purpose of the work is to develop a unit, as a result of which it is possible to reduce the destruction of the soil from wind and water erosion, with the help of separate nodes, discs with general adjustment of the angle of attack and the use of combined working bodies. When adjusting the inclination of the disks vertically, it will be possible to increase the depth of processing. Easy adjustment of the angle of attack makes it possible to use the discs as a peeler. The use of a mulching device will allow you to protect the soil from the effects of wind and water erosion.

4. Results of the researches

The project machine is designed to protect the soil from wind and water soil erosion. The structure and operation of the machine are shown in fig. 2.

And it also provides for covering the row spacing with plant residues from the previous harvest. This reduces evaporation of moisture from the soil. In addition, plant residues in the rows are an obstacle to the spread of weeds, and this reduces the costs of the farm for chemical and mechanical weed control.

The design machine for soil protection against wind and water soil erosion consists (Fig. 2) of the main frame 4, to which the movable frame 5 is hinged, support wheels 3 are suspended from the main frame, and a towing device is attached, which connects the machine to the energy carrier (by tractor).

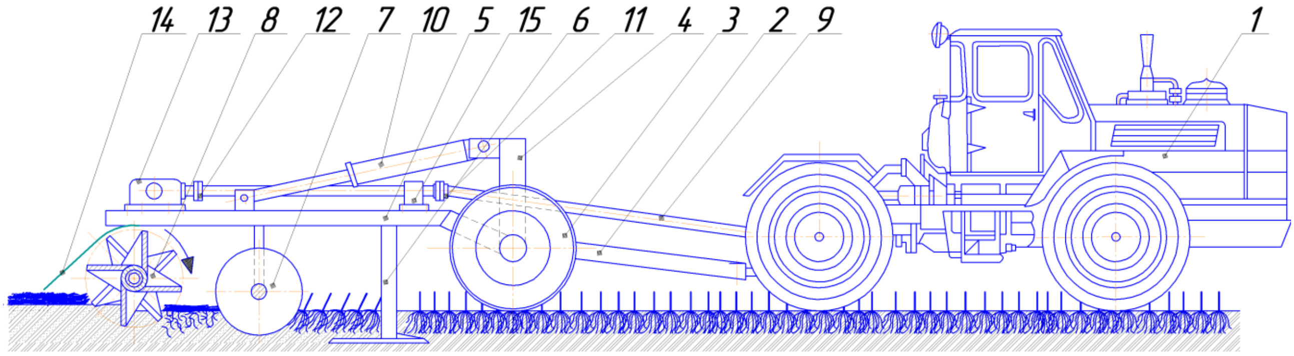

Fig. 2. Structure and operation of the design machine:

1 – Tractor; 2 – towing device; 3 – supporting wheel; 4 – main frame; 5 – movable frame; 6 – flat-cut paw; 7 – disk in the warehouse; 8 – device for soil mulching; 9 – cardan transmission; 10 – hydraulic cylinder; 11 – safety clutch; 12 – connecting clutch; 13 – reducer; 14 – chop shield; 15 – bearing support, intermediate.

The working bodies of the machine are attached to the moving frame 4 - flat-cut legs 6, discs 7, which perform the functions of a disc harrow or a disc harrow and a device for mulching the soil 8. This device is driven by a gearbox 13, which receives torque from the tractor's PTO through a cardan transmission 9 , which is supported by a bearing support 15, a safety 11 and a connecting clutch 12 are attached to the universal joint. A hydraulic cylinder 10 is attached to the movable 5 and main 4 frames to move the machine to the working position and vice versa.

As mentioned above, the device for mulching the soil is driven from the tractor's PTO through the cardan transmission to the reducer. The conical reducer 16 (Fig. 3) is placed on the left side of the device to equalize the weight of the device, as the on-board cylindrical reducer 18 is mounted on the right side, which receives torque from the conical reducer through the safety clutch 17 and transmits it to the mulching device 8.

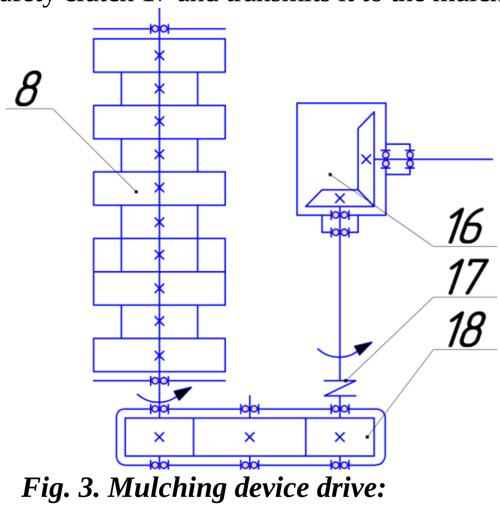

Fig. 3. Mulching device drive:
8 – Device for soil mulching; 16 – conical reducer; 17 – safety clutch; 18 – cylindrical gearbox, on-board.

The disk can perform the function of a disk harrow and a disk husker thanks to the rotary device (Fig. 4), which sets the angle of rotation a depending on the type of soil treatment. The disk rotation mechanism

(Fig. 4) consists of the rotation axis 20 of the disk 19, which is fixed in the housing 21 rigidly welded to the movable frame 5, when the rotary bar 23 moves, the disk turns to a given angle of soil treatment, for the movement of the bar 23, a rotary lever is attached to it 24, which is rigidly hinged to the support bar 22, to achieve the goal of turning the disk, each disk is made separately and attached to the movable frame 5. [4-5].

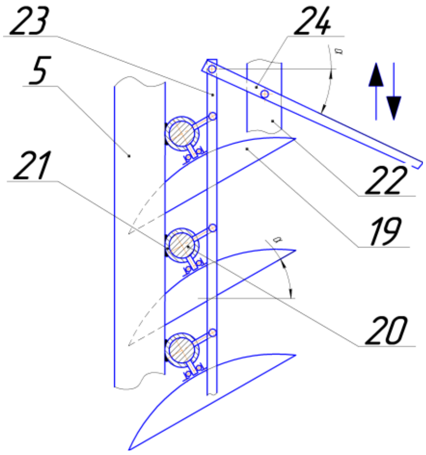

Fig. 4. The disk rotation mechanism:

5 – The frame is movable; 19 – disk; 20 – rotary axis; 21 – housing of the rotary axis; 22 – support bar; 23 – turning bar; 24 – lever for adjusting the angle of rotation of the disc.

The work of the project machine consists in crushing the soil and creating a protective layer on its surface against winds and water flows in the form of mulched partially crushed stubble of the previous crop. The machine is used for pre-sowing soil treatment for sowing with seed drills of the SZS-6 type, namely the stubble seed drill Avers-Agro TSM 3.9 for No-Till and Strip-Till technologies, the machine belongs to the class of combined tillage units.

The machine works as follows: after moving the unit to the working position with the hydraulic cylinder 10 (Fig. 5), the flat-cut paws 6 (Fig. 2) are buried in the soil to the appropriate depth specified by the agrotechnical requirements for the corresponding crop, the paws 6 are buried to a lower depth of passage of the discs 7, disc harrows, to prevent accumulation of soil in front of the discs, the stubble of the previous crop is partially crushed with the discs 7, the discs 7 are deepened in accordance with agrotechnical requirements for sowing. After processing the soil with discs, the soil is ground with a soil mulching device 8, under the action of the shock drums of the device, the slag is crushed and, hitting the deflector 14, falls to the bottom, leaving partially crushed stubble of the previous crop on its surface, thus creating a protective layer of mulch against wind and water erosion of the soil. [6].

In Figure 5, we show the transfer of the machine to the transport position and vice versa to the working position with the hydraulic cylinder 10 and the hinged lever 25.

Water and wind erosion are possible on crop rotation fields. By using various agrotechnical techniques, it is possible to minimize soil erosion. One of these techniques is the creation of shafts about 10 m wide and 80-100 cm high at a certain distance. Effective agrotechnical anti-erosion techniques are splitting (ShChN-2, ShChP-3-7, etc.), special porous and comb plowing, organization of soil-protective crop rotations, strip placement of winter and spring crops, grain and row crops, creation of grass buffer strips, leaching of washed lands and drains.

On slopes and floodplains, it is expedient to carry out clogging - sedimentation of silt by creating bridges and ramparts. After clogging, clarified water is released on floodplains, and on slopes, water is most often absorbed by the soil.

Snow melting can be regulated by creating blackout bands or snow exposure. Darkening strips can be made with fat seeders or spreader trailers, using peat cover, ash, phosphorite flour. The width of such strips should be 10-15 m.

Legume-cereal grass mixtures must be grown on the slopes. They form dense turf that prevents the development of erosion. [7-8].

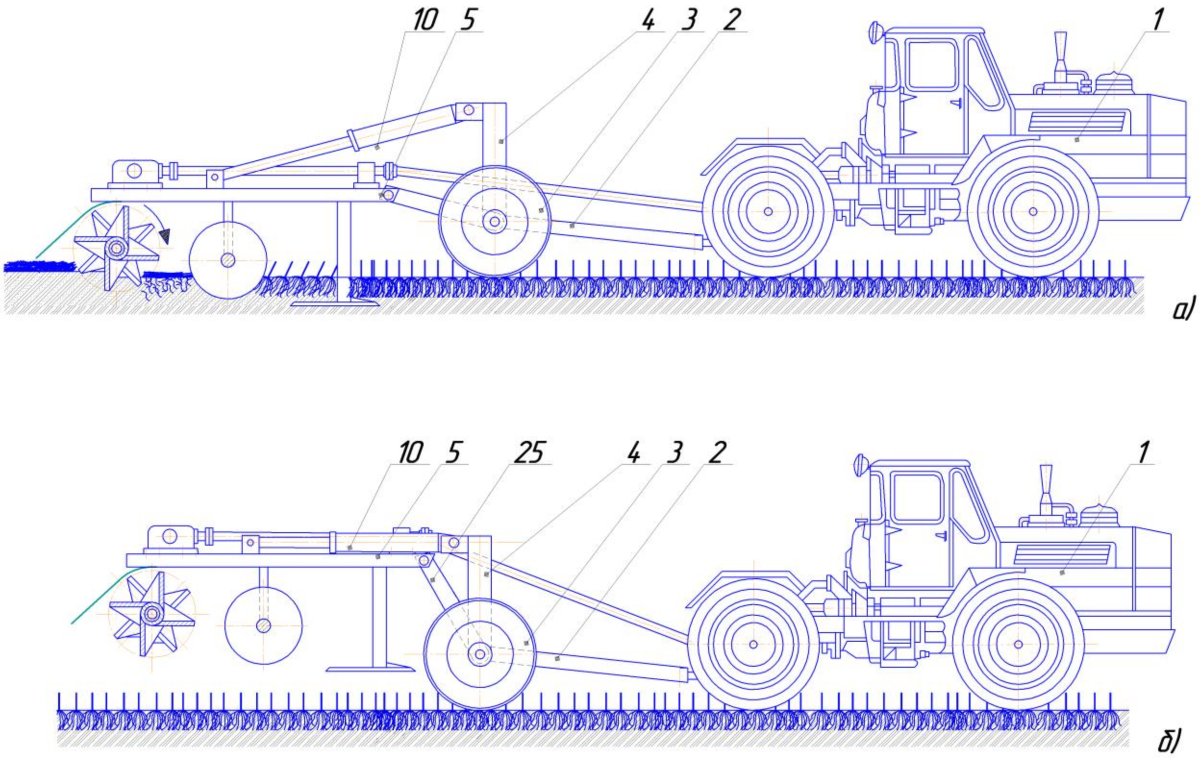

Fig. 5. Transferring the machine to the transport position and vice versa:
a) – Working position of the machine; b) – transport position of the machine: 1 – tractor; 2 – towing device; 3 – supporting wheel; 4 – main frame; 5 – movable frame; 10 – hydraulic cylinder; 25 – hinged lever.

Stopping the development of water and wind erosion on non-steep slopes is also facilitated by strip placement of crops. At the same time, the washed soil from the strip occupied by row crops is evenly placed on the next strip, where winter and early spring cereals or grasses are sown, which contributes to increasing crop yields and improving soil fertility. In the case of curvilinear placement of lanes, it is necessary to create conditions for uniform rotation of units. When using large, especially paired, units (cultivators, planters), the turning radius should be at least 50 m.

The strip placement of fodder crops can be combined with forest strips and ditches on the so-called upper and lower boundaries of the second order, in the middle of the territory make ditches with special organic fillers. It is advisable to create permanent or temporary buffer strips. Permanent (perennial) buffer strips are sown with perennial legume-cereal grass mixtures, and temporary ones with summer or winter ones. After harvesting the grasses, the area is treated with soil protection tools. Permanent buffer strips are especially needed on steep slopes (8-12°).

Irrigation erosion develops on irrigated lands. Therefore, on areas with an exposure of more than 5°, even with well-developed turf, the intensity of watering should be no more than 7-9 mm/h.

Causes erosion processes and watering in furrows. In small areas, soil erosion is possible and in the case of insignificant irrigation rates - the so-called small stream erosion, to which loamy chernozem, gray forest soils and dense clays are susceptible.

Soil erosion in floodplains is mostly wind-driven and is a consequence of generally unsatisfactory land reclamation works (lack of crop rotation, lowering of the groundwater level below the recommended level).

In order to stop erosion on floodplains in crop rotations with row crops, in addition to perennial grasses, after harvesting vegetables, summer re-sowing of legume-cereal mixtures, cruciferous crops - spring and winter rapeseed, oil radish, mustard mixed with oats, etc. should be grown.

Against erosion on natural fodder lands, for example, on low-productivity slopes, surface improvement is carried out using a complex of cultural and technical measures. Here, cattle grazing is stopped for a certain time, and in case of grazing, the grass must be rested to restore the turf. Formed potholes, small hollows are wrapped with plowing or leveled with a bulldozer, after which drainage ditches are arranged.

When developing anti-erosion measures in the system of contour-ameliorative organization of the territory, the following types of soil protection are provided: contour, contour-strip and contour-ameliorative. With the contour system, the boundaries of the fields are designed horizontally, and surface runoff regulation is carried out mainly with the help of agrotechnical measures. The contour organization of the territory can be both curvilinear and rectilinear.

The contour-strip organization of the territory involves carrying out phytomelioration measures with the introduction of manure, lime, organic fertilizers and cultivation along the horizons, long-term limening of individual strips. Strip crops are placed only on fields with pronounced erosion processes.

According to the contour-ameliorative organization of the territory (Fig. 5), the contour placement of fields is combined with the creation of hydrotechnical structures that prevent runoff (installation of embankments, filling in basins, creation of forest strips and gentle basins). In addition, agrotechnical and phytomelioration measures are carried out.

Crop residue remaining on the surface is also a factor in which minimal tillage protects the land from erosion. In general, both plants and their remains on the surface effectively slow down the speed of movement of both water on the surface of the soil and air above it. From a physical point of view, plant cover growing on the surface, as well as plant residues, effectively protects the ground, for example, from the impact of raindrops.

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Analysis of existing machines for soil protection against wind and water erosion was carried out. The proposed design of the machine for plowless tillage.

5. Conclusion

The design of a universal combined machine is presented. The essence of the technology consists in the development of individual disk units with general adjustment of the angle of attack, and the use of combined working bodies. The introduction of additional adjustments of the inclination of the discs vertically will allow to increase the deepening of the disc (increase the depth of processing). Easy adjustment of the angle of attack makes it possible to use the discs as a peeler. The use of a mulching device will make it possible to protect the soil from the effects of wind and water erosion by the method of mulching, i.e. covering the soil surface with the remains of the stubble of the previous crop.

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РОЗРОБКА МАШИННОГО АГРЕГАТУ ДЛЯ РЕСУРСОЗБЕРІГАЮЧИХ ТЕХНОЛОГІЙ ОБРОБІТКУ ҐРУНТУ

На полях сівозмін можлива водна і вітрова ерозія. Застосуван-ням різних агротехнічних прийомів вдається до мінімуму звести змивання ґрунту. Одним з таких прийомів є створення на певній відстані валів близько 10 м завширшки і 80 – 100 см заввишки. Ефективними агротехнічними протиерозійними прийомами є щілювання, спеціальна пориста і гребенева оранка, організація ґрунтозахисних сівозмін, смугове розміщення посівів озимих і ярих, зернових і просапних культур, створення буферних смуг із трав, залуження змитих земель і водостоків.

У степах або районах, де рельєф орних земель має нахил, для протидії вітровій і водній ерозії рекомендується застосовувати різноманітні технології мінімальної обробки ґрунту. Поверхнева обробка землі забезпечує накопичення рослинних залишків у поверхневому шарі ґрунту. Це підвищує кількість органічної речовини у верхніх шарах, що, у свою чергу, поліпшує міцність агрегатів і стійкість ґрунту до дії крапель дощу та поривів вітру. Під час оранки похилих полів корисним методом зменшення ризику ерозії є контурна оранка. Вона використовує рельєф поля для просочування води, запобігаючи її стіканню уздовж рядків.

Поживні залишки, що залишаються на поверхні, теж є чинником, завдяки якому мінімальна обробка ґрунту захищає землю від ерозії. Загалом, і рослини і їх залишки на поверхні ефективно уповільнюють швидкість руху як води на поверхні ґрунту, так і повітря над ним. Із фізичної точки зору рослинний покрив, що зростає на поверхні, так само як і рослинні залишки, ефективно захищає землю, наприклад, від ударів дощових крапель.

Якщо говорити про традиційні культури, слід зазначити, що багаторічні трави забезпечують найкращий захист, а зернові здатні помірно протистояти ерозії. Під час вирощування просапних культур, наприклад, цукрового буряка чи кукурудзи, більша частина землі залишається непокритою, тобто ці культури дають гірший захист. Найгіршим варіантом з точки зору ерозії є пар без вирощування жодних культур і без збереження на поверхні поживних залишків.

Проведено аналіз існуючих машин для захисту ґрунту від вітрової та водяної ерозії. Запропонована конструкція машини для безвідвального обробітку ґрунту.

Ключові слова: *мульчування ґрунту, ерозія, обробіток, рослинні залишки, сівозміна.*
Рис. 5. Літ. 8.

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