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Development of Soil Treatment Technology and Devices Against Water Erosion in Intensive Garden Soils Located on Sloping Fields

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ABSTRACT: This article provides information on soil water erosion occurring in intensive gardens located on sloping fields and the factors that cause it, soil treatment technologies and devices to protect soil from water erosion. At the same time, data are provided on the construction and operation processes of the new ditch opener device proposed to prevent water erosion on sloping garden soils, in accordance with the requirements of the time.

KEY WORDS: Slope, garden, fruit tree, erosion, ditch, seedbed, sheared soil, plow, ditch opener, spherical disc, softener, hydraulic cylinder, tractor, support wheel, blade, returner, ridge.

I. INTRODUCTION

Intensive gardens are spreading and developing throughout the world. The quality and productivity of the fruit is high, and the harvesting process is more convenient. The period of intensive garden cultivation corresponds to the late autumn and early spring periods, and it continuously grows and produces for 18-35 years. According to the obtained statistical analysis, in 2021, intensive gardens amounted to 54.7 thousand hectares [1,3,7].

As a result of the research conducted by the scientists of the Research Institute of Horticulture, Viticulture and Winery named after academician M.Mirzayev, three types of land were found suitable for intensive gardens on mountain and sub-mountain slopes of the republic [2].

Category 1 – irrigated uneven land, where grain crops cannot be cultivated. In such lands, if there is sufficient labor force, a high yield of fruit can be obtained. Intensive gardens are planted horizontally on slopes.

Category 2 – lands where semi-arid irrigation is limited and intensive gardens are established due to rainfall.

Category 3 – semi-arid lands, intensive gardens are only lands with annual precipitation of 500 to 700 mm [2].



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Therefore, the most favorable conditions for the development of intensive gardens are mountain and sub-mountain regions.

These areas include: Bostanlyk, Parkent and Akhangaran districts in Tashkent region, Urgut, Nurota, Khatirchi districts in Samarkand region, Gallaorol, Forish, Zomin districts in Jizzakh region, Kitab, Yakkabog, Chirakchi, Shakhrisabz and Dehkanabad districts in Kashkadarya region, Denau and Sariasiya districts in Surkhandarya region [2, 3].

Above, we said that mountain and sub-mountainous areas, i.e. slopes, are the most convenient places to create intensive gardens, but there is one disadvantage of creating intensive gardens in such conditions. This deficiency causes water erosion in the soil to the surface during irrigation processes on sloping fields.

Water erosion caused by soil consists of water erosion based on the processes of leaching and washout as a result of the strong influence of water flow:

- leaching (washing of the soil surface layer, destruction of the soil structure and displacement of the soil layer under the influence of raindrops);

- washout (formation of leveled and unleveled pits, hollows, ravines as a result of the washing of the soil due to the extremely high velocity of large volumes of water) [2].

According to the conducted experiments, the processes of soil washing occur in March-April and early May when the early spring rains fall, when the slope of the land exceeds $1.5-2^{\circ}$. The soil layer with a thickness of 5-7 cm will flow under the influence of water. As a result, the growing sprouts can be stripped of the root system, significantly damaged and eventually die [4, 7].

Also, it was determined that 30-50 t of fertile layer of soil per hectare was washed away as a result of rapid rainfall of 0.7-1 mm on dark gray soils with a slope of up to 7° [4].

The importance of choosing a garden soil treatment system on a slope is that it is necessary to prevent the erosion process in each area throughout the year.

II. THE DEGREE OF STUDY OF THE PROBLEM

Scientists of the world are giving their recommendations on preventing and eliminating water erosion in the soil.

In particular, the technology of protection of soil from erosion on slopes of the Republic of Ukraine provides for softening the surface at 8-10 cm and opening grooves at intervals of 50-60 cm every 8-10 m, and these pits are 12,000 sometimes 14,000 [4].

In Russia, the step plowing method is used. To use this method, the second body of the three-body plow, the second and fourth bodies of the four-body plow are replaced by deep softener bodies. To do this, the plow's handles are replaced with longer handles (5, 7 and 10 cm long compared to conventional ones). When plowing with such a plow, 5, 7 and 10 cm deep at the bottom of the seedbed, 10-15 cm high ridges are formed on the surface of the seedbed [4].

In the regions of Uzbekistan, technology and devices are used to protect soils with a slope of up to 10° from water erosion, maintain humus balance and basic nutrients. Among them, tillage with a flat cutter and heavy harrows BDT-3 without a tiller is carried out 20-25 cm ha and with a traditional tiller [4, 2, 5, 8].

According to recommendations on soil protection from water erosion, relief that holds the water flow on the soil surface, including sickle step plowing, seedbed ditches, slitting and hole opening and other methods are used [5].

The cross-section of the seedbed treated with a sickle-step plow is presented in Fig. 1.

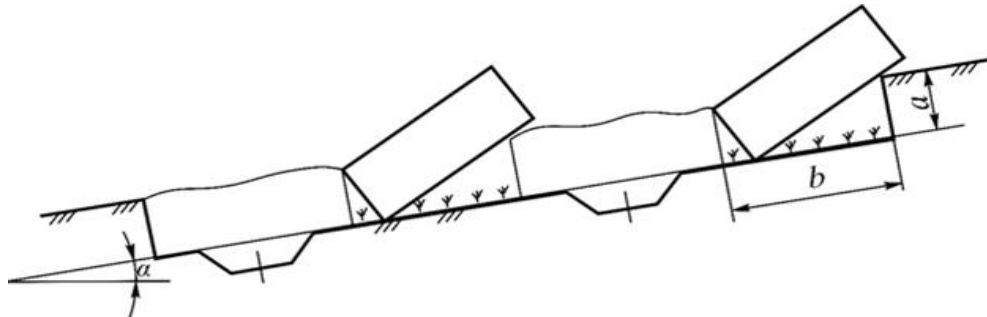


Figure 1. Cross-section of the seedbed treated with a sickle-step plow.

As it can be seen from the scheme presented in Fig. 1, a characteristic feature of the presented technologies is that the complete turning of the blades by 180° at the limit of their edge is carried out alternately with the blades that are not completely turned over. In this case, sickles are formed on the surface of the seedbed, and ridges are formed at the bottom of the soil, which catch and accumulate rainwater, which in turn prevents water erosion (Figure 1) [5].

When the sheared soil is completely turned by 180° , the body 4 first independently, and then interacts with the zaplujnik 5, lays the center of gravity of the sheared soil on its seedbed without moving it to the side. When the sheared soil is not fully rotated, the body 2 and the short zaplujnik 3 rotate the sheared soil to a stationary position, and its further cultivation is carried out only under the influence of the body 2. In this case, the sheared soil should be cultivated at least 135° [5]. Based on the analysis of patents and scientific research works, on the basis of improved technology and linear-step plow with flat plowing, the constructions of the sickle-step plow were developed by scientists of Karshi Institute of Engineering and Economics and the “TIAME” NRU: a sickle-step plow with a casing of different heights installed in turn (the length of the plow is different); sickle-step plow with a deep softener (Fig. 2) [3].

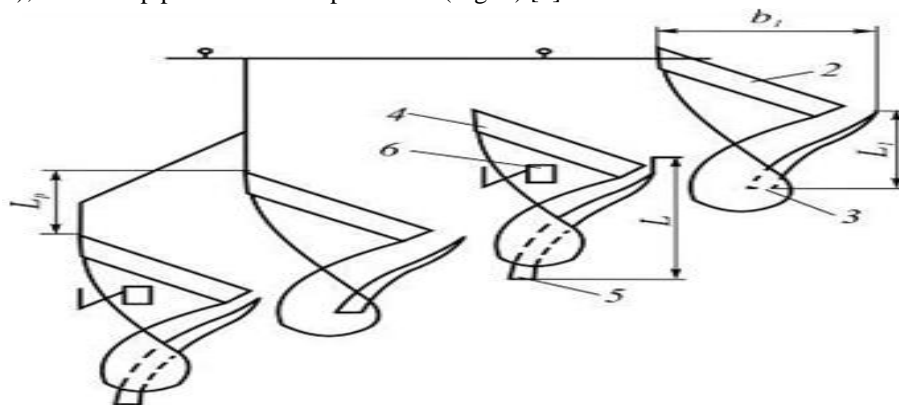


Figure 2. Sickle-step plug scheme. 1 – frame; 2, 4 – screw casing, 3, 5 –zaplujnik, 6 – sickle-step plow with a deep softener.

The sickle-step plug consists of screw casings 2 and 4, which are moved relative to each other. The odd case 2 is equipped with a short plate 3, and the even case 4 is equipped with a long plate 5 [5].

Another unique technology is stepwise loosening of the soil layer to protect sloping fields from water erosion, it was mentioned above that it is not always enough to stop the flow of water due to the formation of ridges in its lower layer. This situation is especially noticeable when the rain falls in the form of a shower. The above mentioned can be eliminated by creating a ridge in the surface layer of softened soil [4, 5, 10].

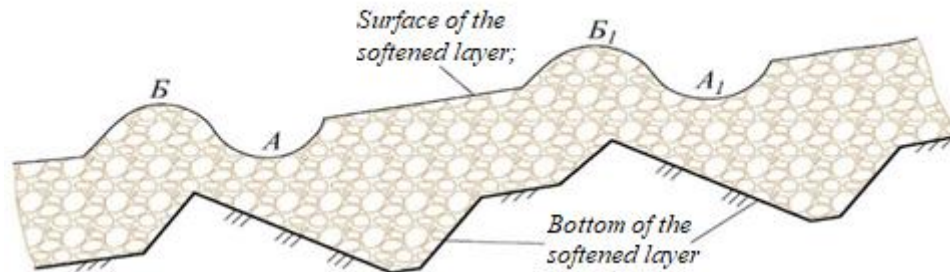


Figure 3. Scheme of the technology of soil softening and ridge formation in sloping fields. A, B, A₁, B₁ – matching seedbeds and ridges.

In order to implement the above-mentioned technology, a new softener scheme was developed, equipped with upper and lower softeners with oblique handles of the “paraplau” type and spherical discs.

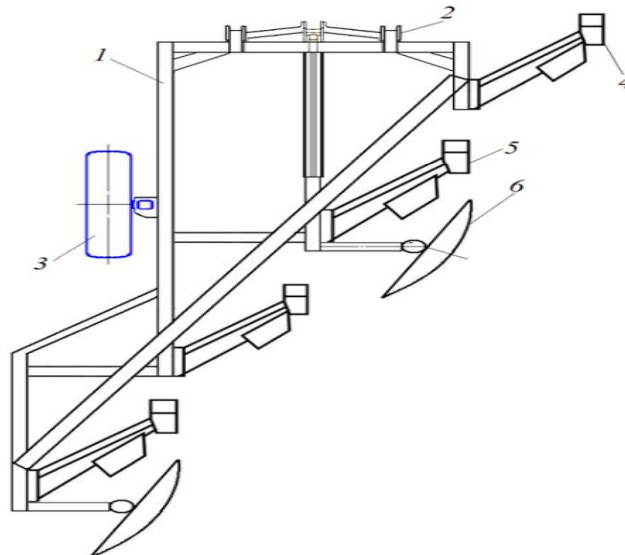


Figure 4. Spherical disc softener. 1 – frame; 2 – suspension device; 3 – supporting wheel; 4 – higher working body; 5 – lower working body; 6 – spherical disk.

The frame is firmly attached softeners with inclined columns, the support wheel. The position of the spherical disc forming the ridge is changed by a special turning mechanism. The upper working body tills the soil at a depth of 25 cm and the lower working body at a depth of 35 cm without a tiller. Spherical disks form ridges that catch rainwater on the surface of the cultivated field and retain moisture in the soil. In the process of work, the softeners soften the soil, and the spherical disk creates a ridge [4, 9].

Using the technology and devices mentioned above, it is possible to prevent water erosion in the soil on sloping fields. However, the working processes and size of these devices make it difficult to use in intensive gardens, and these devices cannot be attached to garden tractors.

III. RESEARCH RESULTS

Scientists of the “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” National Research University have developed a device that forms a ridge on one side and opens a ditch in order to prevent water erosion in intensive garden soils located on sloping fields.

The purpose of creating a ditch on one side is to prevent water erosion in the soil of intensive orchards located on slopes, that is, to protect the fruit tree trunk from washing away the soil around it.

The difference between the open ditch and the existing ones is that the resulting ridge is not on both sides of the ditch, but only on the right, that is, on the downhill side of the slope. For this, the right and left ditch openers and the mechanism for switching them to working and transport states were developed separately.

Scheme of the proposed device: 1 – suspension device; 2, 3 – right and left hammers, respectively; 4, 5 – right and left ditch opening working parts; 6 – base wheel; 7 – adjustment screw; 8 – hydraulic cylinder; 9 – tractor. The resulting ridge is marked with 11 and the fruit tree is marked with 10.

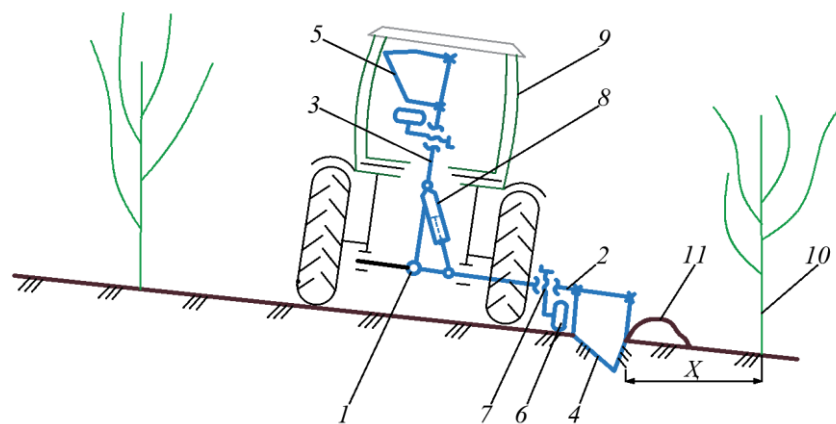


Figure 5. Schematic diagram of the back view of the device that opens the ditch and creates a ridge on one side. 1 – suspension device; 2, 3 – right and left hammers, respectively; 4, 5 – right and left ditch opening working parts; 6 – base wheel; 7 – adjustment screw; 8 – hydraulic cylinder; 9 – tractor; 10 – fruit tree; 11 – ridge.

Placement in sloping fields is carried out as follows: opening a ditch between garden rows and creating a ridge. (Fig. 5) After the device is inserted between the garden rows, a protective zone L distance is left from the fruit tree 10 as shown in Fig. 5, and the working part is lowered into the working position and moved. A ridge is formed on the downhill side of the slope due to the soil from the opening ditch.

The view of the working part, which implements the method of forming a ridge on one side, is presented in Fig. 6. It consists of plowshare (1), blade (2), returner (3) and base (4).

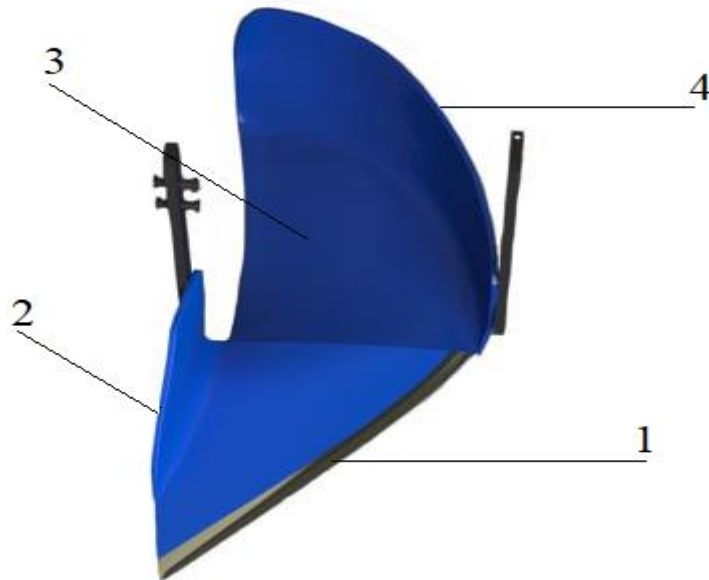


Figure 6. A ditch opener that forms a ridge on one side. 1 – plowshare, 2 – blade, 3 – base, 4 – returner.

The peculiarity of this working part is that it opens a ditch in a triangular shape. The resulting soil is always directed to the right side and forms a ridge by placing it on the surface of the field. This process occurs in the following manner: plowshare 1 cuts its triangular sheared soil and transfers it to base 3. Blade 2 separates the sheared soil from the field by cutting it along the side. By moving the sheared soil separated from the bottom and sides along the base, it is removed to the surface of the field under the influence of the returner 4 and the ridge is formed. The working depth of the working part is reduced or increased by the screw mechanism 7 of the support wheel 6 (Fig. 5).

When the device reaches the end of the garden row, the right working part 2 is transferred to the transport position and the left working part 3 is brought to the working position with the help of the hydraulic cylinder 8, and the ditch opening process is continued. In such a way, a ditch is opened in each row of the garden and a ridge is formed (Fig. 5).

IV. CONCLUSION

In order to protect the soil of intensive gardens established on slopes from water erosion, opening a ditch between the rows and creating a ridge only on the downhill side of the slope with the soil from it provides the expected result. For this, the device with the working part must be equipped with a turning mechanism.

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