

# Deep tillage using biosolvent preparation before soil washing

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**Abstract.** The article presents a new tool for deep soil tillage, as well as design, operation principles and parameters of two-tier deep tillage device used in the process of deconsolidation of gypsum and dense soil layers according to a special technology with active rotating working bodies and the technology of its application, while improving the ameliorative state of saline soils using the biosolvent chemical composition with spraying on the soil surface and inner layer, before the autumn washing with salt, and washes out harmful salts from the soil. The developed tools and the parameters of their device for deep tillage of the soil and the technology of its application, the results of theoretical and experimental studies are presented.

## 1 Introduction

With deep processing, the cotton root system grows under favorable conditions, deforms little, does not squeeze, bends less and is covered with off-shoots along its entire length. Thus, according to M.V. Mukhamedzhanov, S. Suleymanov, when plowing to a depth of 30 cm and loosening the soil up to 55 cm, the number of taproots directed vertically downward without deformation was 4 times more than when plowing to a depth of 30 cm without tillage [3]. A. Dzhuraev's experiments [5] confirmed that loosening the subsoil horizon up to 50 cm made it possible for cotton roots to penetrate to a depth of up to 90 cm, which led to an increase in the yield of raw cotton. A.K. Kamilov [6] came to the same conclusion: in his experiments, loosening by 50 cm in combination with plowing by 30 cm contributed to the emergence of cotton roots beyond the subsurface horizon, in the thickness of 0 ... 120 cm, roots accumulated by 27 ... 36 % more. The development of roots contributed to the accumulation of bolls, and increased cotton yields.

Deep soil tillage reduces the density and provides an increase in the overall duty cycle due to porosity. A. Zakirov [4] found that the total breed in the layer of 30 ... 60 cm before tillage was 45.8%, after tillage 50.3%, and this increased the water permeability of the soil compared to conventional plowing with loosening by 40 cm by 3.5%, by 55 cm by 15.2%.

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In this regard, the closest to the invention has been the subsoiler GRKh-2-50 on the UzMPEI recommendation of 1989 for loosening the subsurface horizon in combination with conventional plowing [2].

This subsoiler consists of ripper points, a linkage mechanism, extensions and support wheels with a mechanism for regulating the tillage depth. The ripper point includes left and right shoes, two shares and a chisel. The support wheels are attached to the extensions and are installed after the tractor tracks, which ensures the stability of the depth of the ripper points. The soil is loosened by a driven method. The tools are adjusted to the rear depth during the first pass, setting both support wheels in the same position. With the help of the central link of the linkage mechanism, the frame is horizontally positioned. When the frame is tilted forward or backward, the stability of the ripper points at depth is violated. The tractor linkage mechanism is adjusted according to the three-point scheme.

The disadvantage of this tool is a high traction resistance, however, the working bodies of this subsoiler form a rotary plough pan, between them there is an untreated ridge 18-20 cm wide and 6-8 cm high, which has a negative effect on the plant growth and development [1].

The disadvantage of the above-mentioned research on the deep tillage device is that the existing tool has a high traction resistance and low work productivity and therefore has not been widely used in production. As a result of long-term deep tillage from the lower layer of 35-40 cm at a certain depth, a plough pan of the so-called dense soil layer is formed, which negatively affects the growth and development of the plant.

The existing tools have some drawbacks: high traction resistance, low productivity and quality of work, lack of two-tier processing, lack of use of a biosolvent chemical preparation to increase soil porosity, and was considered as a problem and the object of study was chosen.

Research object. Substantiation of the parameters of the two-tiered deep soil tillage device and the introduction of a biosolvent chemical preparation to increase the soil porosity and to reduce the soil salinity.

## **2 Materials and methods**

When conducting research, the authors applied methods of system analysis, fundamental laws and provisions of theoretical mechanics, higher mathematics and mathematical statistics. In experimental methods, the researchers studied mathematical planning and strain measurement, as well as existing regulatory documents.

## **3 Results**

Based on the above problem, we have developed a new design of two-tier deep soil tillage, formalized the application, and developed its design in the form of invention IAP 20220664 - Deep Tillage Device. The device was performed in models for laboratory conditions. The invention is used in the field of agricultural mechanization for subsoil layer tillage and simultaneous injection of a biosolvent preparation to increase soil porosity before washing and for effective soil washing [17].

It is known that in many regions of the country there are areas that are difficult to develop due to the mechanical composition of the soils of arable land, which are developed in different ways. One of them is carrying out agrotechnical measures with the help of aggregates for deconsolidation of subarable soil layers with simultaneous spraying of the soil surface and the inner layer with a biosolvent preparation.

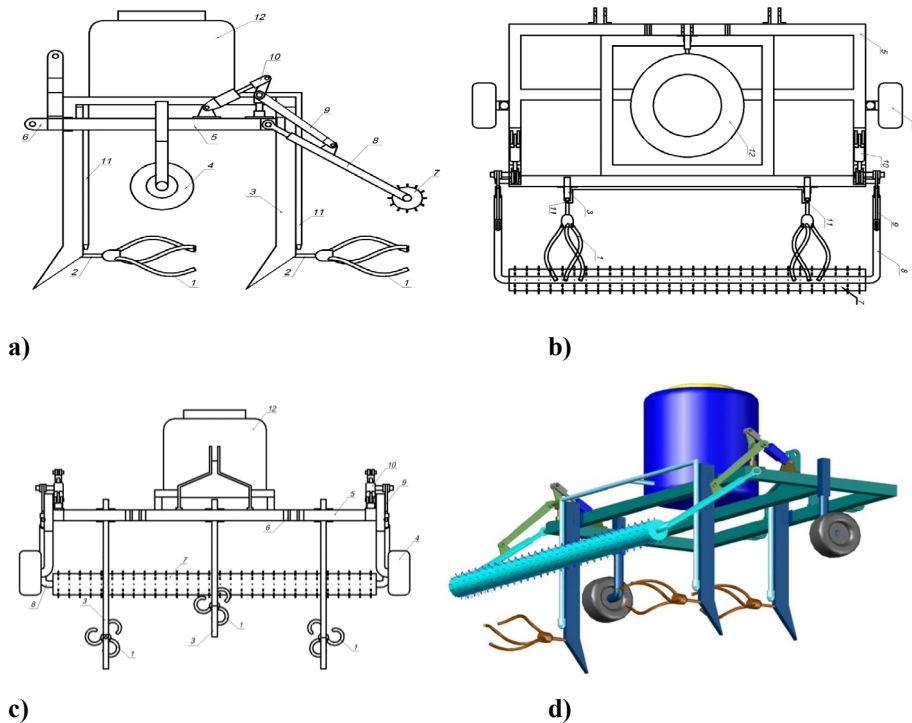
In agriculture, especially in soils that are over-compacted in the lower part, in medium and highly saline soils, deep tillage of the soil is required in order to create conditions for

washing the soil and removing harmful salts. For this purpose, during the tillage of the soil, one should simultaneously apply the biosolvent preparation to the surface and into the interior of the soil. In this invention for deep tillage, the researchers give the design of the tool, the principles of operation, its general view with additional devices for applying the biosolvent preparation. Unlike existing devices, the biosolvent amount is applied per hectare and in two layers: it is sprayed inside the soil and on top of the soil with special spraying devices. This provides an increase in soil porosity to wash out harmful salts from the soil.

The authors show the design and operation principle of the proposed new deep-ripper tool with re-equipped working bodies in Fig. 1.a, b, v, d, which shows a schematic view of the device for deep processing of dense soil with a rotating active working body with the simultaneous introduction of a biosolvent preparation.

Traction-type scheme of a deep tillage device, its design and operation principle:

(1) rotating ripper for a tillage of the soil dense layer rotates and loosens with the translational movement of the device through (2) a tension stick attached to (3) a rack with working bodies; (4) support wheel for adjusting the tillage depth and stable movement of the device; (5) frame device for fastening the working bodies; (6) hinges of the device frame for hanging the device on the tractor's rear part; (7) ridged cylindrical working bodies serving to move the biosolvent preparation along with the soil to compact it; (8) thrust of the ridged cylindrical working body serves (9) as a tension rod for lowering and lifting into the working and transport position with the help of (10) a hydraulic cylinder and (11) sprayer of the rear rack of the device working bodies.



**Fig. 1.** Schematic view of the deep tillage device: a) side view; b) top view; c) rear view; d) 3D view.

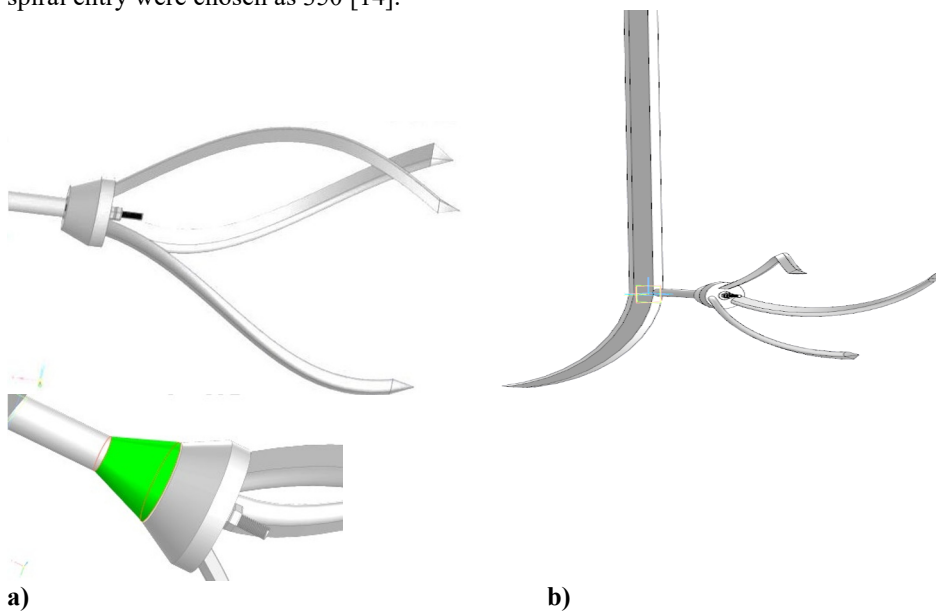
(1) tillage element (ripper) of the device; (2) tension stick; (3) racks with wavy ripper points; (4) wheel; (5) device frame; (6) hinges of the device frame; (7) ridged cylindrical working bodies; (8) thrust of the ridged cylindrical working body; (9) tension rod of a ridged cylindrical working body; (10) hydraulic cylinder; (11) sprayers; (12) capacity

For this purpose, the authors developed a new device for deep tillage.

Therefore, this device is used for deep tillage with simultaneous spraying of a biosolvent preparation to increase the soil porosity, to create conditions for the removal of harmful salts from the soil after washing it.

For the manufacture of mock-up samples, rotating, decompressing working bodies were made in 3D format (Fig. 2).

This working body with a variable pitch and the same angle of all its elements with the direction of the device translational movement assumes a high quality of crumbling and a relatively low tool traction resistance. The ripper device is in the floating position. When the knife-shaped rack is moved, under the action of the lateral components of the soil reactions, the working bodies begin to rotate. For undercover tillage and conservation of stubble, the diameter of the cone base was chosen so that the thickness of the soil stubble layer was at least 5 cm. Based on theoretical and experimental studies, the cone angles and the conical spiral entry were chosen as 350 [14].



**Fig. 2.** Samples of working bodies for deconsolidation of subsoil, soil layers, a) rotating working bodies, b) installation on the rack lower part.

Theoretical and experimental studies substantiated the parameters of a two-tier deep-ripper with active working bodies of redactive action. While working on two layers of soil loosening, it operates in a driven way. The researchers determined total and specific resistance forces by the following formula [13, 14].

$$F = fG + (k_1 + \varepsilon_1 \vartheta^2)A_1 + (k_2 + \varepsilon_2 \vartheta^2)A_2, \quad (1)$$

where  $A_1$  and  $A_2$ – depending on the treatment depth ( $h_1$ ) first layer volume ( $A_1$ ) and the treatment depth ( $h_2$ ) second layer volume ( $A_2$ ) soil cross section,  $m^2$ ;

$k_1$  and  $k_2$ – soil resistivity in accordance with the tillage depth, and cross-sectional area, Pa;

$\varepsilon_1$  and  $\varepsilon_2$ – soil coefficients on the dependence of the tillage depth and on the physical and mechanical properties of the soil,  $H \cdot s^2/m^4$ .

The volume of the loosened zone of the cross section  $A_1$  and  $A_2$ , depending on the tillage depth and the spacing of the working bodies.

$$A_1 = nb(h_1 - h_2) - n\frac{b}{4}h_1 + n(h_1 + h_2)^2 ctg\psi_1, \quad (2)$$

$$A_2 = (h_1 - h_2)B_k - \frac{1}{2}(n - 1)[0,5(M - b)^2 tg\psi_1 - 2(M - b)(h_1 - h_2) + 2(h_1 - h_2)^2 ctg\psi_1] \quad (3)$$

We substitute the value (2) and (3) for  $A_1$  and  $A_2$  in formula (1) and determine the total traction resistance of the subsoiler with two-tier tillage at different depths, spraying the biosolvent overgrowth with the following formula.

$$F = fG + (k_1 + \varepsilon_1\vartheta^2)[(h_1 - h_2)B_k - \frac{1}{4}(n - 1)(M - 2h_2 tg\psi_1 - b)] + (k_2 + \varepsilon_2\vartheta^2)[nb(h_1 - h_2) + n\frac{b}{4}h_1 + n(h_1 + h_2)^2 tg\psi_1], \quad (4)$$

$$K = \frac{F}{A_1 + A_2} \quad (5)$$

Theoretical and experimental research continues to substantiate the parameters of a two-tier subsoiler with a sprinkler.

## 4 Discussion

In course of conducted experimental and theoretical research, many authors concluded that, for cotton-growing regions of the republic, one should perform deep tillage of the soil at a depth of 50 to 60 cm or more in 2-3 years. In the author's variant, in a place with deep tillage, we supposed to perform deep soil tillage with the biosolvent preparation removal to increase the soil porosity. This drug is taken into the soil in two layers by special devices. It gives a good result for soil washing with easy harmful salt removal and saving water by 1.5-2 times with conventional soil washing.

## 5 Conclusion

The invention is applied in the field of agricultural mechanization, in particular, for washing heavily and moderately saline lands. The device is used for deep tillage with biosolvent spraying, applying biosolvent to the soil before washing, increasing porosity and creating conditions for soil washing with the lowest water consumption. For washing heavily and moderately saline soil, the authors developed a new design of a deep-ripper tool with introducing and spraying of biosolvent on the surface and the inner part of the soil to a depth of 50-60 cm with an application rate of 5-6 kg of biosolvent diluted by 194-196 liters of water per hectare. Device works in closed conditions with deep tillage, with rotating tillage working bodies to a depth of 50-60 cm. Simultaneous application of the biosolvent preparation serves to increasing soil porosity during washing to facilitate the removal of harmful salts from the soil.

The device is equipped with three working bodies and three rotating tillage working bodies for mixing the biosolvent preparation.

Through the aforementioned technological process, before washing, porosity is increased and conditions are created to remove harmful salts from the soil, creating the basis for high plant yields.

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