IOP Conference Series: Materials Science and Engineering

PURPOSE-LED PUBLISHING™

**PAPER** • **OPEN ACCESS**

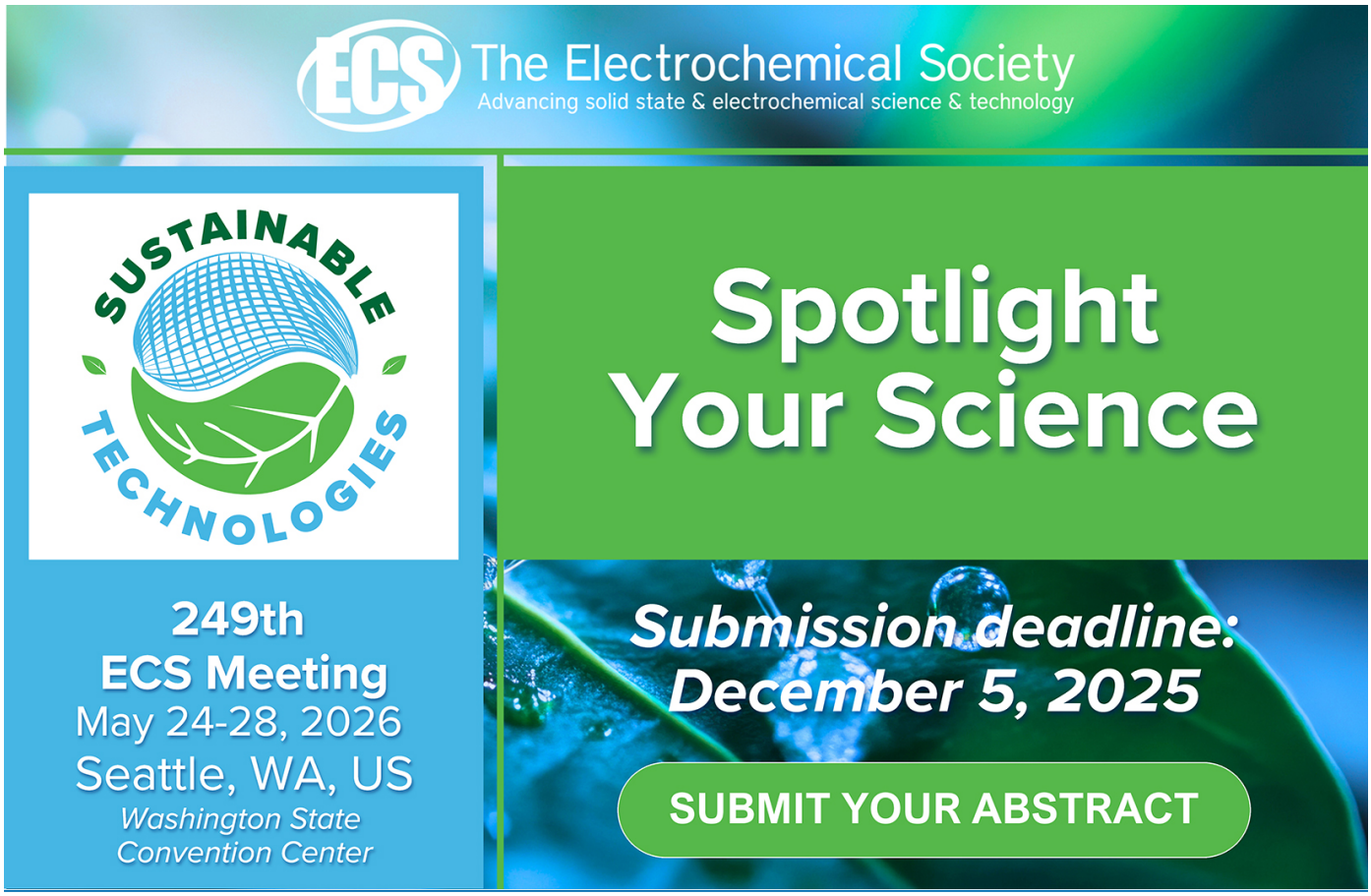
# The quality of loosening the soil with subsoilers of the combined machine

To cite this article: Kh Fayzullayev *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1030** 012171

View the article online for updates and enhancements.

You may also like

- Study on combined machine for the subsurface soil treatment
Kh Ravshanov, F Mamatov, B Mukimov et al.
- Development of a machine for preparing the soil for sowing melons under the film
I Temirov, Kh Ravshanov, Kh Fayzullaev et al.
- Soil preparation machine parameters for the cultivation of cucurbitaceous crops
D Chuyanov, G Shodmonov, I Avazov et al.




This content was downloaded from IP address 37.110.211.80 on 31/10/2025 at 02:21

# The quality of loosening the soil with subsoilers of the combined machine

**Kh Fayzullayev[1], S Mamatov[1,2], M Radjabov[1], Sh Sharipov[1], R Tavashov[1,3] and M Nurmanova[1]**

[1]Karshi Engineering Economic Institute, 180100, Karshi, Uzbekistan
[2]Karshi branch of Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 180100, Karshi, Uzbekistan
[3]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 100000, Tashkent, Uzbekistan

E-mail: xfayzullayev77@mail.ru

**Abstract**. The aim of the study is to study the influence of the parameters of subs oilers on the quality of loosening of the soil when preparing the soil for sowing melons and gourds under a film with a combined machine. The authors have developed a combined machine for preparing the soil for sowing melons and gourds under a film. The structural diagram of the developed machine is presented. Theoretically, the completeness of loosening of the soil by subs oilers of the machine is determined from their parameters and relative position. Theoretical and experimental studies have established that the scheme of pair wise arrangement of subs oilers inclined to the right and left of the combined machine with working surfaces facing each other, as well as shifted relative to each other in the longitudinal plane, provides the required quality of work, while the longitudinal distance between the subs oilers should be 75 cm, and the transverse distance is 60 cm.

## 1. Introduction

High-quality soil preparation for cultivation of melons and gourds is an urgent task in agriculture. The existing technologies of soil preparation for sowing melons are carried out by single-operation machines in several passes, which leads to excessive soil compaction, a decrease in labor productivity, an increase in labor and funds consumption, a delay in soil preparation, intensive soil drying, which entails a decrease in yield [1-8; 20-28]. The problems of soil preparation for sowing melons and gourds are considered in many scientific works [1-5; 7-14; 18-27]. Research on improving soil preparation technologies for sowing melon crops, creating machines for melon growing, substantiating the structures and parameters of their working bodies were carried out by F.Mamatov, [1-16; 21-29; 33] B.Mirzaev [1-8; 12-14; 21-25; 28-29], D.Chuyanov [6; 20-22], U.Kodirov [4; 17], I.Ergashev [4-5], H.Ravshanov [18-19] V.I.Malyukov [30], V.G.Abezin [31], A.D.Em [32], V.N.Zhukov [32] and others. V.G.Abezin [32] substantiated and developed working bodies for pre-sowing soil cultivation and sowing melon seeds. All these studies are aimed at improving technologies and technical means of processing for preparing the soil for sowing melons in open ground. These technical means cannot be used to prepare the soil for sowing melons under a tunnel-type film.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

The aim of the study is to study the influence of the parameters of subsoilers on the quality of loosening of the soil when preparing the soil for sowing melons and gourds under a film with a combined machine.

## 2. Methods

The authors have developed a combined machine (Fig.1) for preparing the soil for sowing melons and gourds under a film, which consists of a frame 1, a duckfoot paw 2, paired left 3 and 5 and right subsoilers 4 and 6, a furrow cutter 7 and rotary working bodies 8. The machine, based on the technology of sowing melons and gourds under a closed tunnel-type film, must process and prepare a strip with a width of 1.4 m in one pass. During the operation of the machine, the duck foot share 2 superficially processes a strip equal to the width of the furrow cutter 7, loosens the soil and cuts off the roots of weeds. First, the chisels of 9 subs oilers 4 and 5 with an inclined stand enter the soil and loosen it. Thus formed cracks spread to the soil surface at an angle □=40-45º. After that, the subsequent subs oilers 3 and 6 in the same way affect the soil. The result is the best soil crumbling in the sowing area. Then the furrow cutter 7 cuts the furrows in the middle of the sowing zone. The process of soil preparation for sowing under a closed tunnel-type film ends with the processing of the strip for sowing melons and gourds with rotary working bodies 8.

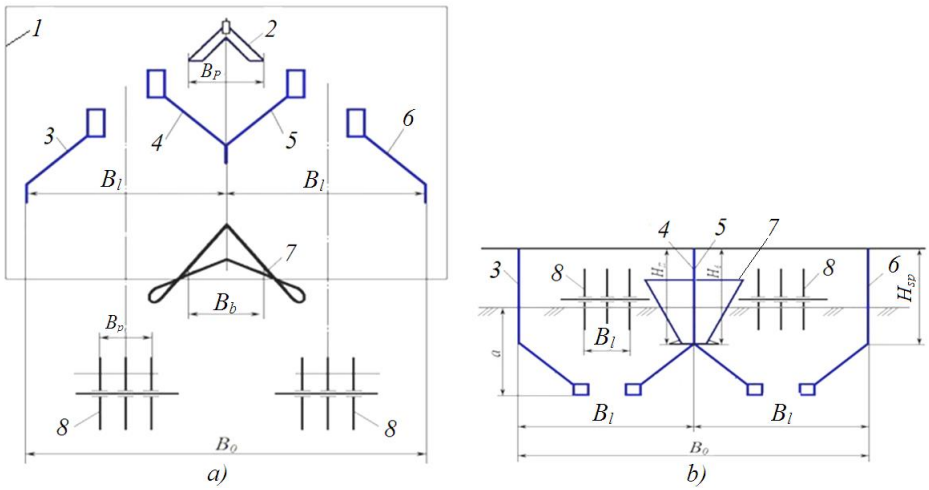



**Figure 1**. Schematic diagram of a combined machine for preparing soil for sowing melons and gourds under a film: *a* – top view; *b* – rear view

The main quality indicator of the combined machine, which determines its efficiency, is the quality of soil loosening. The area of the loosened soil zone by subsoilers affects, on the one hand, the energy consumption of soil cultivation, on the other, the ability to retain and accumulate soil water. Therefore, when choosing a scheme for the location of subsoilers and their parameters, it is necessary to study the quality of soil loosening.

The quality of loosening is estimated by the completeness of loosening - the loosening coefficient η. For subs oilers, the coefficient $\eta$ is the ratio of the cross-sectional area of the loosened soil zone between the right and left subs oilers to the total area located in a plane perpendicular to the direction of movement of the machine and limited by the working width and maximum loosening depth, i.e.

$$\eta = \frac{S_1 + S_2}{S}, \tag{1}$$

where $S_1$ and $S_2$ – respectively, the cross-sectional area of the loosened soil layer by the working bodies of the first and second rows, m$^2$; $S$ – total cross-sectional area of the soil between the working bodies, m$^2$.

When determining the completeness of loosening the soil, we assume that the width of the chisels and the height of the inclined part of both working bodies are the same. Fig.2 shows that when

loosening the soil in the zones of soil cultivation with chisels of the right and left subsoilers, the zones of propagation of soil deformation intersect with each other. In this case, a ridge with a height of $h_y$. Then the cross-sectional area of the loosened soil layer by the working bodies of the first row (Fig.2).

$$S_1 = F_1 + 2F_2 + F_3 \tag{2}$$

Cross-sectional area of the loosened soil layer by the working body of the second row

$$S_2 = F_2 + F_3 + F_4 + F_5 + F_6 + F_7 \tag{3}$$

From Fig. 2 we have

$$F_1 = [2(a - h_c)ctg\,\psi_2 + b_i]h_c; \tag{4}$$

$$F_2 = \frac{1}{2}(a - h_c)^2 ctg\,\psi_2; \tag{5}$$

$$F_3 = b_i(a - h_c); \tag{6}$$

$$F_4 = h_y^2 ctg\,\psi_2; \tag{7}$$

$$F_5 = \frac{1}{2}[(a - h_c) - h_y]^2 ctg\,\psi_2; \tag{8}$$

$$F_6 = [2h_y ctg\Psi_2 - (a - h_c)ctg\,\psi_2](a - h_c - h_y);$$

$$F_7 = Mh_c - \frac{1}{2}h_c cg\Psi_2 \tag{9}$$

where $M$ – is the distance between the tracks of the working bodies.

From rice

$$M = B_k - 2H_k ctg\beta_k - b_i, \tag{10}$$

where $\beta_k$ – angle of inclination of the subsoiler rack in the transverse plane, degree.

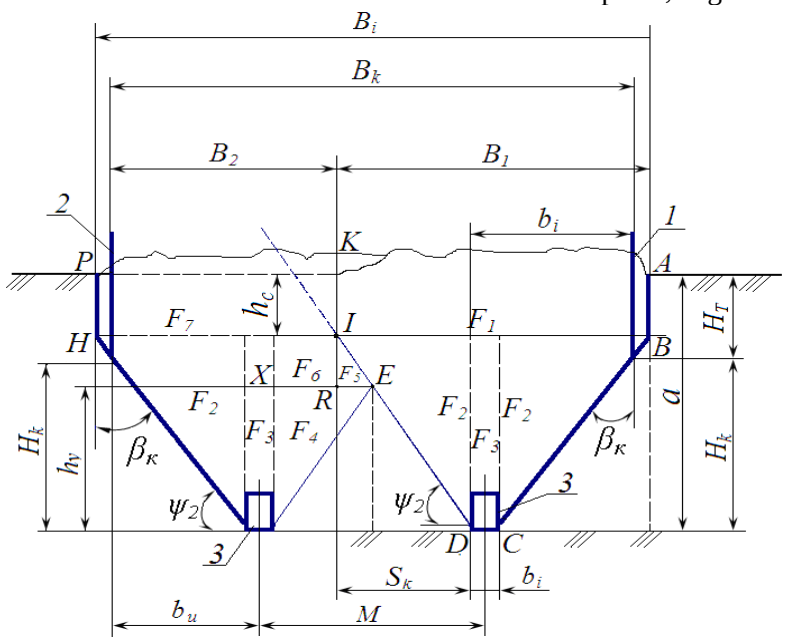



**Figure 2.** Scheme for determining the completeness of loosening the soil with subsoilers: 1 and 2 – right and left subsoilers; 3 – chisels

Substituting the values $F_1$, $F_2$, $F_3$, $F_4$, $F_5$ $F_6$ and $F_7$ according to (3) – (9) in (2) and (3) we get

$$S_1 = (a^2 - h_c^2)ctg\,\psi_2 + ab_i, \tag{11}$$

$$S_2 = (a-h_c)^2 ctg\,\psi_2 + b_n(a-h_c) + \frac{3}{2}h_y^2 ctg\,\psi_2 - (a-h_c)h_y ctg\,\psi_2 + \\ + (2h_y - a + h_c)(a - h_c - h_y)ctg\,\psi_2 + (B_k + 2H_k ctg\beta_k - b_i)h_c. \quad (12)$$

The total cross-sectional area of the soil between the working bodies is

$$S=B_i a, \quad (13)$$

where $B_i$ – width of capture of subsoilers, m.

From Fig.2 we have

$$B_i = 2(a-h_c)ctg\,\psi_2 + b_i + M. \quad (14)$$

Substituting the value of $M$ according to (10) into (13) and (14), we obtain

$$B_i = 2(a-h_c)ctg\,\psi_2 + B_k - 2H_k ctg\,\psi_2. \quad (15)$$

$$S = [2(a-h_c)ctg\,\psi_2 + B_k - 2H_k ctg\,\psi_2]a. \quad (16)$$

Substituting the values of $S_1$, $S_2$ and S in (1), we obtain the following expression to determine the coefficient of loosening completeness $\eta$

$$\eta = \frac{(a^2 - h_c^2)ctg\,\psi_2 + ab_i}{a[2(a-h_c)ctg\,\psi_2 + B_k - 2H_k ctg\,\psi_2]} + \frac{(a-h_c)^2 ctg\,\psi_2 + b_n(a-h_c) + \frac{3}{2}h_y^2 ctg\,\psi_2 - (a-h_c)h_y ctg\,\psi_2}{a[2(a-h_c)ctg\,\psi_2 + B_k - 2H_k ctg\,\psi_2]} + \\ + \frac{(2h_y - a + h_c)(a - h_c - h_y)ctg\,\psi_2 + (B_k + 2H_k ctg\beta_k - b_i)h_c}{a[2(a-h_c)ctg\,\psi_2 + B_k - 2H_k ctg\,\psi_2]}, \quad (17)$$

It can be seen from (17) that the coefficient of loosening completeness $\eta$ depends on the parameters of subsoilers, the transverse distance between them, the depth of soil cultivation, and the physical and mechanical properties of the soil.

Fig.3 shows the graphs of the dependence of the soil loosening coefficient on the depth of cultivation of the soil of subs oilers at $\beta_к$=45º, $\psi_2$=45º and $b_i$=5 см.

Fig.3 shows the graphs of the dependence of the soil loosening coefficient on the depth of soil cultivation of subsoilers at and from the graphs it can be seen that with an increase in the lateral distance between the subsoilers and the depth of soil cultivation, the coefficient of loosening increases. In this regard, the transverse distance between the subs oilers and the depth of tillage must be selected based on agro technical requirements.

The height of the ridges at the bottom of the furrow is also one of the main agricultural indicators. From Fig.2 we have

$$h_y = \frac{M - b_i}{2} tg\,\psi_2. \quad (18)$$

Substituting the value of $M$ according to (10) into (18), we have

$$h_y = \frac{B_k - 2H_k ctg\beta_k - 2b_i}{2} tg\,\psi_2. \quad (19)$$

It is known that during soil cultivation, the upper part of the ridge collapses, in this regard, the height of the ridge decreases, then the actual height of the ridge is determined by the following formula [34]

$$h_{yx} = K_y h_y, \quad (20)$$

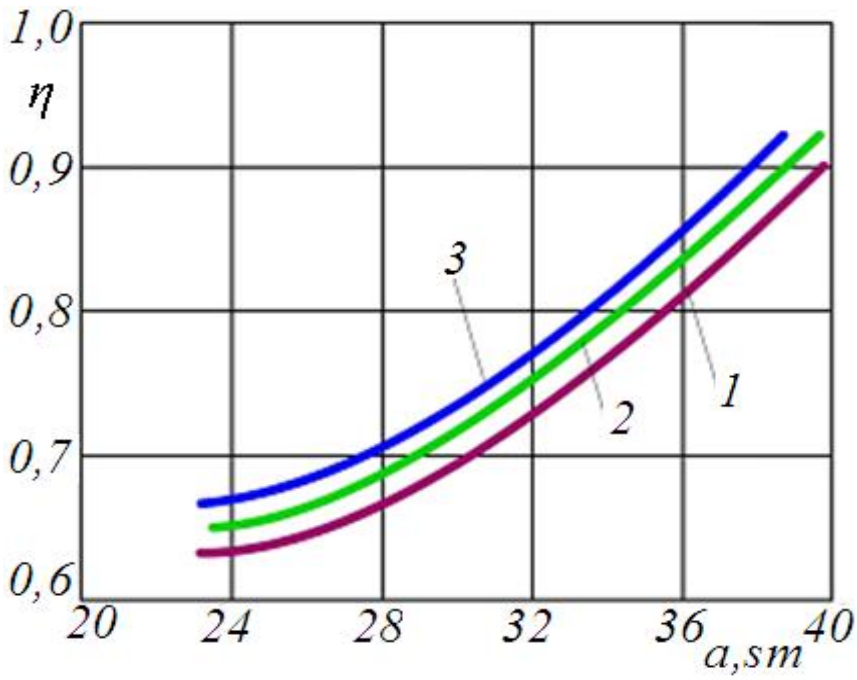



**Figure 3.** Graphs of the dependence of the coefficient of soil loosening on the depth of soil cultivation: 1 – $B_k$ =60 cm; 2 – $B_k$ =70 cm; 3 – $B_k$=80 cm

where $K_y$ – is a coefficient that takes into account the destruction of the ridge.

Taking into account (20), formula (19) has the following form

$$h_y = K_y \frac{B_k - 2H_k ctg\beta_k - 2b_i}{2} tg\psi_2. \quad (21)$$

The value of $K_y$ is within the following range of 0,49-0,61 [35].

It can be seen from (21) that the height of the crest at the bottom of the furrow depends on the lateral distance between the subs oilers, the height of their working part, the width of the bit, and the physic mechanical properties of the soil.

## 3. Results and Discussions

Experimental studies were carried out to study the effect of the mutual arrangement of subsoilers, as well as the operating speed on the degree of soil crumbling. The results of the experiments are shown in Fig. 4. According to the data of the experiments, it was found that at speeds of 6-9 km / h, to ensure the required quality of work with minimal energy consumption, the longitudinal distance between the subs oilers should be 75 cm, and the transverse distance should be 60 cm.

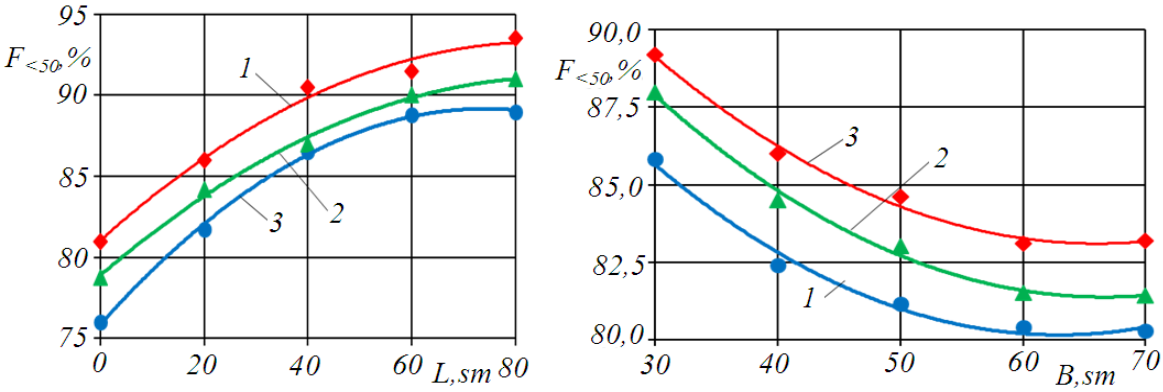



**Figure 4.** Graphs of the dependence of the degree of soil loosening on the longitudinal and transverse distance between subs oilers: 1, 2, 3 – respectively, at a soil cultivation depth of 25, 27,5 and 30 cm

## 4. Conclusions

The scheme of pairwise arrangement of subsoilers inclined to the right and left of the combined machine with working surfaces facing each other, as well as offset from each other in the longitudinal plane, provides the required quality of work with minimal energy consumption.

With a longitudinal distance between the subsoilers of 75 cm and a transverse distance of 60 cm, high-quality operation of the combined machine is ensured according to the required requirements with minimal energy consumption.

## Acknowledgments

We thank all our colleagues who worked closely with us on this paper

## References

[1] Mirzaev B, Mamatov F, Tursunov O. A justification of broach-plow's parameters of the ridge-stepped ploughing https://doi.org/10.1051/e3sconf/20199705035.

[2] Mirzaev B, Mamatov F, Avazov I , Mardonov S. Technologies and technical means for anti-erosion differentiated soil treatment system E3S Web of Conferences. https://doi.org/10.1051/e3sconf/20199705036.

[3] Mamatov F, Mirzaev B, Shoumarova M, Berdimuratov P, Khodzhaev D. Comb former parameters for a cotton seeder International Journal of Engineering and Advanced Technology (IJEAT) Volume-9 Issue1 October DOI: 10.35940/ijeat.A2932.109119 pp 4824-4826

[4] Mirzaev B, Mamatov F, Ergashev I, Ravshanov H, Mirzaxodjaev Sh, Kurbanov Sh, Kodirov U and Ergashev G. Effect of fragmentation and pacing at spot ploughing on dry soils E3S Web of Conferences 97 https://doi.org/10.1051/e3sconf/201913501065.

[5] Mirzaev B, Mamatov F Ergashev I, Islomov Yo, Toshtemirov B, Tursunov O. Restoring degraded rangelands in Uzbekistan Procedia Environmental Science, Engineering and Management 2019. № 6. – pp 395-404 .

[6] Mirzaev B, Mamatov F, Chuyanov D, Ravshanov X, Shodmonov G, Tavashov R and Fayzullayev X. Combined machine for preparing soil for cropping of melons and gourds XII International Scientific Conference on Agricultural Machinery Industry. doi.org/10.1088/1755-1315/403/1/012158.

[7] Mirzaev B, Mamatov F, Aldoshin N and Amonov M. Anti-erosion two-stage tillage by ripper Proceeding of 7th International Conference on Trends in Agricultural Engineering 17th-20th September (Prague Czech Republic) – pp 391-396.

[8] Umurzakov U., Mirzaev B., Mamatov F., Ravshanov H., Kurbonov S. A rationale of broach-plow's parameters of the ridge-stepped ploughing of slopes // XII International Scientific

Conference on Agricultural Machinery Industry IOP Conf. Series: Earth and Environmental Science 403(2019) 012163 IOP Publishing. doi:10.1088/1755-1315/403/1.

[9] Aldoshin N., Mamatov F., Ismailov I., Ergashov G. Development of combined tillage tool for melon cultivation // 19th international scientific conference engineering for rural development Proceedings, Volume 19 May 20-22, 2020. ISSN 1691-5976.

[10] Mamatov F., Ergashev I., Ochilov S., Pardaev X. Traction Resistance of Soil Submersibility Type "Paraplau" // Jour of Adv Research in Dynamical & Control Systems, Vol.12, 07-Special Issue, 2020. DOI: 10.5373/JARDCS/V12SP7/20202336. ISSN1943-023X.

[11] Mamatov F.M., Eshdavlatov E., Suyunov A. The Shape of the Mixing Chamber of the Continuous Mixer // Jour of Adv Research in Dynamical & Control Systems, Vol. 12, 07-Special Issue, 2020 // DOI: 10.5373/JARDCS/V12SP7/20202318. ISSN 1943-023X.

[12] Aldoshin N., Didmanidze O., Mirzayev B., Mamatov F. Harvesting of mixed crops by axial rotary combines // Proceeding of 7th International Conference on Trends in Agricultural Engineering 2019. 17th-20th September 2019 Prague, Czech Republic. – pp.20-26.

[13] Mamatov F., Mirzaev B., Batirov Z., Toshtemirov S., Tursunov O., Bobojonov L. Justification of machine parameters for ridge forming with simultaneous application of fertilizers // CONMECHYDRO – 2020. IOP Conf. Series: Materials Science and Engineering 883 (2020) 012165. doi:10.1088/1757-899X/883/1/012165.

[14] Mamatov F., Mirzaev B., Berdimuratov P., Turkmenov Kh., Muratov L., Eshchanova G. The stability stroke of cotton seeder moulder // CONMECHYDRO – 2020. IOP Conf. Series: Materials Science and Engineering 883 (2020) 012145. doi:10.1088/1757-899X/883/1/012145.

[15] Mamatov F.M., Eshdavlatov E., Suyunov A. Continuous Feed Mixer Performance // Journal of Advanced Research in Dynamical and Control Systems (JARDCS). – Volume-12, 07-Spesia1 Issue, 2020. DOI: 10.5373/JARDCS/V12SP7/20202343. ISSN 1943-023X.

[16] Aldoshin N.V., Mamatov F.M., Ismailov I.I. Agregat dlja podgotovki pochvy pod bahchevye kul'tury // Izvestija Sankt-Peterburgskogo Gosudarstvennogo Agrarnogo Universiteta. Ezhekvartal'nyj nauchnyj zhurnal. – № 2(59). – str.141.

[17] Kodirov U., Aldoshin N., Ubaydullayev Sh., Sharipov E., Muqimov Z and Tulaganov B. The soil preparation machine for seeding potatoes on comb // Materials Science and Engineering, 2020. CONMECHYDRO – 2020. doi:10.1088/1757-899X/883/1/012143.

[18] Ravshanov Kh., Fayzullaev Kh., Ismoilov I., Irgashev D., Mamatov S. The machine for the preparation of the soil in sowing of plow crops under film // International scientific conference «Construction mechanics, hydraulics and water resources engineering» CONMECHYDRO-2020. – Tashkent, 2020. doi:10.1088/1757-899X/883/1/012138.

[19] Ravshanov H, Babajanov L, Kuziev Sh, Rashidov N, Kurbanov Sh. Plough hitch parameters for smooth tails// International scientific conference «Construction mechanics, hydraulics and water resources engineering» CONMECHYDRO-2020. – Tashkent, 2020. doi:10.1088/1757-899X/883/1/012139.

[20] Chuyanov D., Shodmonov G., Avazov I., Rashidov N, Ochilov S. Soil preparation machine parameters for the cultivation of cucurbitaceous crops // International scientific conference «Construction mechanics, hydraulics and water resources engineering» CONMECHYDRO-2020. – Tashkent, 2020. doi:10.1088/1757-899X/883/1/012122

[21] Mamatov F.M., Chujanov D.Sh., Mirzaev B.S., Ergashev G.X. Agregat dlja novoj tehnologii podgotovki pochvy pod bahchevye kul'tury [The unit for a new technology of soil preparation for melons]// Kartofel' i ovoshhi [Potatoes and vegetables]. Moskva, 2011. – № 1. – P.27. [in Russian].

[22] Mamatov F.M., Chujanov D.Sh., Mirzaev B.M., Ergashev G.X. Agregat dlja predposevnoj obrabotki pochvy [Unit for presowing tillage] // Sel'skij mehanizator [Rural mechanic]. Moskva, 2011. – № 7. – P.12-13. [in Russian].

[23] Mamatov F.M., Mirzaev B.S., Avazov I.J., Buranova Sh.U., Mardonov Sh.X. K voprosu jenergosberegajushhej potivojerozionnoj differencirovannoj sistemy obrabotki pochvy [On the

issue of energy-saving anti-erosion differentiated soil treatment system]// Innovacii v sel'skom hozjajstve [Innovations in agriculture]. Moskva, 2016. – № 3(18). – P.58-63. [in Russian].

[24] Mirzaev B.S., Mamatov F.M. Protivojerozionnaja tehnologija grebnisto-stupenchatoj vspashki i plug dlja ee osushhestvlenija [Anti-erosion technology of comb-stepping plowing and plow for its implementation]// Prirodoobustrojstvo [Environmental Engineering]. Moskva, 2015. – № 2. – P.81-84. [in Russian].

[25] Mamatov F.M., Mirzaev B.S., Avazov I.J. Agrotehnicheskie osnovy sozdanija protivojerozionnyh vlagosberegajushhih tehnicheskih sredstv obrabotki pochvy v uslovijah Uzbekistana [Agrotechnical foundations for the creation of anti-erosion water-saving technical equipment for soil cultivation in Uzbekistan]// Prirodoobustrojstvo [Environmental Engineering]. Moskva, 2014. – № 4. – P.86-88. [in Russian].

[26] Ubaydullayev Sh.R., Mamatov F.M. The phytogenic effect of different aged black saxaul plants on the productivity of wormwood-ephemeral vegetation under the conditions of Karnabchul // Ekologiya i stroitelstvo. 2019. –№1. – P. 31-39. doi: 10.35688/2413-8452-2019-01-005.

[27] Mamatov F.M., Batirov Z.L., Khalilov M.S., Kholiyarov J.B. Trekhyarusnoe vnesenie udobreniy tukoprovodom-raspredelitelem glubokorykhlitelya [Three-tiered fertilizer application with a spreading funnel of a subsoil tiller]. Sel’skokhozyaystvennye mashiny i tekhnologii. 2019. Vol.13. – № 4. 48-53 (In Russian). DOI 10.22314/2073-7599-2019-13-4-48-53.

[28] Mirzaev B.S, Mamatov F.M . Erosion preventive technology of crested ladder-shaped tillage and plow design. Europaische Fachhochschule. European Applied Science. № 4. 2014. – pp. 71-73. ISSN 2195-2183.

[29] Mamatov F.M., Mirzaev B.S. The new antierosion and water saving technologies and tools for soil cultivation under the conditions of Uzbekistan// Ekologiya i stroitelstvo.

[30] Maljukov V.I. 1982. Mechanization of melon farming (Volgograd Lower Volzh) Prince publishing house.

[31] Abezin V.G. 2004. The mechanization of cultivation of gourds based on resource-saving soil protection technologies Dis Dr tech Sciences (Volgograd) – p 478.

[32] Em A.D, Zhukov V.N and Kodirov A.Je. 1989. Recommendations on the use of mechanized technology and a complex of machines for the cultivation of gourds (Toshkent) – pp 1-13.

[33] Lobachevskiy Ja. P., Mamatov F.M., Ergashev I.T. Frontal'nyj plug dlja hlopkovodstva [Frontal plow for cotton growing] // Hlopok [Cotton]. Moskva, 1991. – № 6. – P.35-37. [in Russian].

[34] Murotov M.M., Bajmetov R.I., Bibutov N.S. Mehaniko-tehnologicheskie osnovy i parametry orudij dlja razuplotnenija pochvy. – Tashkent: Fan, 1988. – 101 s.