Development of technology and equipment for improving the reclamation state of saline soils

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Abstract. This article develops techniques and technologies for improving the reclamation of lands. It is based on the parameters of the working bodies of the chisel softener for softening the birch and gypsum layer and the parameters of the device that creates hole drainage before the autumn saline wash in saline soils and their application technologies. Due to the use of devices, porous drainage is created compared to the traditional method, and the duration of saline washing is reduced by 15 days when plowing and saline washing. The annual economic efficiency of the chisel softener is 11645758.8 soums. The annual economic efficiency due to the use of the unit for the creation of perforated drainage amounted to 12678675.5 soums.

1 Introduction

In the world of developing technologies and technical means for improving the reclamation state of saline soil, it takes a leading place. "Considering that, on a global scale, 44-46 percent of the cultivated areas allotted for agricultural crops are salinized to varying degrees," the development of chisel rippers used to improve the reclamation state of lands with dense and gypsum soil layers, as well as technical means for laying worm drains on lands with high groundwater levels are considered an important task. From this point of view, much attention is paid to the production of machines and units for loosening lands with dense and gypsum layers of soil and on saline lands for laying worm drains [1, 2].

In the world, research is underway aimed at developing new scientific and technical foundations of technologies for loosening dense, and gypsum layers, laying worm drains under the arable layer of saline soils, and technical means for their implementation. In this direction, including the development of structural diagrams of the chisel ripper, for loosening dense and gypsum layers of soil and devices for creating worm drains under the arable layer, as well as substantiation of technological processes that ensure resource-saving of the working parts of the chisel ripper when loosening dense and gypsum layers. In addition, when laying worm drains under the arable layer of saline soils, it becomes important. At the same time, it is considered necessary to produce a resource-saving chisel

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cultivator that loosens dense, gypsum layers of soil with poor reclamation conditions and a device that forms worm drains to remove subsoil waters [3, 4].

In the Republic, large-scale measures are being taken to reduce energy consumption in agricultural production, improve the reclamation state of the land, and grow agricultural plants based on advanced technologies and produce high-performance reclamation machines. Special attention is paid to the production of technical means -transparent implementation of the processes of loosening of dense and gypsum layers of soil, laying worm drains in saline soils. The Strategy for the Further Development of the Republic of Uzbekistan for 2017-2021 includes the following "... increase in the gross domestic product by 2030 ... optimization of sown areas for 2017-2020, rational use of land and water resources, the introduction of modern intensive agricultural technologies2 ". In the implementation of these tasks, including a chisel ripper and a device for laying worm drains, processing of dense and gypsum layers in saline soils, and increasing the efficiency of washing saline soils are important tasks [5, 6].

Large-scale scientific research devoted to the development of resource-saving techniques and technologies to improve the land reclamation state and methods to reduce costs are carried out in leading research centers and institutes, such as Texas A & M University (USA), Institute of Engineering Research (England), University of Bonn, Thullen Institute (Germany), The Swedish University of Agriculture Sciences (Sweden), Wageningen University (Holland), Senshu University (Japan), Hejiang Agricultural Research Institute (China), All-Russian Institute of Mechanization, Chelyabinsk Research Institute of Agricultural Mechanization and Electrification (Russia), Belarusian National Academy of Agricultural Mechanization (Belarus), Ukrainian Research Institute for Agricultural Mechanization (Ukraine), Kazakh Research Institute for Mechanization and Electrification (Kazakhstan).

As a result of research carried out in the world on technologies for improving the land reclamation state and improving technical means, a number of results have been obtained, in particular, the following results: to ensure a reduction in energy consumption during deep loosening of the soil, loosening devices have been developed, through soil deformation, stretching it (Texas Agricultural & mexanikal University, USA, Institute of Engineering Research (England); developed energy-saving technologies for loosening the solid layer of soil and carrying it out, having a 2-dimensional blade, loosening agents (Wageningen University, Holland), developed pneumatic methods that loosening the soil under the influence of air and improving its aeration, methods (The Swedish University of Agriculture Science, Sweden), revealed an increase in plant productivity by loosening the subsoil (University of Bonn, Thullen Institute, Germany), developed devices that form mole drains by explosion of gases in pasture lands (Sens hu University, Japan); (Hejiang Agricultural Research Institute, China); for good development of the root system of plants, loosening of the subsoil, dense and gypsum layers of soil, technical means have been developed intended for deep loosening (University of Hohenheim, University of Gottingen, Germany; University of Minnesota, USA; Center of Eksptertise and Transfer in Organic and Community Agriculture, France); technologies for deep cultivation of saline soils, salt washing have been developed (University Bologna, Institute for Agricultural mexanization, Italy, China Agricultural University,); machines that form worm drains were developed and their parameters were substantiated and a technology for their application was developed (All-Russian Research Institute of Mechanization, Chelyabinsk Research Institute of Mechanization and Electrification of Agriculture, Russia; Belarusian National Academy of Agricultural Mechanization, Belarus; Ukrainian Scientific Research Institute of

Agricultural Mechanization, Ukraine; Kazakh Research Institute of Mechanization and Electrification, Kazakhstan).

In the world, spending less energy, loosening the subsoil, dense, and gypsum layers of the soil, efficiently performing technological processes of laying worm drains, producing combined machines and technical means, improving the land reclamation state by deep loosening and forming worm drains using the technology of washing salts in In several areas, including the following sustainable areas, scientific research is being conducted: development of subsoilers of the subsoil layer of the soil, creation of machines that form mole drains before washing saline lands and lands with a close location of subsoil groundwater, along with the fact that with deep loosening, the development of combined machines, processing the upper layers of the soil, improvement of the design of the working parts of chisel-rippers, development of working bodies with increased strength with deep loosening and the formation of worm drain.

The degree of study of the problem: On the creation of machines and technical means for cultivating the soil to improve the ameliorative state of lands, studying their changes in agromeliorative, water-physical properties under the action of their working bodies and loosening, spending less energy, subsurface, and dense soil layers, as well as developing theoretical and practical foundations for creating devices and technologies for improving the land reclamation state, were engaged abroad by JVStafford, FELowy, HHTawlor, MG Huck, J. Balaton, HJLut, RDWismer, K. Kawanishi, K. Araya, L. Kosisira, AJKolen, V. P. Goryachkin, V. A. Zheligovsky, A. N. Zelenin, G. N. Sineokov , V.V. Borodkin, V. G. Kiryukhin, A. N. Kostyakov, S. N. Rizhov, N. I. Bazilevich, E. I. Pankova, I. S. Rabochev, V. M. Legostaev, S. F. Averyanov, N.G. Minashina, A.E. Nerozin, V.A.Kalantaev, and others carried out research work.

In the Republic, G.M. Rudakov, R.I.Boymetov, M.M. Murodov, F.M. Mamatov, A.Tukhtakuziev, I.M. Murodov, F.M. Mamatov, A.Tuhtakuziev, I. Ergashev, N.M. Murodov, N.S. Bibutov, O.R. Kenzhaev, Kh.R. Gaffarov, T.S. Khudoyberdiev, B.V. Khushvaktov, R.A. Abdurakhmonov, M.A. Akhmedzhanov, G. N. Kim and others, A.A. Rachinsky, N.F.Bespalov, K. M.Mirzazhonov, O. Ramazonov, F.M.Rakhimbaev, Kh.I. Yakubov, G.V. Eremenko, M.Kh.Khamidov, F.A.Baraev and others [1-20].

As a result of these studies, technologies and technical means were developed to improve the reclamation state of lands, loosen the subsoil layers, create open and closed drainages, apply in agriculture, and achieve positive results. However, in these studies, the issues of loosening dense and gypsum layers to improve the land reclamation state, the development of technology, and technical means for creating worm drains in saline and closely located subsoil groundwaters have not been sufficiently studied.

Purpose of the study: Justification of the parameters of the working bodies of resource-saving chisel rippers for decompaction of dense and gypsum layers of soils and devices for laying worm drains in the subsurface layers of saline soils and application technology, as well as improving the land reclamation state with their help.

Research objectives: development and substantiation of the design of a resource-saving chisel ripper, which ensures high-quality processing of dense and gypsum soil layers; development of a device for creating mole drainages and their application technologies for improving the reclamation state of saline soils and closely located subsoil groundwater; substantiation of the parameters of the working bodies of chisel rippers, loosening dense and gypsum layers of soils, as well as devices that lay mole drainages in saline lands; study of lands with a bad reclamation state in the Bukhara region, for the use of a resource-saving chisel ripper and a device for laying mole drains;

study of the influence of the recommended technical means on the water-physical properties of the soil, as well as on the efficiency of washing the salts of highly saline, dense, and gypsum soils;
testing resource-saving chisel rippers and devices for laying worm drains and determining the economic efficiency of their use.

The object of the study is dense gypsum and saline soils, resource-saving chisel rippers used to improve the reclamation state and installation for laying worm drains.

The research subject is the parameters of the working bodies of resource-saving chisel rippers and devices for laying worm drains. The processing of dense and gypsum soils, the boundary conditions for the regularities of the inflow of groundwater to the mole drainage, changes in the patterns of quality, and energy indicators of chisel rippers and devices that create mole drains.

2 Methods

During the research, the methods of system analysis, fundamental laws and provisions of theoretical mechanics, higher mathematics, and mathematical statistics were used, the experiments used the methods of mathematical planning and strain gauging, as well as existing regulatory documents (Tst 63.03.2001, Tst 63.04.2001), "Methodology for conducting field experiments" NIIKHSА and used recommendations to improve the reclamation state of saline soils.

3 Results and Discussion

In Uzbekistan, saline lands with poor reclamation conditions, with dense and gypsum layers and their use in agricultural production, problem statement, research objectives, and conclusions are given. Full mechanization of reclamation works is based on the appropriate optimal calculations of reclamation machines, which ensures decreased labor costs and high quality of work. To carry out reclamation work, special reclamation and agricultural machines are widely used.

The total area of irrigated land in Bukhara region is 275,200 ha, of which non-saline - 37,998 ha (13.8%), low salinity - 170,110 ha (61.9%), medium salinity - 60,054 ha (21.8%), and highly saline soils - 6878 ha (2.5%).

In the course of the research, the hardness was studied in areas freed from cotton before plowing, after processing with a chisel ripper to a depth of 45 cm. Experiments have shown that the decrease in soil hardness in layers of 0-10 cm ranges from 1.98 MPa to 1, 03 MPa. In layers 10-20 cm from 3.12 MPa to 1.4 MPa, in layers 20-30 cm from 4.17 to 1.98 MPa, in layers 30-40 cm from 4.27 MPa to 2, 62 MPa as well as layers of 40-50 cm from 4.92 MPa to 3.27 MPa. On alfalfa areas, the moisture content in soil layers 0-10, 10-20, 20-30, 30-40, and 40-50 cm is 8.15-9.07%, hardness is 1.89-5.12 MPa, and the density is 1.23-1.53 g / cm³. It can be seen that these values increased with increasing depth. The moisture content in the soil in cotton fields is 11.52-12.97%; the hardness is 1.18-5.12 MPa, the density is 1.37- 1.68 g / cm³; in the sown areas of wheat is 9.85-11.32%, 1.82-4.78 MPa, and 1.38-2.74 g / cm³, respectively [7.8].

Dense and gypsum layers of soil must be decompacted using special technology without it with the fertile soil layer. Therefore, to study the force of traction resistance in the

process of loosening, it is necessary to substantiate the parameters and shapes of the side profile of the rack.

Justification of the parameters and side profile of the working body of the resource-saving chisel ripper is described below. In the process of decompaction of gypsum soils at a depth, the loosening working body affects the thickness of the gypsum layer and the layer of soil under it, while the soil cracks without loosening not lower than the critical depth (). In the process of movement of the working body, cracks appear on the gypsum layer without moving with the fertile soil layer (Fig. 1).

a) Cross-section; b) longitudinal section;

Fig. 1. Impact of the loosening working body on the soil

It is enough only to form cracks in the gypsum layer under the influence of loosening paws without deforming it completely. Based on this, the solution to the problem being resolved will be as follows: to perform the technological process of deformation, it is necessary to find such a shape of the lateral profile of the working body, in the process of work, it had a minimum traction resistance. The main vector of forces acting on the point M, taking into account the fact that the soil crumbles on a curved elementary surface of the working body, has the following form [9, 10]:

$$Qds = \rho_o \left[1 - \frac{Y(M)}{H} \right] k v_o^n \cos^n \beta ds, \quad (1)$$

here s is an arbitrary element surface; M - inner point of the element; H is processing depth; k is coefficient that takes into account loosening and soil resistance during movement; ρ_o - soil density, kg / m³; v_o - unit movement speed, m / s; β - coal between the normal force N and the speed of movement V of the soil particle, degree.

As a dynamic component of traction resistance or a component of dynamic resistance, we take the dynamic soil pressure acting on the working body. The dynamic component of

the resistance force will be denoted by and its elementary component; after appropriate transformations, we will determine the shape of the side profile of the working rack.

The laboratory and field experiments results showed that at $R = 0.20-0.24$ m, when processing gypsum and dense soil layers with an energy-saving chisel ripper to a depth of 0.40 m, it has a minimum traction resistance.

In the process of cultivating the soil with an unsatisfactory ameliorative state and poor water-physical properties, it is important to study changes in soil properties as a result of the impact of working bodies on them. With an increase in the radius of curvature and speed of the unit movement, an increase in traction resistance was observed (Fig. 3).

Fig. 3. Changing the traction resistance depending on the curvature of the radius (R) and the unit's speed (V) at the processing depth $H = 0.45$ m and the outreach of the rack $L = 0.210$ m.

The minimum traction resistance of the working bodies of the chisel of the ripper was observed when the strut overhang $L = 0.210$ m, the processing depth $H = 0.45$ m, and the radius of curvature of the strut was $R = 0.20-0.25$ m; this is explained it is that less friction of the soil from the working surfaces of the rack.

With an increase in the unit's speed from 1.10 m / s to 2.55 m / s, the traction resistance increased according to the parabola law.

According to the results of the experiment at $V = 2.1$ m / s, the optimal parameters are: $H = 0.45$ m; $L = 0.210$ m; $R = 0.230$ m; $\alpha = 27^\circ$

Theoretical and technological foundations of the formation of mole-drainage in saline soils, the results of theoretical and experimental studies are described, making it possible to substantiate the shape and size of the working body of the drainage-mole device. In addition, in the course of theoretical studies during the formation of worm drains, soil stresses were studied. For this, we used nonlinear or linear equations of the mechanics of a deformable solid during the motion of a fluid in a worm drain [11].

Considering the elastic property of the medium, i.e., disregarding the brittleness of the soil, the radial and contour stresses can be determined as follows:

$$\sigma_r = A/r^2 + B; \quad \sigma_\theta = -A/r^2 + B, \quad (2)$$

Here σ_r is the radial stress, N / m²; σ_θ is loop stress, N / m². A and B are random constants, which are determined using the boundary condition.

$$\sigma_r = \frac{B_s \gamma}{2k_r \text{tg} \varphi} \left[e^{(k_r \text{tg} \varphi (\frac{2H}{B_s}) - 1)} \right] + q e^{(k_r \text{tg} \varphi (\frac{2H}{B_s}))} \quad (3)$$

Here B_s is total width of the mole drainage, m; q is the force of pressure or pressure from the force of gravity of the soil, N / m²; the Christensen coefficient will be equal to $k_r = 1 + 2\text{tg}^2 \varphi$

When the drainage mole tool operates to a depth of 0.6-0.7 m with flat soil deformation, the maximum stress will be, and its value is equal to $\sigma_r = 1.30-1.40 \cdot 10^3 \text{ k H / m}^2$.

The main parameters of drainage mole tools, indicators, and their values for medium soils: diameters of mole drainage $d_m = 50-150 \text{ mm}$; for stable soil $d_m = 100-300 \text{ mm}$. These parameters are substantiated based on theoretical and experimental studies (Fig. 4).

1 is cone-cylinder; 2 is steel wire rope; 3 is rack; 4 is chisel; 5 is movable frame;
 6 is hydraulic cylinder; 7 is fixed frame

Fig. 4. Drainage device mole tool

The parameters of the drainage mole tool are determined using the following expressions: the length of the cylinder cone $\ell_y = (1,5-2,0)d_m$; the speed of movement of the unit $\alpha_c = 0,6-1,0 \text{ m / s}$; steel rope length $\ell_a \geq (0,1-0,15) \text{ m}$. Depending on the length of the steel cable, the change in the traction resistance of the working bodies of the cylinder cone with a diameter of 0.105 m with a cable length of 0.30 m, the average value of the traction resistance was 5.1 kN.

In this process, a high-quality mole-drainage is formed; the filtration coefficient is 0.45 m / day. This is accepted as the best option for working bodies (Fig. 5).

During operation, the following forces act on the drainage mole tool [14,15]:

$$F_{dt}=R_{res}+F_{rc}+F_{ktsp}+F_{st}+F_{sbp}+F_{kdbp}, \tag{4}$$

here R_{res} is resistance force when cutting the soil with a knife, N;
 F_{rc} is resistance force of the cone-shaped cylinder of the working body, N;
 F_{ktsp} is surface resistance of a tapered cylindrical housing, N;
 F_{st} is the resistance of the steel cable connecting the working rack with conical cylinder body, N .;
 F_{sbp} is force of resistance of soil adhesion to the cone surface cylinder, N .;
 F_{kdbp} is resistance force due to soil adhesion to the surface of the conical cylinder head, N.
 The total tractive power of the drainage mole implement during the working process is determined by the following expression:

$$N = \frac{F_{dt} \vartheta}{\eta} \tag{5}$$

here FDT is the sum of the resistance forces to the thrust of the device, N;

Fig. 5.Tool processing depth: H = 40 cm; H = 50 cm; H = 60 cm.

Change in traction resistance and soil filtration coefficient depending on the diameter of the cylinder cone

$\eta = 0,75...0,80$ - The efficiency of the drainage mole machine. Based on theoretical and experimental research during the operation of a dredge-mole tool from external forces, the traction resistance is 9-11 kN, respectively, 7.5-13.5 kW of power is required.

With diameters of 0.105 m of the cone-shaped cylinder, the filtration is 0.62-0.65 m/day (Fig. 5).

The difference between the results of theoretical and experimental studies on filtration coefficients was 30-40%.

In addition, the filtration coefficient is influenced by such factors as the mechanical composition of the soil, the type of processing and their quality, etc.

Experimental research of scientific research work on fields with a poor ameliorative condition, with a degree of salinity of 0.978% and with a heavy texture of the soil, where the location of the groundwater level is 1.0-1.2 m deep. Each field was divided into three

sections. The first option is the control one (without loosening and drainage). In the second option, the soil was loosened to a depth of 0.45 m and plowed to a depth of 0.35 m. In the third, plowed at 0.35 m and mole drainage at a depth of 0-0.60 m with a distance between drains of 2-3 m.

In the first field, the leaching rate is 4500 m³ / ha, in the second - 5500 m³ / ha, and in the third - 6500 m³ / ha (Table 2).

Table 2. Desalination experiment results.

Indicators	Washing rate, m ³ /ha								
	4500			5500			6500		
Variants	1	2	3	1	2	3	1	2	3
Salt content, %	0.704	0.578	0.467	0.596	0.464	0.389	0.432	0.198	0.132
Desalinization factor	1.4	1.7	2.1	1.6	2.1	2.5	2.2	4.9	7.4

In field experiments, leaching rates were applied in winter: in the first field - in 2 steps (that is, twice with a break of 1 month, approximately in equal shares), in the second and third fields - in 3 steps.

All three technology options, regardless of the leaching rate, showed a decrease in the content of salts in the soil (Table 2). The best results were achieved in the third variant of the technology, that is, during plowing and drainage. It is quite natural that the maximum effect was achieved at a leaching rate of 6500 m³ / ha: the salt content decreased from 0.978% to 0.132%, the desalinization coefficient reached 7.4.

With the technology according to the third option, the duration of flushing irrigation is reduced by 15 days compared to control, which ensures the timely start of spring agricultural work. In years with a sufficient amount of water, it is possible to leach soils at a rate of 6500 m³/ha. In addition, in case of water shortage - at rates of 4500 or 5500 m³/ha against the background of loosening the soil to a depth of 0.45 m and mole drainage at a depth of 0-0.6 m which provide high efficiency of flushing.

In all nine variants of experiments, diesel fuel consumption during plowing was approximately the same - 40-45 kg/ha. In the case of pretreatment with the chisel to a depth of 0.45, this figure dropped to 38-42 kg/ha. In the third variant, with additional work of the drainage-mole implement, diesel fuel consumption was even less - 35-38 kg/ha. For highly saline soils, the most economical in terms of water consumption and effective in terms of desalinization is considered the treatment option with a drainage mole tool [16].

To calculate the technical and economic efficiency of the developed tools with reasonable parameters, we used the reference material for the economic assessment of agricultural machinery and machines. Calculations have shown that the use of a chisel ripper on soils with gypsum and dense layers and a drainage mole tool on saline soils can reduce energy consumption by 9-14.5%, labor costs by 7.91-14.11%, operating costs for 8.16-11.0%, increase labor productivity by 16.3-18.0%, which is generally expressed in annual economic efficiency, equal to 11.6-12.6 million sums.

4 Conclusions

The proposed design of the subsoil chisel has the following optimal parameters of the tool. The radius of curvature is 0.23 m, strut overhang 0.210 m; rack height 0.9-1.0 m; the width of the lancet paws 0.15 m. Between following the working bodies 0.45-0.50 m and the parameters of the drainage-mole tool as the diameter of the cone-cylinder 0.105-0.110 m. The length of the steel cable 0.3-0.35 m, the swath width of the undulating chisel 0.055-0.080 m, the angle of installation of the working bodies is 27-300, the speed of the unit is 1.20-2.34 m/s, and high-quality performance of the technological process is ensured for the removal of harmful salts from the fertile soil layers.

References

1. Pankov E.I., Konyushkov M.V., Gorokhova I.N. On the problem of assessing salinity of soils and the methodology of large-scale digital mapping of saline soils. *Ecosystems: Ecology and Dynamics*, Volume 1, p. 26-54. (2017)
2. John V. Stafford, Paul G. Carter. 10th European Conference on Precision Agriculture (Part III). *Precision Agric* (2017) 18:899 DOI 10.1007/s11119-017-9547-0.
3. Trufanov V.V. Deep chizelovanie soil. -M., (1965)
4. Murodov N.M., Juraev F.U. Justification of the parameters of tools for decompression of gypsum soils. // *Agricultural Science*. - No. 11.-P.30-31. Moscow- (2014)
5. Egidijus K., Rostislav Ch., Miloslav L., Vytenis J. Wear modelling of soil ripper tine in sand and sandy clay by discrete element method. *Biosystems Engineering*. Volume 188, Pages 305-319. December (2019)
6. Tukhtakuziev A. Ensuring uniformity of the depth of tillage. *Agricultural machinery and technologies • Volume 13 • N3 • (2019)*. C.34-38.
7. Lobachevsky Y.P. Starovoitov S.I. The optimal profile of the anterior surface of the chisel working body. *Sels-khozyaystvennyemachines and technologies • Volume 12 • No. 2. pp.26-30. (2018)*
8. Lobachevski Y. P., Starovoitov S. I. Theoretical and technological aspects of the work of the cultivating working body // *Agricultural machines and technologies*. (2016). N5. S. 17-23.
9. Khamidov M.Kh., Juraev F.U. The device and principles of operation of the drainage mole gun. // *Irrigatsiya vaMellioratsiya*. –Toshkent,. No. 1 (7). - B.9. -12. (2017)
10. Mamatov F.M. Batirov Z.L. Khalilov M.Kh. Kholiyarov E.B. Three-tier fertilizer application with a fertilizer-distributor subsoiler. *Agricultural Machines and Technologies • Volume 13 • N4 • pp.48-53. (2019)*
11. Mironenko B.A. Dynamics of groundwater. Moscow. pp.201-360. (1983)
12. Filin A.N. Rigid deformable body mechanics.. p. 125-132. Moscow. "Science", (1975)
13. Ibrahmi A., Bentaher H., Hbaieb M., Maalej A., Mouazen A.M. Study the effect of tool geometry and operational conditions on mouldboard plough forces and energy requirement: Part Finite element simulation. *Computers and Electronics in Agriculture*. (2015); 117: 258-267.
14. Pazova T.Kh. Technologies and means of mechanization for anti-erosion cultivation of inclined soils of the Kabardino-Balkarian Republic. Moscow, (2009). Author's abstract of the dissertation on competition of a scientific degree of doctor of technical sciences. From. 11-12.
15. Isokova Z.X. Parameters of artificial pipe forming working apparatus // *European science review scientific journal*, – Vienna, – № 9-10. – P. 181-182. (2018)

16. Juraev F.U., Musulmanov F.Sh. Application of technology and technology for washing highly saline soils. *Agricultural Machinery and Technologies • Volume 14 • N2 •* (2020)
17. Rakhmonov S., Umurzakov U., Rakhmonov K., Bozarov I., Karamatov O. Land use and land cover change in Khorezm, Uzbekistan. *E3S Web of Conferences*, 227, 01002, (2021)
18. Umurzakov U., Mamatov F., Aldoshin N., Mirzaev B. Exploration of tillage technologies in the Republic of Uzbekistan, *IOP Conference Series, Earth and Environmental Science*, 614(1), 012168, (2020)
19. Umurzakov U., and Djuraev B. Prediction of prices for agricultural products through markov chain model, *International Journal of Psychosocial Rehabilitation*, 24(3), pp. 293–303, (2020)
20. Umurzakov U., Mirzaev B., Salahodjaev R., Isaeva A., and Tosheva S. Energy consumption and economic growth: Evidence from post-communist countries. *International Journal of Energy Economics and Policy*, 10(6), pp. 59–65, (2020)