Innovative cultivator for cultivating soil and applying liquid fertilizers to reduce the use of irrigation water

Batyr Orazgylyjov[1*], *Gozel* Atamuradova[2], and *Kasym* Jumayev[3]

[1]Turkmen Agricultural Institute, Dashoguz, Turkmenistan
[2]Project "Conservation and Sustainable Management of Land Resources and High Nature Value Ecosystems in the Aral Sea Basin for Multiple Benefits", Ashgabat, Turkmenistan
[3]CSO Ecodurmush, Dashoguz, Turkmenistan

Abstract. In the course of these scientific studies, a cultivator of the KR 3-25 type was developed to stimulate the root system of cotton and apply liquid fertilizers to increase its yield. In the course of scientific work, liquid fertilizer was applied to the root system of cotton using a KR 3-25 cultivator; scientific research was carried out for 3 years. The effect on plant growth, yield and thirst was studied. As a result, this has led to an improvement in the underground balance of moisture and nutrients in the soil where the roots of the cotton plant are located, leading to significant savings in water consumption and an increase in cotton yield. This also helped reduce soil salinity. This paper presents the results of many years of scientific research on the effect of an innovative top-dressing cultivator on reducing water consumption and increasing crop yields.

1 Introduction

71 percent of the earth's surface is covered with water, only 0.4 percent of it is considered usable. This important indicator forces us to use water resources rationally and economically. In the public sector, especially in agricultural production in dry countries, this situation reveals many problems. After all, it is felt more acutely in the lower reaches of the Amdura and Syr Darya [1, 3].

The arid region includes the deserts of Kazakhstan and the states of Central Asia. Annual precipitation is 10-15 times less than water evaporation. 85-86 percent of the water resources of the Aral Sea basin are distributed between the countries of Kyrgyzstan and Tajikistan, the remaining 14-15 percent - between the countries of Kazakhstan, Uzbekistan and Turkmenistan. Of all the water supplied to these states, 90% is consumed for agricultural production. Therefore, in the agriculture sector of these countries there is an urgent need to introduce water-saving technologies [4, 6, 8].

Due to the fact that Turkmenistan is an agricultural country, one of the important tasks is the transition from the extensive method to intensive agriculture, there is a need to

* Corresponding author: batyrtohi@gmail.com

introduce and use agricultural machinery in the production in accordance with soil and weather conditions and the needs of agricultural technology [2, 5].

Currently, in irrigated agriculture, to create favorable conditions for crops, the traditional method of mechanical tillage is widely used in agricultural production. The tasks of providing the population with food and production of products in the national economy require modern, highly productive and cost-effective agricultural machinery. Currently, focusing on energy and resource-saving production of innovative agricultural machines is considered a priority.

As noted above, to ensure the growth of agricultural crops under favorable conditions, the 1980s methods of mechanical tillage are widely used, and this in turn requires a lot of energy and labor, as well as a lot of water resources [10-11, 15].

To preserve soil as the main means of production, it is necessary to provide scientifically based technological operations for processing soil and cotton in accordance with agrotechnical requirements. At the same time, soil cultivation, sowing and care of cotton plants should help maintain and increase soil fertility.

A device for applying liquid mineral and organic fertilizers (cultivator) to the root zone of crops is designed to destroy the plow sole, introduce nutrients into the root system of cotton, deepen the arable horizon of the soil and loosen the soil to a depth of 15 to 25 cm, in order to preserve moisture in arid conditions season [14-15].

Design diagram of a nutritious cultivator of mineral fertilizers and its main characteristics when cultivating a cotton field. Reducing the cost of each product in agricultural production, including environmental indicators, is a fundamental direction in the development of modern agricultural technology. Characterizing soil conditions and their composition is key to the development and analysis of tillage and conservation technologies. Soil composition, in turn, is its unique control factor. One of the tools for managing soil conditions is a cultivator.

In studies of prominent scientists, especially in traditional irrigated areas, the average mass of the solid sedimentary layer is 1.8-1.9 g/cm^3. The standard step of agricultural technology is provided for the planting layer of 1.1-1.25 g/cm^3, but its increase or decrease by 0.1-0.3 g/cm^3 negatively affects soil productivity and reduces yields by 20-40 percent. Depending on the fact that the basic indicator of heavy soils does not exceed 1.2 g/cm^3, it is necessary to loosen the soil to a depth of 8-10 cm of the seed layer in spring and 30-35 cm in autumn. Based on these conditions, the maximum permissible indicator of the top layer is 1.3 g/cm^3. 0.5 kgf/cm^2 in spring and 0.8 kgf/cm^2 in autumn are not tolerated. When soil moisture is less than 20 percent, soil pressure of up to 2.0 kgf/cm^2 is allowed.

The root of the plant cannot penetrate the thick layer, its food and ventilation area is very small, and it does not receive the biological growth it needs. The solution is a reduction consisting of two stages: the first mechanical reduction; the second consists of biological (by adding organic fertilizers) reduction.

A universal agro-reclamation machine KR 3-25 has been scientifically and technically developed, which meets the above important indicators, meets the agrotechnical requirements of agricultural crops, saves water for washing the soil and growing plants, and pours liquid fertilizers to the required depth [12-13].

Rationale for using a cultivator. Today, in Dashoguz velayat it is planned to organize research experiments on the agro-reclamation universal machine KR 3-25, the main goal of which is the specialization of modern tractors and their study under various soil and weather conditions, as well as obtaining high cotton yields. The versatility of the KR 3-25 agro-reclamation machine is adjusted in accordance with the composition of the soil or is carried out in the following order:

- Loosening 25 cm soil layer.
- Provides liquid fertilizer to any depth of softening.

As a result, the following problems will be solved:

- To ensure the balance of nutrients and restore the natural order of the agro-landscape.
- The saving of 2 growing water in growing crops is on average. Each irrigation is approximately from 0.8 to 1.2 thousand m^3/ha. The average is 1 thousand m^3/ha.
- Sustainable harvesting.
- Reducing the use of mineral fertilizers.
- Reducing labor costs.
- Increasing the efficiency of fertilizer.
- Decrease in groundwater level.
- Preventing land degradation.

In conditions of mechanical and biological softening of the hard soil layer on heavy soils of Turkmenistan, the use of methods and technologies of new agro-reclamation universal units in the technical, economic and constructive aspects is of great importance for solving many agricultural problems. The development of relevant innovations for the corresponding agro-landscape and the expansion of the machine and tractor fleet will be a great contribution to the development of agriculture at the local level. The agro-reclamation measures carried out will also help improve the ecological situation of the area and improve the reclamation condition of irrigated lands.

The results of theoretical studies and many years of rich production experience of agronomists indicate the need to improve agricultural technology, which means it is time to take a step towards an integrated approach to improving the condition of soils in irrigated agriculture. This, in turn, will have a significant impact on ensuring food security in the country and increasing agricultural production.

2 Materials and methods

Research will be conducted in the field. Where observations will be made to implement the planned experiments. An assessment will be made of the influence of one factor on another while simultaneously controlling the impact of external factors.

The study will be carried out in three phases:

- Design phase, the result of which is the construction of a cultivator model and a plan for its operation.
- The technological phase, the result of which is the implementation of the system, i.e. hypothesis testing.
- The reflexive phase, the result of which is an assessment of the effectiveness of the cultivator and the determination of the need for its further correction.

The collected data will be organized and structured so that it is easy to analyze, for which an Excel table will be created. In addition, a protocol will b edrawn up for each event.

Specifications. The 3-row plant feeder cultivator KR-3-20 is designed for pre-sowing tillage, inter-row tillage and fertilizing of row crops sown with row spacing of 90-60 cm in all soil and climatic zones of Turkmenistan on soils that are not clogged with stones and not subject to wind erosion. The cultivator-plant feeder is used with tractors of traction class 1.4; 2.0 (MTZ-80/82; MTZ-1221). The cultivator-plant feeder, depending on the installed working parts and devices, performs the following technological operations:

- Trimming weeds.
- Loosening the soil and simultaneous application of liquid mineral and organic fertilizers on both sides of the row at a distance from the protective zones.
- Version KR-3-20 with a set of working tools and a feeding device for a row spacing of 90-60 cm.

Construction of a kinematic diagram of a feeding cultivator. Based on theoretical data and workpiece arrangement. Depending on the purpose of the tool, it determined the method of screwing together the working parts, the joint placement of the working parts and the lifting mechanism, attachment to the tractor, and the kinematic links of the mechanisms.

Home 3-25 The tool blank is firmly attached to the screw. The stuffed workpieces are placed in cultivators with a transport length of 3.5 m, which undergo full processing.


Fig. 1. Working condition of the cultivator.

Table 1. Comparative analysis of the technical characteristics of domestic cultivators.

Indicators	**Unit change**	**Cultivators-plant feeder**		
		KHU-4L-01 (domestic)	**KRPN-5,6-03**	**KR-3-25 (proposed)**
Aggregation	Tractor class	3	1.4	1.4
Unit power consumption	kW	33.3-49.1	33.3-49.1	We'll have to find out during the experiment
Aggregation method		hard	hard	Hard
Performance	for an hour	1.1–2.2	2.35	We'll have to find out during the experiment
Working speed	km/h	4.6–6.2	5–10	We'll have to find out during the experiment
Transport speed	km/h	20	15	We'll have to find out during the experiment
Working width	M	4.5±0.2	5.6	4 .5±0. 2
Processing depth depending on the type of processing	Cm	4-18	2-12	15-20
Fertilizer application depth	Cm	-	6–12	15 – 20
Number of rows processed by the cultivator in one pass	PC	4	5	4
Width of processed row spacing	Cm	90 or 60	90	90 or 60
Fertilizer hopper capacity, m^3	m^3	-	0.48	0.25-1
Ground clearance	Mm	not less than 400	not less than 400	not less than 300
Overall dimensions in working position	Mm	6000×4300×1900	6570×2015×1135	3000×850×1035
Weight of the cultivator depending on the type of working parts	Kg	2100	880-1080	420-700

3 Results and Discussion

Experimental observations of a prototype nutrient cultivator for applying organic and mineral liquid fertilizers when processing cotton. The fertilizer conveyor of the feed cultivator consists of:

- Cone-shaped vessel directing the spill flow.
- The outlet pipe is connected to the back of the softener stand, its diameter is 15mm.

Depending on the properties of the soil, softening wedges are placed on each rack. As a result, this will allow feeding cotton during the growing season.

For arid areas, including in the soil and weather conditions of Turkmenistan, on the basis of the KR-3-25 implement, a universal agro-reclamation unit will be developed for deep softening of rows of plants and feeding with liquid fertilizer, and its technical, economic, favorable indicators and new technology will be presented agricultural production. In accordance with this, scientific and technical information will be obtained on efficiency and stability, and measures to prevent salinization. As a result, a solution to the following problems will be found:

- Water shortage.
- Ensuring nutrient balance.
- Restoration of the natural state of the agricultural landscape.
- Obtaining a stable harvest.
- Achieving bioclimatic conditions of the fields.

4 Conclusion

Research hypothesis. To apply this inter-row tillage technology, depending on the mechanical composition of the soil and the distance between rows, you will need 12-20 m^3/ha.

The technology will help reduce 2 irrigation waterings. Each irrigation is approximately from 800 to 1200 m^3/ha. On average this is 1 thousand m^3/ha.
As shown above, the following calculation can be done:

$$1000m^3\text{-}20m^3=980\ m^3.$$

As you can see, with one treatment per 1 hectare you can save 980 m^3 of water, and in the full growing season of cotton you can reduce 2 irrigation waterings.

$$1\ ha\ 980m^3 \times 2=1{,}960\ m^3.$$

Using this technology in one season of one hectare, you can save water in the amount of 1960 m^3, when cotton is sown on approximately 580 thousand hectares throughout the country.

Below is a simple calculation:

$$580{,}000\ ha \times 1{,}960m^3=1{,}136{,}800{,}000\ m^3.$$

Thus, using an innovative cultivator in cotton growing in the country, it will be possible to save up to 1,136,800,000 m^3 of water annually.

Note: The innovative cultivator can be used for all crops grown using furrow methods.

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