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Physical and Mechanical Properties of Soil in Fields Used for Cucurbit Crops

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Abstract

The article presents the results of studies on the physical and mechanical properties of the soil of fields intended for cucurbit crop cultivation before planting. The fields are cultivated by dehkan and фермер хозяйства of the republic. During the research, the soil hardness, moisture content, and density of pre-tilled fields, as well as the dimensions of the formed ridges, were determined in accordance with current GOST standards and regulatory documents. The obtained results will serve as the basis for the development of a new combined агрегат for transplanting cucurbit crop seedlings.

Keywords: Cucurbit crops, technology, machinery, mulch film, seedling, soil, hardness, moisture content, density, ridge dimensions, combined machine.

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1. Introduction

One of the main factors in creating new types of agricultural machinery, improving the designs of existing ones, designing them based on energy and resource-saving requirements, and optimizing the technological parameters of their working parts is the study of their operating conditions. In particular, the technological and energy indicators of machines performing soil cultivation, sowing, and other technological operations are directly dependent on the physical and mechanical

properties of the soil.

In recent years, the use of combined units that perform minimal tillage, mulching, sowing, and several technological operations simultaneously has been expanding. To design such machines effectively, it is necessary to possess reliable experimental data on the physical and mechanical properties of the soil. Based on this data, it will be possible to scientifically substantiate the geometric parameters, movement mode, structural dimensions, and strength indicators of the working parts.

In this regard, research has been conducted to study the technologies currently used in the cultivation of melons and gourds by the republic's farms and dehkan farms, as well as their operating conditions [1].

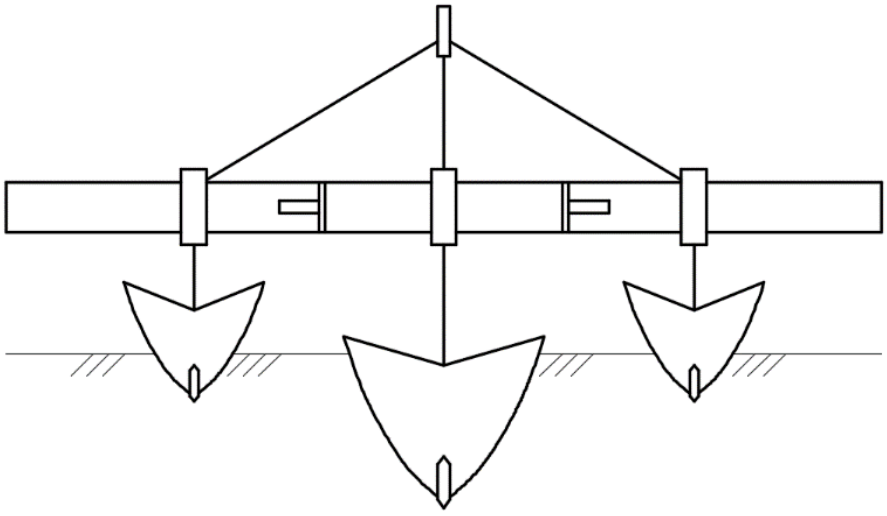
2. Methods

Research was conducted using the methods specified in existing regulatory documents (GOST 20915-2011 and O'zDSt3412:2019) on the field areas of dehkan and private farms growing melons in the Yangiyul district. According to the results of the analysis of literature sources and practical experience, technologies for cultivating melons and gourds in open fields and under film are currently widely used by dehkan, household, and private farms in the republic [2].

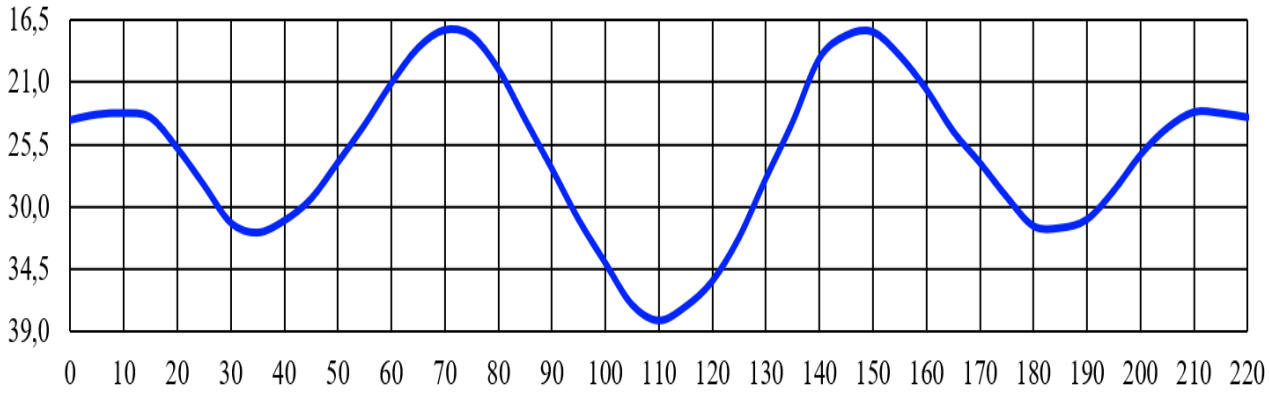
When cultivated in open fields, the following processes are performed: fields plowed in autumn are chiseled in spring, and pre-sowing treatment is performed. With the help of furrow cutters, furrows are opened and organic fertilizers are applied to the furrows by hand, then the furrows with fertilizers are buried with the help of an furrow cutter and a ridge is formed. Seeds or seedlings of melons are manually planted on the formed ridges [2].

In the technology of sowing melon crops under film by seedling method, the process proceeds as follows: fields plowed in autumn are chiseled, harrowed, and harrowed in early spring, then furrowers are used to create irrigated furrows between the rows in accordance with the sowing scheme of melon crops [3].

Furrow openers are handmade for the purpose of laying film over the opening furrow (Fig. 1a). The furrow dimensions shown in Fig. 1-b are in accordance with O'zDSt 3412:2019 "Testing of agricultural machinery. Machines and tools for soil surface cultivation. Test program and methods" were determined using a special rod with a length of 2.2 m and divided into scales every 5 cm, a 50 cm ruler, and an angle gauge. A special rack was installed transversely and horizontally over the furrows formed, and the vertical distance from the rack to the soil surface was measured with a ruler at a distance of 0.1 cm every 5 cm and recorded in the field log. The measurements were repeated six times.



a)



b)

Fig. 1. Structural diagram of the furrow opener used for cultivating melon crops under film (a) and the profile of the furrows opened with it (b).

Subsequently, the furrows opened by hand are covered with film, and the edges are buried; various handmade devices for planting melon seedlings are used to drill holes in the sowing zone on the ridges and prepare pits over the rolled-out film. To moisten the soil, some water is added to the prepared pits, and melon seedlings are planted. The added water serves to provide sufficient moisture until the roots of the melon seedlings develop. In this process, the hardness density and moisture content of the ridge and furrow soil prepared for sowing (before the film is laid) are determined in accordance with GOST 20915-2011 "Testing of Agricultural Machinery. Methods for determining test conditions" [4] were determined using the regulatory document.

When determining soil hardness, the hardness of the 0-5, 5–10, and 10–15 cm layers was determined in 6 (on a single diagonal) locations along the field diagonals using a VISKHOM hardness meter. Before the measurement, the hardness meter was calibrated and the calibration coefficient was determined.

When determining soil density, soil hardness was measured using a special cylinder with a volume of 601.4 cm3, samples were taken from soil layers 0-5, 5-10, and 10-15 cm, and the soil density was determined by the ratio of the soil mass in the cylinder to its volume.

To determine soil moisture, samples were taken using chalk from the 0-5, 5-10, and 10-15 cm layers where the field soil hardness was measured. The obtained samples were thoroughly mixed, and 30-40 g of soil was placed in special aluminum cups (buckets) and tightly sealed with a lid. The mass of the soil-filled box was measured on an MN-390 electronic scale with an accuracy of +0.01 g, and the masses of the numbered box were recorded in the field log. The soil in the measured buckets was dried for 8 hours in a special furnace with a thermostat providing 105 °C of heat with the lid open. Then the buckets were cooled with the lids closed, weighed again, and their ratios were determined.

3. Results

The obtained data are presented in the table below and in fig. 2.

Soil moisture, hardness, and density of irrigation furrows and ridges

Soil layer, cm	Hardness, MPa		Density, g/cm3		Humidity, %	
	on the ridges	in an irrigation furrow	on the ridges	in an irrigation furrow	on the ridges	in an irrigation furrow
0-5	0,54	0,61	1,02	1,15	13,18	14,98
5-10	0,72	0,89	1,11	1,27	16,54	16,75
10-15	1,05	1,16	1,21	1,41	17,54	17,63

Fig. 2. Photographs from the process of determining the physical and mechanical properties of the soil

4. Discussion

As a result of evaluating the geometric parameters of the furrow profile, it was determined that the average depth of the irrigation furrow is 20.6 cm, and the average depth of the furrows for covering the edges of the film is 9.0 cm, indicating that the cultivation zone, i.e., the upper part of the ridge, is formed in the form of a convex hump. The indicators of soil moisture, hardness, and density in the irrigation furrows and ridges increased accordingly as the soil layer deepened.

5. Conclusions

The results of the aforementioned research show that the technology for growing melon crops under film is widely used in practice in the republic. At the same time, about 80% of technological operations in this technology are still performed by manual labor. As a result, labor productivity is decreasing, which negatively affects the economic efficiency of production. To eliminate this problem, it is necessary to create a combined unit that allows for the simultaneous application of film and the planting of melon seedlings in flat or ridged areas. The substantiation of the structural parameters of this unit and the consideration of its operating conditions during the design process are of significant scientific and practical importance.

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