Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH

ISSN: 2394-6709

DOI:10.47191/rajar/v8i12.02

Volume: 08 Issue: 12 December-2022

International Open Access

Impact Factor- 7.108

Page no.- 858-862

Physical–Mechanical Properties and Dimensions of Cotton Rows

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ARTICLE INFO

Published Online: 06 December 2022

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ABSTRACT

Studying the physical–mechanical properties of the soil is one of the important issues when basing the parameters of the device that softens the knot between cotton rows. At the same time, it is necessary to determine these properties when studying the effect of the device on energy and quality indicators. The physical, mechanical and technological properties of the soil (soil moisture, density and hardness) were studied in 0–15 cm layers at intervals of 5 cm according to GOST 20915–2011. It can be seen that the physical and mechanical parameters of the soil increase as its depth increases. It was determined that soil moisture in the range of 0-15 cm varies in the range of 14.8–24.0% hardness, 0.13–0.38 MPa, and density in the range of 0.86–1.05 g/cm^3. The moisture of the soil corresponds to the agrotechnical requirements for processing between rows of cotton.

KEYWORDS: soil compaction, soil density, hardness, moisture, twerdomer, compaction thickness, cotton sprouts, growth period, thermostatic drying oven, analytical balance, cutting ring.

It is known that in the technology of cotton cultivation, during the germination period of cotton sprouts, due to seasonal rains, clumps are formed between rows of cotton. In this case, the physical and mechanical properties of the soil differ from each other.

The physical and mechanical properties of the soil have a significant impact on the energy and quality indicators of the compaction device, and knowledge of these properties is important in justifying the dimensions of the device [1, – p. 1–2].

The physic–mechanical and technological properties of the soil (soil moisture, density and hardness) were studied in 0–15 cm layers at intervals of 5 cm according to GOST 20915–2011, without softening and after softening of the clod formed between cotton rows [2].

Laboratory–field experiments on the study of the physical and mechanical properties of the soil during the formation of cotton between cotton rows were conducted in April–May 2022 in the 10.8–hectare field of the farm “Hayitov Ikrom Sakhavati”, Vobkent district, Bukhara region. According to the mechanical composition of the soil of the field, it belongs to the type of irrigated meadow soil with a medium sandy content. Samples were taken from the 0–5 cm, 5–10 cm and 10–15 cm layers between cotton rows.

Figure 1 shows the field after the rain where the seed has germinated. As can be seen from this picture, the formation of clumps has a negative effect on the development of cotton seedlings.

Figure 1. The view of the cotton field after the rain

A stainless steel cutting ring was selected for soil sampling. Density measurements for clay soils were determined using a 70 mm^3 cutting cylinder [3, 22–26]. The mass of the cutting ring was determined by weighing on an analytical balance. The volume of the ring was calculated using the following expression:

$$V = \frac{\pi d^2 h}{4}, cm^3.$$

where d – the diameter of the ring; h – the height of the ring. Glass plates were selected and their mass (m^2, gr) was determined.

Experiments were carried out by taking samples from 5 places in relation to the diameter of the field where cotton sprouted, and the results are shown in Tables 1 and 2. The natural density of the soil sample is determined by the following expression:

$$\rho = \frac{m - m_1 - m_2}{V}, g/cm^3$$

where, m1 is the weight of the empty ring, gr; m^2 – weight of 2 glass plates, gr; m – weight of the ring together with 2 plates and soil, gr.

Figure 2. Determination of soil density. The density of the soil between the rows of cotton (between 0–15 cm layers)

Table–1

Ordinal number of samples	Measurement results						Density of soil in its natural state, g/sm^3	
	d, sm	h, sm	m, gr	m_1, gr	m_2, gr	V, cm^3	Average of samples	Average of samples
1	5.5	5.2	500	220	140	123	1,18 g/cm^3	1,25 г/cm^3
2	5.5	5.2	520	220	140	123	1,30 g/cm^3	
3	5.5	5.2	490	220	140	123	1,19 g/cm^3	
4	5.5	5.2	510	220	140	123	1,28 g/cm^3	
5	5.5	5.2	520	220	140	123	1,30 g/cm^3	

Density of soil in softened state (between 0–15 cm layers)

Table–2

Ordinal number of samples	Measurement results						Density of soil in its natural state, g/cm^3	
	d, cm	h, cm	m, gr	m_1, gr	m_2, gr	V, cm^3	Average of samples	Average of samples
1	5.5	5.2	460	220	140	123	0,81 g/cm^3	0,86 g/cm^3
2	5.5	5.2	450	220	140	123	0,73 g/cm^3	
3	5.5	5.2	470	220	140	123	0,89 g/cm^3	
4	5.5	5.2	470	220	140	123	0,89 g/cm^3	
5	5.5	5.2	480	220	140	123	0,97 g/cm^3	

The moisture content of the soil between the dense cotton rows is determined using the following expression [3].

$$W = (q_1 - q_2)/(q_2 - q_0) \times 100, \%$$

Here, q_1 – is the dry weight of the soil, gr; q_2 – weight of water in soil pores, gr. In this case, samples are taken every 5 cm in 0–15 cm layers and dried at 100–1050^0 C for 6–8 hours. The experiments were carried out in 3 repetitions and the obtained results were treated statically.

Moisture content of cotton between rows (between 0–15 cm layers)
Table–3

№	Bucks weight, grams			Weight of dry soil, m, gr, q_2–q_0	humidity, %	
	In the free state, m, gr, q_0	With wet soil, m, gr, q_1	With dry soil, m, gr, q_2		Average from experience	Average from experience
1	4	35	31	27	14,8	19,3%
2	4	35	30	26	19,2	
3	4	35	29	25	24,0	

Figure 3. Determination of soil moisture by thermostatic drying

Table 4 shows the moisture, hardness and density of field soil where experimental studies were conducted.

Soil moisture, hardness and density of the experimented field
Table–4

№	Soil layer, cm	Humidity, %	Hardness, mpa	Density, g/cm^3
1	0–5	14.8	0.13	0.86
2	5–10	19.2	0.26	1.1
3	10–15	24.0	0.38	1.2
4	0–15	19.3	0.26	1.05

From Table 4, it can be seen that the physic–mechanical parameters of the soil increase as its depth increases. It was determined that soil moisture in the range of 0–15 cm varies in the range of 14.8–24.0% hardness, 0.13–0.38 MPa, and density in the range of 0.86–1.05 g/cm^3. The moisture of the soil corresponds to the agrotechnical requirements for processing between rows of cotton.

Soil hardness is measured with a tverdomer instrument and is expressed in MPa. The level of hardness depends on the mechanical composition, structure, condition and moisture content of the soil. Hardness decreases as humidity increases. Soil hardness is important for cotton root growth. During the initial growth of plants, the hardness of the soil should not exceed 0.7–0.8 MPa, and during intensive growth should not exceed 0.22 MPa [4, – p. 51–53].

Unimmersed state of the hardometer tool | **The position of the hardometer tool immersed in the soil**

Figure 4. Measuring the hardness of the soil using a tvordomer device

To measure the thickness of the soil, the hard layer is excavated until the surface to be measured is cleaned and the soft soil is exposed, after which it is measured using a ruler and a caliper with an accuracy of ± 0.1 cm. The result is presented in Table 5.

Measurements were made in a field where soil moisture and density were determined

Figure 5. The thickness of the skin was determined with an accuracy of ± 0.1 cm using a ruler and a caliper

The thickness of the soil between cotton rows after rainfall
Table–5

№	Indicator name	Indicator value
1	The average thickness of the thicket, cm	3,1
2	The mean square deviation of the thickness, cm	0,52
3	Coefficient of variation of the thickness of the coating, %	7,8

As can be seen from Table 5, after the heavy rainfall in the fields of cotton sprouting in the conditions of Bukhara region, a thick layer of 3.1 cm appeared.

In short, through the physical and mechanical properties of the compacted soil created as a result of the experiments, it is possible to determine the traction resistance of the device and the degree of friction of the softening working body with the soil. The results of this study are taken into account in determining the parameters of the work body that softens the scum formed between cotton rows, agrotechnical and energetic indicators.

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