Influence of basic treatment of irrigated land on Fertility indicators and harvest formation of sweet pepper

Serazhutdin Aminovich Kurbanov*, and *Diana Sultanovna* Magomedova

FSBEI HE Dagestan State Agrarian University, 367032, st. M. Gadjiev, 180, Makhachkala, Russia

Abstract. The purpose of the research was to establish the most rational soil cultivation system for irrigated conditions, contributing to the preservation of ecological balance and increasing the profitability of pepper production. Experimental studies were carried out on meadow-chestnut soils of the plain zone of the Republic of Dagestan in 2017-2019. in a two-factor experiment to determine the most effective combination of soil cultivation and irrigation regime. The paper presents the results of the influence of plowing and disc cultivation on the water-physical properties of the soil and its biological activity, as well as on the yield of sweet pepper under drip irrigation. The results of three-year research have established that, under irrigation conditions, the most effective method of basic soil cultivation is moldboard soil cultivation to a depth of 0.23 ... 0.25 m, which contributed to the improvement of soil density, its permeability, structural state and increased biological activity in the treated layer. On plowing, the yield of sweet pepper fruits was obtained at the level of 6.23 t/ha. The use of disc processing by 0.10 ... 0.12 m leads to a deterioration of agrophysical indicators of fertility, phytosanitary state of irrigated fields by 1.7 ... 2.2 times, a decrease in yield by 5.1 ... 9.6% and profitability of pepper fruit production by 25.3 ... 31.0%.

1 Introduction

One of the main and labor-intensive elements in the technologies of cultivation of agricultural crops is the main tillage, which is designed to promote the rational use and preservation of its natural fertility, and the growth of crop yields. Among the yield-forming factors, it accounts for up to 20% [9] and at the same time, about 40% of the energy and 25% of the labor resources used to grow crops are spent on its implementation [21]. The problem of resource conservation with existing agro-ecological problems of agriculture requires the introduction of minimized and soil-protective methods and techniques of basic soil cultivation. According to a number of scientists, studies on minimizing soil cultivation carried out in many regions of Russia have shown that its efficiency, including in terms of resource conservation, depends on many factors [4, 10, 12, 14, 17, 20, 22, 23, 24]. The effectiveness of minimization in terms of preventing soil degradation and erosion, mineralization of or-

* Corresponding author: kurbanovsa@mail.ru

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ganic matter, reducing soil moisture loss, reducing energy intensity is beyond doubt, but this is more related to rain-fed lands. The disadvantages of minimization include deterioration of the phytosanitary situation, soil compaction, a decrease in water permeability and moisture reserves, an increase in the consumption of pesticides, the problem of applying fertilizers, especially organic fertilizers [13], and on irrigated lands these disadvantages are increasing.

In the conditions of irrigated agriculture, the minimization of the main tillage is aggravated by the compacting effect of water, which worsens agrophysical indicators of fertility due to increased soil moisture, increased reproduction of weeds, pests and diseases, and increased costs for plant care [3, 5, 18]. Numerous studies have established the advantage of moldboard tillage for perennial grasses and row crops, and surface and flat-cut basic tillage are more promising for grain crops and forage crops for continuous sowing [1, 2, 7, 8, 11, 16].

2 Materials and methods

In 2017-2019, to achieve the research aim a field experiment was laid on the meadow-chestnut medium loamy soils of the educational and experimental farm of the Dagestan State Agrarian University, it was conducted to establish the effect of plowing at a depth of 0.23 ... 0.25 m (control), disc cultivation by 0.10 ... 0.12 m and different irrigation regimes (70, 80 and 90%) on the ontogeny of sweet pepper plants maintained using a drip irrigation system. When growing pepper, a zonal technology was used with planting seedlings in a wide-row way (0.7x0.3 m) in the first half of May at the age of 60...62 days. The method of observation, accounting and analysis is generally accepted in irrigated agriculture and vegetable production [15].

3 Discussions and results

One of the factors of soil fertility is its agrophysical properties, which largely determine the dynamics of soil processes, including biological activity. Under irrigation conditions, important indicators of the physical condition of the soil are the density and permeability of the soil. The bulk density is a complex indicator that reflects the entire set of physical properties of the soil, to a large extent, depends on the methods of soil cultivation. Studies carried out on medium loamy soils indicate that with a soil density of 1.0 ... 1.3 t/m^3, the best water-physical and air properties are created for the growth and development of plants.

Our research has established that the use of plowing by 0.23...0.25 m contributes to a decrease in the density of the arable layer to 1.19 t/m^3; while disc cultivation by 0.10...0.12 m compacts the arable layer up to 1.26 t/m^3. The use of different methods of soil cultivation determined the unequal composition of the arable and sub-arable soil layers. If, during plowing, the soil density during the growing season increases gradually with depth, then during disc processing the transition from the surface layer of 0.0...0.1 m to a layer of 0.1...0.2 m is sharp and amounts to 0.04 t/m^3. During the growing season, the arable layer gradually becomes denser and, during plowing, approaches the equilibrium density (1.27 t/m^3), while when working with discs, a significant overcompaction of the soil is observed, exceeding the equilibrium density by 0.06 t/m^3 (Table 1).

Table 1. Influence of the main tillage and moisture thresholds on soil water-physical properties (2017-2019).

Main tillage	Soil moisture threshold, %	Soil density, t/m^3		Content of water-resistant units, %	Soil permeability, mm/h
		beginning of vegetation	end of vegetation		
Plowing at 0.23-0.25 m, control	70 K	1,19	1,27	46,6	153
	80	1,19	1,27	45,7	149
	90	1,20	1,25	45,4	143
Disc tillage at 0.10-0.12 m	70 K	1,26	1,35	43,5	123
	80	1,27	1,33	42,7	118
	90	1,27	1,32	41,8	106

Analysis of soil density with an increase in the threshold of soil moisture indicates its decrease by 0.02...0.03 t/m^3 in comparison with the control (70%), regardless of the use of moldboard processing or disk tillage. Since porosity is a function of soil density, the lowest porosity (49.8%) was observed in the variant with disc cultivation, which, in our opinion, is associated with the compacting effect of increased irrigation rates.

One of the main characteristics of the water properties of the irrigated soil is its water permeability, the values of which depends on the aftereffect of the basic tillage techniques and determines the effectiveness of the studied pre-irrigation soil moisture thresholds. The use of disking reduced the permeability of the soil in comparison with plowing by an average of 32.7 mm/h, which, in our opinion, is associated with a higher layer density of 0.1...0.2 m ($y = -381.0x + 626.7$ $R^2 = 0.650$) and a 7.0% decrease in the number of water resistant units ($y = -37.62x + 93.13$ $R^2 = 0.639$). Agroecological assessment of soil permeability [19] showed that the transition to resource-saving disc cultivation transfers the irrigated soil from the group with high permeability (more than 150 mm/h) to the group with medium water permeability (50…150 mm/h).

An increase in the pre-irrigation moisture threshold up to 90% and the associated increase in vegetation irrigation had a greater effect on water permeability than the methods of basic soil cultivation. Determination of water permeability in the zone of closure of the moistening contours showed that against the background of disking at a pre-irrigation threshold of 90%, water permeability decreases by 13.8% or 2 times more than during plowing.

The content of water-resistant aggregates is of great importance in assessing the methods of soil cultivation in irrigated conditions. Carrying out plowing contributes to the preservation of 2.5...2.8% more water-resistant aggregates than disk processing, which increases the coefficient of water resistance during moldboard processing from 0.77 to 0.89. This is due to the fact that during moldboard processing as a result of technological operations with the soil, an even distribution of plant residues and organic matter is ensured in it. When processing with disks by structuring processes, only the upper 0.0...0.12 m layer is affected. A direct correlation was also noted between the content of water-resistant aggregates and water permeability ($y = 9.984x - 310.1$ $R^2 = 0.989$).

According to a number of researchers, dumping creates better conditions for the formation of the mass of the root system, an increase in the biological activity of the soil, which enhances the formation of humic acids and, as a consequence, an increase in the content of water-resistant aggregates [6, 17].

Our studies on the effect of plowing and disc cultivation indicated an increased biological activity of moldboard soil cultivation in comparison with disc cultivation, which was assessed by integral indicators: cellulose decomposition activity and “soil respiration” by the intensity of carbon dioxide release (Table 2).

It has been established that dumping to a depth of 0.23...0.25 m promotes an increase in the decomposition of cellulose of plant residues by 21.3%, and most intensively at 70%. At the same time, the rate of loss of the weight of linen fabric during moldboard processing is higher and if in the first month the difference between the methods of basic processing was 23.9%, then in 3 months it increased to 29.3%.

Table 2. Cellulose-destroying and CO2- capacity capacity of the soil, depending on the methods of-main tillage and irrigation (2017-2019).

Main tillage	Soil moisture threshold, %	Cellulose-destroying capacity, %			CO_2- capacity capacity, mg $CO_2/m^2 \cdot h$
		1 month	2 months	3 months	
Plowing at 0.23-0.25 m, control	70 K	46,4	62,8	75,4	959
	80	44,7	59,9	72,3	928
	90	43,3	58,3	70,5	915
Disc tillage at 0.10-0.12 m	70	35,1	45,3	52,7	845
	80	34,0	43,7	51,4	829
	90	33,2	42,4	50,1	822

An increase in the pre-irrigation threshold to 90% reduces the activity of cellulose-decomposing organisms by 4.9% during moldboard tillage and by 2.6% during disc cultivation. nutrition of sweet pepper and provides, along with fertilizers, a significant increase in yield, and on the other hand, a decrease in the biological activity of the soil during disc cultivation slows down the decomposition of organic matter and it can be assumed that the processes of humification will intensify.

The most universal indicator of soil biogenicity is the production of CO_2 by soil organisms or "soil respiration". Our studies have shown that the highest level of carbon dioxide emission was observed during moldboard plowing - 934 mg $CO_2/m^2 \cdot h$, which is 10.8% higher than with disc plowing, and we associate this with the deterioration of the water-physical properties of the soil during disc plowing. ... There was a direct correlation between the cellulose-destroying and CO_2-producing capacity of the soil ($y = 0.201x - 115.8$ $R^2 = 0.982$). As for the levels of pre-irrigation soil moisture, there is a tendency for the "soil respiration" to decrease with an increase in the moisture threshold from 70 to 90%, because the difference is in the range of 2.7...4.6%.

One of the disadvantages of the transition to resource-saving soil cultivation is an increase in the weediness of fields, and under irrigation conditions, not only the phytosanitary situation worsens, but also the accumulation of phytopathogens is noted [13, 18].

Our research found that minimization of the main tillage is a weak regulatory effect on the weed phytocenosis of sweet pepper plantings, since the weediness of crops increases both in quantitative terms, on average from 23.7 to 48.3 pcs/m^2, and in weight ratio - from 120.4 to 189.7 g/m^2, while the increase in weediness is associated with an increase in the number of juvenile weeds in the weed phytocenosis (white-backed weeds, garden purslane, chicken millet, green bristles, etc.). The use of disc treatment leads to a significant increase in the potential debris of the arable layer, which increases from 319 to 678 ml.pcs.seeds/ha. The transition from 70 to 90% practically did not affect the number of weeds and potential soil contamination, which is associated with the peculiarities of local soil moisture during drip irrigation.

Productivity is the most important indicator of the responsiveness of sweet pepper plants to the studied agricultural techniques. A field experiment showed that of the two factors affecting the yield of sweet pepper, the most effective methods of basic tillage, which provided an increase in yield of 14.2 t/ha (34.6%). An increase in the pre-irrigation moisture threshold of the active 0.5 m layer increased the yield of pepper by an average of only 26.7% (Table 3).

Table 3. The yield of sweet pepper and the structure of the yield, depending on the irrigation regime and methods of main tillage, t/ha.

Main tillage	Soil moisture threshold, %	Productivity, t/ha	Fruit weight from 1 plant, kg	Number of fruits per plant, pcs.	Weight of 1 fruit, g.	Marketability, %
Plowing at 0.23-0.25 m, control	70 K	48,4	1,02	17,3	53,9	93,4
	80	62,3	1,32	21,6	61,0	93,3
	90	54,8	1,16	20,2	57,6	91,7
Disc tillage at 0.10-0.12 m	70	35,4	0,75	14,1	53,0	92,5
	80	43,9	0,94	17,2	54,7	92,8
	90	43,7	0,93	16,4	56,9	91,4

HCP_{05} (t/ha): for processing methods - 2.9; for soil moisture thresholds - 2.3; for the interaction of factors - 3.4.

The decrease in yield during disk tillage is explained by the deterioration of the agrophysical indicators of the fertility of the meadow-chestnut soil, as well as the deterioration of the phyto-sanitary state of sweet pepper plantings. The highest yield of sweet pepper fruits was obtained with a combination of moldboard processing by 0.23...0.25 m and maintaining the pre-flood threshold not lower than 80% - 62.3 t/ha.

4 Conclusions

On irrigated meadow-chestnut soils for the cultivation of sweet pepper, the most effective is moldboard tillage to a depth of 0.23…0.25 m, which, when using drip irrigation and maintaining the moisture content of the active soil layer in the range of 80...100%, yields more than 62 t/ha of fruits.

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