Possibilities of drip irrigation of vegetables in agricultural land of Uzbekistan

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Abstract. Reducing water consumption in crop irrigation in the world agriculture, studying soil moisture and water consumption by different irrigation methods, improving soil agrophysical properties and increasing productivity, as well as increasing the productivity of vegetable crops by various irrigation methods and improving phytosanitary conditions (weed and pest density, disease). Extensive research is being conducted to assess the level of one of the most pressing issues in agriculture is the development, improvement and widespread introduction of cost-effective irrigation methods in the spring and summer planting and care of vegetable crops in conditions of water scarcity.

1. Introduction

In today's era of rapid development of science and technology, efficiency can be achieved in vegetable growing and other areas through the introduction of modern, convenient drip irrigation systems [1, 2]. This method has several advantages over drip irrigation [3]. Drip irrigation saves 25\% - 50\% of water compared to other irrigation methods, depending on the type of crop. Because, in the drip irrigation method, the crop is directly irrigated, not the field [3, 4]. Crop yields and crop quality are improved. Yields increase up to 20\% in vegetables and harvest is very average 20 days early [5]. The use of the technique in drip irrigation is significantly reduced, the technique is not used because the soil is loosened and the fertilizer is given along with the water. In the usual way the tractor enters 6-7 times, in the drip method only 1-2 times [6]. It saves 50-70 liters of fuel per hectare. In the drip irrigation method, fertilizers are used significantly less [7]. Costs for fertilizers applied during the growing season are reduced by 50\%. The coefficient of fertilizer absorption by crops is 90\% higher [8].

Extensive measures are being taken in the country to ensure food security, efficient use and protection of water resources [9]. One of the urgent tasks is the use of agro-ameliorative measures against soil erosion, the development and widespread introduction of innovative water-saving technologies for irrigation of vegetable and potato crops in the spring and summer [10]. In this regard, in 2017–2021, “On five priority areas of further development of the Republic of Uzbekistan” - the strategy of action states that "... it is important to introduce intensive methods of agricultural production, first of all, modern agro-technologies that save water and resources, to further strengthen the country's food security" [11].
The aim of the study was to fertilize carrots, white cabbage, sweet peppers, tomatoes and potatoes from vegetable crops in the conditions of typical irrigated gray soils of Tashkent province, Uzbekistan by fertilizing them with 40 tons of organic fertilizer per hectare and improving water-efficient irrigation methods that improve the phytosanitary condition of arable land, saving land resources.

2. Materials and Methods

The research was conducted in 2014-2018 at the TSAU Research and Training Experimental Station. In this research, several data collection methods such as observation, analysis, and measurements were used to deeply digest the actual issue according with the topic of interest. To undertake so, “Methods of conducting field experiments”, multivariate analysis of variance by BA Dospekhov, and VF Belik’s “Field experiment technique in vegetable growing and melon growing” and “Recommendation on the technology of cultivation of vegetables, melons and gourds in the conditions of irrigated agriculture in Central Asia” practical and manual guidelines were used [8-11]. Besides that, the statistical analysis of experimental data was performed in computer programs such as R studio and Statistica 7.0 for Windows, and such mathematical analysis software as MatLab.

3. Results and Discussion

Of the economical irrigation methods, drip irrigation plays an extremely important role in restoring, maintaining and increasing soil fertility. Has a positive effect on the agrophysical and agrochemical properties of the soil.

The effect of the irrigation method on the aggregates carried out during the growing season of the soil in the area of ‘Dar Tashkenta’ variety of sweet pepper cultivars of the experimental field was studied (Table 1).

| Irrigation methods | Soil layer, cm | Macro-aggregates (> 0.25 mm), % | Micro-aggregates (< 0.25 mm), % | Aggregates, 1-20 mm, % | Aggregates, 10 mm > … < 0.25 mm, % | Structure coefficient |
|--------------------|----------------|---------------------------------|---------------------------------|------------------------|-----------------------------------|----------------------|
| Furrow (Control)   | 0-20           | 18.5                            | 81.5                            | 64.5                   | 35.5                              | 1.81                 |
|                    | 20-40          | 17.3                            | 82.7                            | 67.2                   | 32.8                              | 2.04                 |
| Sprinkling         | 0-20           | 19.0                            | 81.0                            | 61.3                   | 38.7                              | 1.58                 |
|                    | 20-40          | 16.9                            | 83.1                            | 65.2                   | 34.8                              | 1.87                 |
| Drip               | 0-20           | 17.7                            | 82.3                            | 67.9                   | 32.1                              | 2.11                 |
|                    | 20-40          | 16.0                            | 84.0                            | 65.1                   | 34.9                              | 1.88                 |
| Subsurface         | 0-20           | 20.3                            | 79.7                            | 67.9                   | 32.1                              | 2.04                 |
|                    | 20-40          | 16.4                            | 83.6                            | 66.3                   | 33.7                              | 1.96                 |

According to the results of agrophysical analysis (Table 1), the amount of aggregates larger than 0.25 mm in the 0–20 cm layer in the control variant was 18.5%. In the method of underground irrigation, the amount of macro-aggregates increased by 20.3% or 1.8% compared to control. Microaggregates below 0.25 mm accounted for 81.5% in the 0–20 cm control variant. In the drip irrigation method, the amount of micro-aggregates increased by 82.3% or 0.8% in a 20 cm layer. The amount of macro-aggregates from 1 to 0.25 mm in the control variant was 64.5%. Drip irrigation increased by 67.9% or 3.4% compared to control. The structural coefficient was 1.81 in the control variant. The volume mass of the soil by the method of irrigated irrigation was 1.31 g/cm³ and the grain size was 51.1%.
In the drip irrigation method, the volumetric mass in the 0-60 cm layer was 1.38 g/cm³ and the grain size was 56.5%, or in the drip irrigation method, where the volume mass was 0.07 g/cm³ and the grain size was 5.4% higher than in the control option.

The results of agrochemical analysis of the 0-30 cm layer of soil showed that at the beginning of the flowering period the amount of nitrate nitrogen (Table 2) was 24.6 mg/kg by irrigation, 27.5 mg/kg by ground irrigation, and at the end of the application period. In the control variant, it was 11.0 mg/kg in the 0-30 cm soil layer, 15.3 mg/kg in the case of sprinkler irrigation, and 12.4 mg/kg in the case of drip irrigation. Decreases in nitrate nitrogen at the end of the growing season have also been noted in other irrigation methods. Due to the frequent formation of sediments in the method of sprinkler irrigation, the plant does not absorb mineral fertilizers well due to low soil moisture. Therefore, it was observed that the growth of vegetables was much slower. At the end of the application period by drip and underground irrigation was 12.4–15.3 mg/kg. The amount of ammonia nitrogen in the 0-30 cm control variant was found to be 35 mg/kg at the beginning of the application period and 22 mg/kg at the end of the application period. This indicates that the plants assimilated ammonia nitrogen during the growing season. Ammonia nitrogen does not accumulate in soil and plant matter. In the underground and drip irrigation method, ammonia nitrogen was 36-38 mg/kg at the beginning of the application period and 20-28 mg/kg at the end of the application period.

Table 2. Changes in soil aggregates of the experimental area planted with sweet pepper variety ‘Dar Tashkenta’ depending on the method of irrigation (2014-2016)

| Irrigation methods | Nitratiazole (N-NO₃) | Ammonia nitrogen (N-NH₄) | Mobile phosphorus (P₂O₅) | Exchange potassium (K₂O) | Soil reaction, (pH) |
|--------------------|----------------------|--------------------------|--------------------------|--------------------------|---------------------|
| Furrow (control)   | 24.6                 | 35.0                     | 40.0                     | 176.0                    | 6.9                 |
| Drip               | 26.5                 | 36.0                     | 45.0                     | 178.0                    | 7.0                 |
| Sprinkling         | 27.5                 | 38.0                     | 47.0                     | 163.0                    | 7.2                 |
| Subsurface         | 27.5                 | 38.0                     | 47.0                     | 163.0                    | 7.2                 |
| Furrow (control)   | 11.0                 | 22.0                     | 18.0                     | 116.0                    | 7.0                 |
| Drip               | 12.4                 | 20.0                     | 26.0                     | 131.0                    | 7.1                 |
| Sprinkling         | 16.0                 | 31.0                     | 18.0                     | 114.0                    | 7.0                 |
| Subsurface         | 15.3                 | 28.0                     | 32.0                     | 110.8                    | 7.1                 |

This is the highest rate, and in the method of underground irrigation, mineral fertilizers are evenly distributed in a layer of 0-30 cm, creating a favorable feeding regime for plants. The assimilated phosphorus element is of great importance in plant development, especially in fruiting, and at the beginning of the application period was the control option - 40 kg/mg in the irrigation method, at the end of the application period - 18.0 kg/mg. Phosphorus fertilizer is applied at the beginning of the application period by rain, drip and underground irrigation methods 42; 45 and 47 mg/kg, 18 at the end of the application period; 26 and 32 mg/kg. The best feeding regimen has been proven to be drip and underground irrigation (Table 2).

When morning vegetable crops were irrigated in the traditional way, the seasonal irrigation norm was 3,716 m³/ha in carrots, 6,206 m³/ha in white cabbage and 11,594 m³/ha in sweet pepper crops. The most promising method for vegetable crop types is drip irrigation, with seasonal irrigation rates of 1,759, 3,237 and 5,924 m³/ha during the three-year study period. At the same time, irrigation water savings for the season amounted to 52.3% in carrots, 47.9% in white cabbage and 48.9% in sweet
peppers. Irrigation methods have had different effects, depending on the water saving, the timing of planting crops (Table 3).

Table 3. Seasonal irrigation norms for vegetable crops according to different irrigation methods, m$^3$/ha (2014-2016)

| Irrigation methods    | Carrot       | White cabbage | Sweet pepper |
|-----------------------|--------------|---------------|--------------|
|                       | Seasonal water discharge, m$^3$/ha | Saved water, % | Seasonal water discharge, m$^3$/ha | Saved water, % | Seasonal water discharge, m$^3$/ha | Saved water, % |
| Furrow (control)      | 3,716        | 0             | 6,206        | 0             | 11,594        | 0             |
| Sprinkling            | 1,981        | 46.7          | 4,857        | 21.7          | 5,518         | 52.4          |
| Drip                  | 1,759        | 52.3          | 3,237        | 47.9          | 5,924         | 48.9          |
| Subsurface            | 2,290        | 38.4          | 4,794        | 39.9          | 5,324         | 54.1          |

The greatest water savings in early potatoes were noted in the variant using the drip irrigation method. In this experimental option, the total seasonal irrigation rate is 1,714 m$^3$/ha, while the control option - 54.3% or 2,036 m$^3$/ha compared to the method of irrigated irrigation (3,750 m$^3$/ha).

The next place in terms of water savings is occupied by options for rainfall and underground irrigation. The amount of water saved compared to the control was 50.0% or 1,873 m$^3$/ha and 49.8% or 1,867 m$^3$/ha, respectively.

Irrigation methods also had a significant effect on early potato yields. In the irrigated (control) option, the yield was 20.2 tons (t)/ha, while in the drip and underground irrigation methods, the highest yields were 23.0 and 22.2 t/ha, respectively, or 2.8 and 2 compared to the control. In the control option, 185.6 m$^3$/ha of water was used for 1 quintal (q) of crop, while in drip and sprinkle irrigation methods, 80 and 81 and 84 m$^3$/q, or 105.6 m$^3$/q, respectively, were used (Table 4).

Table 4. Potato yield according to irrigation methods and water consumption for 1 quintal of harvest

| Irrigation methods | Yield productivity per year, tons/ha | Seasonal water discharge, m$^3$/ha | Water demand for 1 quintal of yield, m$^3$/quintal |
|--------------------|-------------------------------------|-----------------------------------|-----------------------------------------------|
|                    | 2014  | 2015  | 2016  | Average | Additional yield |                                 |                                |
| Furrow (control)   | 19.8  | 20.5  | 20.4  | 20.2    | 0              | 3750                             | 185.6                           |
| Sprinkling         | 20.9  | 21.2  | 21.4  | 21.2    | 1.0            | 1714                             | 80.0                            |
| Drip               | 22.4  | 23.5  | 23.3  | 23.0    | 2.8            | 1873                             | 81.0                            |
| Subsurface         | 21.6  | 22.7  | 22.3  | 22.2    | 2.2            | 1883                             | 84.0                            |
| EKF$_{0.5}$        | 4.6   | 3.9   | 4.0   |         |                |                                 |                                |
| S$_x$, %           | 1.6   | 1.7   | 1.2   |         |                |                                 |                                |

Economical irrigation methods also had a significant impact on the biochemical composition of the early potato. While the dry matter content was 18.0% in the control, this figure was 19.0% in the drip irrigation method and 18.9% in the variant where ground irrigation was used. A similar situation was observed in the amount of starch, except that the highest amount of starch was observed in the experimental variant, where the method of underground irrigation was used (Table 4).

High rates were obtained due to the convenience of the feeding regime when conducting underground irrigation. The average yield of morning carrots was 25.3 t/ha in the control variant. The
high-yield drip irrigation method yielded an additional 28.2 t/ha or 2.9 t/ha compared to the control option.

Irrigation and underground irrigation methods had higher yields than 2.3 and 1.1 t/ha, respectively. In the cultivation of summer white cabbage, high yields were recorded by 47.2 t/ha by rain-fed irrigation and 4.6 t/ha by rain-fed irrigation compared to the control variant. Additional yields of 4.2 and 2.0 t/ha were obtained by drip irrigation methods, respectively. In the cultivation of sweet peppers in economical irrigation methods, the yield was 24.2 t/ha in the control variant. The high yield was 5.2 t/ha by drip irrigation. Additional yields of 2.7 and 2.8 t/ha were obtained, respectively, by underground and rain irrigation methods.

Drip irrigation reduces manual labor since there are no ditches and ditches in the field, there is no need for the diver to follow the water. There is no need to prepare the field for irrigation, that is, to prepare grass, cellophane, paper and other equipment. A single irrigator can easily irrigate 10-20 hectares of land a day. As a result, its labor productivity increases.

Land use efficiency increases and crops are also grown on lands that remain at the edges of the field due to the lack of tractors. No wastewater is discharged into ditches or ditches in the field, the need for ditches is reduced and as a result the field ecology is not disturbed. Field soil is not eroded, the fertile layer of soil is preserved. As the water is cleaned from the filter, the weed seeds do not flow and the field does not catch fire. Excess water is not given when irrigating crops, the depth of groundwater does not rise. In a field with low groundwater levels, seasonal salinization of the soil does not occur. Soils that are not re-salted during the season do not need to be washed in the winter. As a result of the decrease in salinity, digging ditches in the fields is reduced. In vertical well areas, pump performance is reduced, resulting in significant energy savings.

4. Conclusions
In the cultivation of vegetable crops by economical irrigation methods, the law of increasing soil granularity was observed. Compared to drip and drip irrigation, the agrophysical properties of the soil increased by 0.06-0.08 g/cm³, soil granularity by drip irrigation 49.2-50.5%, the amount of agronomically valuable fractions increased by 4-11%, the coefficient of soil structure was about 2.11% by drip irrigation.

The norm of seasonal irrigation of vegetable crops per hectare was 3,716 m³/ha in the morning carrot crop, 6,206 m³/ha in the summer white cabbage, 11,594 m³/ha in the sweet pepper and tomato crop. The drip irrigation method was found to be the most efficient, with water consumption of 1,503, 3,054, and 5,920 m³/ha, respectively. At the same time, seasonal irrigation water savings were 49% per hectare for carrots, 50% for white cabbage, 51% for sweet peppers and tomatoes, and 49.8% for potatoes. Weed seeds do not fall on the field due to drip irrigation. As a result, weed germination is reduced by 70-80 percent.

There was no water erosion in the drip irrigation ditches and we applied 40 tons of organic fertilizer per hectare, which resulted in improved soil fertility and increased productivity. Irrigation method saved 50% of water compared to the control option. Yields on average vegetable crops increased by 10-15% and crop quality improved.

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