

Article

Drip Irrigation Technologies

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Abstract: It will be necessary to reduce water loss through the gradual re-use of lands that have become obsolete as a result of the deterioration of irrigation and land reclamation over the years, the introduction of water-saving technologies and the reconstruction of internal irrigation networks. The use of the following water-saving technologies, such as drip irrigation, drip irrigation and other similar water-saving technologies, is one of the urgent tasks of today. The main parameters are the mode of operation of drip irrigation, the mode of drip irrigation and the design features of the system. The parameters of the drips and the total consumption of drips required to set a single irrigation norm are determined.

Keywords: Water Saving, Irrigation Technology, Drip, Irrigation Mode, Irrigation Rate, Irrigation Consumption

1. Introduction

The need for efficient water resources management is a pressing global challenge: in regions where dependence on agriculture to support economic and food security is a key factor, the vulnerability to water scarcity is also a concern. Almost 20 million hectares of land, including 3.2 million hectares of irrigated fields, are used for food production and economic demands in Uzbekistan and agricultural productivity is based on the efficiency of irrigation systems. Driven by this necessity, water saving technologies like drip irrigation has been under research to save water and promote increased crop yield. The capillary drip irrigation system provides a variable water distribution to the plant root zones by distributing moisture directly to the plant root zones thereby minimizing gravitational loss of water. The method is aligned with the aims described in 2020–2030 "Concept for the Development of the Water Management System of the Republic of Uzbekistan", aiming for water-saving and adoption of innovative irrigation systems. Nevertheless, this technology may be successfully implemented only after the level of irrigation norms is carefully calibrated according to soil moisture levels and crop water needs. Despite well developed irrigation technology, gaps remain in the application optimization for differing soil compositions, climatic consideration, and crop types. Previous works determined irrigation norms

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and analyzed physical properties of soils but in order to generalize these parameters further investigation is yet to be done .

Moreover, the interaction between irrigation technologies and mineral fertilizers provides an underexplored avenue for optimal use of available resources and minimizing resource wastage in agriculture. The effectiveness of the drip irrigation technologies under Uzbekistan's climatic conditions are examined from a quantitative perspective in this study. Formulas are used in the analysis to calculate irrigation norms, irrigation time, and total seasonal water consumption. The research addresses specific growth stages and soil characteristics with the hope of resulting in actionable insights on how to improve agricultural water management practices. The findings are expected to elaborate on the possibility of drip irrigation systems reduced the use of water by up to 50 per cent, and using fertilisers more efficaciously while maintaining suitable agricultural productivity that is sustainable. Implications of this research extend to policymakers and agricultural practitioners, for a greater emphasis upon the incorporation of water saving technologies in national agricultural strategies in response to water scarcity and increased food security.

2. Materials and Methods

This study is based off of the methodologies on the quantitative analysis drip irrigation devices designed for Uzbekistan's agricultural conditions. The objective of the research is to establish irrigation norms, water consumption and irrigation efficiency for vegetables and potatoes under specific growth stages and soil conditions. Advanced irrigation systems, designed to dispense water only to the plant root zones were used in experimental fields from which data were collected. Standard agronomic formulas, including calculation of single and seasonal irrigation norms, were used in the calculations. They arrived at these norms through evaluation of how much soil moisture is required at various growth stages, in order to deliver that amount of water without wasting any of it. A dissolved mineral fertilizer (DMF) was also used in the study, to assess the impact of the use of such fertilizers in irrigation water on nutrient efficiency and crop productivity. Parameters for drip irrigation systems (i.e., dripper spacing, flow rates, etc.) were systematically varied to conform to crop water requirements and climatic conditions. Water use efficiency, soil moisture retention and yield were measured during the irrigation process. By comparing these metrics through different soil types and climatic conditions, the research seeks to develop guidelines on the proper use of drip irrigation technologies in Uzbekistan. The methodology stresses applied approach in experimental outcomes matching objective of the national water management strategy. The study integrates scientific calculations with agricultural practice in real life, to generate actionable insights on how to optimally use water, increase crop yields, and resiliently farm in water scarce areas.

3. Result and Discussion

Currently, over 20 million hectares of agricultural land, including 3.2 million hectares of irrigated fields, are being utilized to produce food products for the population and raw materials needed for economic sectors.

To efficiently manage water resources in the future, the President of the Republic

of Uzbekistan issued a decree on July 10, 2020, approving the "Concept for the Development of the Water Management System of the Republic of Uzbekistan for 2020–2030." The decree outlines projected measures to improve the efficiency of agricultural land use during 2020–2030 [1-5].

Utilizing water-saving technologies has become one of the pressing tasks of today. We propose determining irrigation norms for drip irrigation of vegetable crops and potatoes using the following formula.

$$M = 100 \gamma h S (W_{\text{ППВ}} - W_i), \text{ m}^3/\text{ha}$$

S - is determined using the following formula:

$$S = \frac{W}{ab}$$

here: W - the area moistened by one dripper, m^2 ;

a - the distance between irrigation pipes, m ;

b - the distance between drippers, m .

As an example, we will demonstrate the drip irrigation process for potatoes as a vegetable crop. Potatoes require the most water during the following growth stages: tuber initiation, the beginning of flowering, post-flowering, and during the period of maximum tuber growth.

Late-season potatoes produce tubers weighing 85–100 grams each, with a yield of 1–1.2 kg per plant. The planting density of potato crops is approximately 40,000 plants per hectare.

The irrigation norm depends on the depth of soil moisture, which increases from 0.25 m to 0.6 m during different growth stages of the potatoes:

h - depth of soil moisture at planting, $h = 0.25 \text{ m}$;

h - depth of soil moisture during the flowering stage, $h = 0.5 \text{ m}$;

h - depth of soil moisture during tuber formation and accumulation of tuber weight.

To calculate the irrigation norm, it is necessary to determine the area of soil moisture.

$$S = W/a \cdot b$$

here: $W = 0,7 \cdot 1 = 0,7 \text{ m}^2$, $a = 1,4 \text{ m}$, $b = 0,7 \text{ m}$,

$$S = 0,7/1,4 \cdot 0,7 = 0,71$$

We propose calculating the single irrigation norm using the following formulas:

$$M_1 = 100 \cdot 1,37 \cdot 0,25 \cdot 0,71 (21,06 - 16,38) = 113,80 \text{ m}^3/\text{h}$$

$$M_2 = 100 \cdot 1,37 \cdot 0,5 \cdot 0,71 (21,06 - 16,38) = 227,61 \text{ m}^3/\text{h}$$

$$M_3 = 100 \cdot 1,37 \cdot 0,6 \cdot 0,71 (21,06 - 16,38) = 273,13 \text{ m}^3/\text{h}$$

The total water consumption for all drippers in the plot is determined using the following formula:

$$Q = 0,0022 \cdot 10204 = 22,45 \text{ m}^3/\text{coat}$$

T - the calculated irrigation time, which depends on the precise single irrigation norm:

$$T_1 = m_1/Q = 113,8 / 22,45 = 5,07 \text{ hours}$$

$$T_2 = m_2/Q = 227,61 / 22,45 = 10,14 \text{ hours}$$

$$T_3 = m_3/Q = 273,13 / 22,45 = 12,16 \text{ hours}$$

The irrigation norm for one season consists of the total irrigation during the vegetation period.

In favorable climatic conditions, it is recommended to perform five irrigations during the vegetation period: the first irrigation in July, three irrigations in August and September, and one irrigation in October, making a total of five irrigations.

The irrigation norm for the vegetation period is determined using the following formula:

$$m_{\text{ver}} = \sum m_k, \text{M}^3$$

here: m_k - The amount of water for a plant during its specific vegetation period,

$$m_k = M_k \cdot N_k$$

here: N_k - irrigation number

$$m_1 = M_1 \cdot N_1 = 113,81 = 113,8 \text{ M}^3/\text{га}, m_2 = M_2 \cdot N_2 = 227,613 = 682,83 \text{ M}^3/\text{га}$$

$$m_3 = M_2 \cdot N_2 = 273,134 = 1092,52 \text{ M}^3/\text{га}, m_{\text{ver}} = 113,8 + 682,83 + 1092,52 = 1889,15 \text{ M}^3/\text{га}$$

It has been determined that applying mineral fertilizers dissolved in irrigation water allows for the saving of 44-57% of nitrogen fertilizers.

In the case of drip irrigation, the water delivered to the plant's root zone percolates through the soil layer via capillaries. In this process, the effect of gravity is minimal, and the moisture distribution mainly occurs due to capillary forces [7, 8].



Drip irrigation technology

The required water layer is determined according to the following formula.

$$P = \varphi \cdot H \cdot (\beta_{\text{чднс}} - \beta_c), \text{M}$$

here: P – calculated layer, m;

H – calculated depth at 1 meter, m;

$\beta_{\text{чднс}}$ – the soil moisture at the lower limit of plant growth during the dormant period;

β_c – the upper limit of soil moisture, determined by the following formula:

$$\beta_c = \beta_{\text{чднс}} \cdot a$$

α – conductivity coefficient;

φ – water consumption coefficient, accounting for the distribution of moisture across the profile (for heavy soils, $\varphi = 1.12$; for sandy soils, $\varphi = 1.10$; for light soils, $\varphi = 1.05$; for sandy loam soils, $\varphi = 1.0$).



Rain-fed water-saving irrigation technology



Water-saving irrigation technology

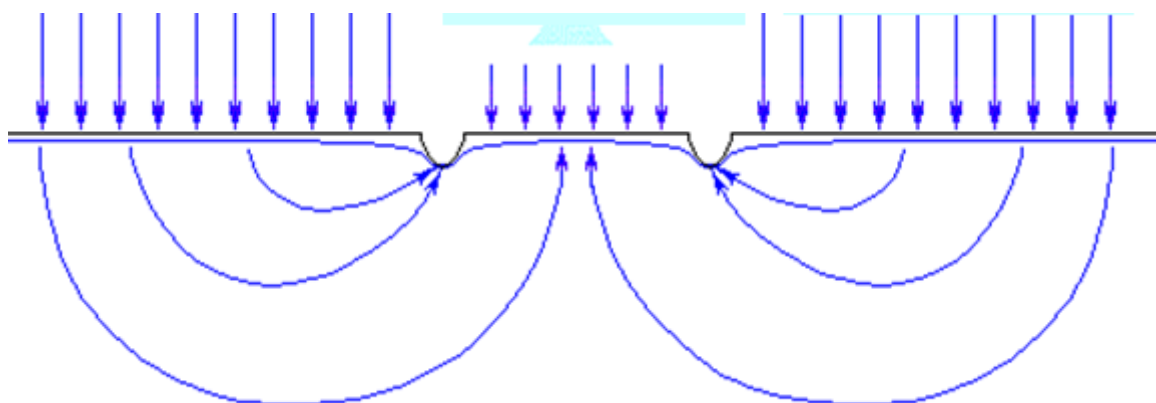


Irrigation through siphon system



Mulching irrigation technology

The irrigation scheme for local areas with shallow groundwater using drip irrigation



4. Conclusion

In conclusion, it can be said that water-saving irrigation technologies cannot be applied in the following cases:

1. In areas with heavy mechanical composition, salinized or prone to salinization, and with shallow groundwater (less than 1.5 m and with mineralization greater than 3 g/l).
2. If the field is used for crop rotation and has saline soil, waterlogging and salt accumulation will occur in the drip irrigation area.
3. In conditions of significant interruptions in the supply of electrical energy.
4. When the irrigation water is more than 3 g/l in mineralization.
5. When the water is highly saline.

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