SUBSURFACE DRIP IRRIGATION FOR COTTON UNDER WATER-SCARCE CONDITIONS.

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КАПЕЛЬНОЕ ВНУТРИПОЧВЕННОЕ ОРОШЕНИЕ ХЛОПЧАТНИКА В УСЛОВИЯХ ДЕФИЦИТА ВОДЫ

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Annotation

This article analyzes the efficiency of subsurface drip irrigation in cotton cultivation under water-scarce conditions, focusing on its impact on irrigation timing and rates. The research was conducted under the agro-climatic conditions of the Andijan region. Methods for determining crop water consumption were applied based on soil moisture reserves, evapotranspiration, wind speed, air temperature, and relative humidity using the FAO-recommended Penman method. The study highlights the potential for rational use of water resources, increasing crop yields, and enhancing the volume of agricultural output per 1 m³ of water. The water requirements of cotton were calculated according to its growth stages, and factors affecting yield were scientifically evaluated.

Keywords: drip irrigation, evapotranspiration, FAO Penman method, cotton crop, water consumption, irrigation rate, agrometeorological indicators, water resource saving, crop productivity.

Аннотация

В данной статье проанализирована эффективность внутрипочвенного капельного орошения при выращивании хлопчатника в условиях дефицита воды, а также его влияние на сроки и нормы полива. Исследования проводились в агроклиматических условиях Андижанской области. Для определения водопотребления растений использовались методы на основе запасов влаги в почве, испарения (эвапотранспирации), скорости ветра, температуры воздуха и относительной влажности по методу Пенмана, рекомендованному ФАО. В работе показаны возможности рационального использования водных ресурсов, повышения урожайности и увеличения объема сельскохозяйственной продукции на каждый 1 м³ воды. Потребности хлопчатника в воде рассчитывались по фазам его роста, а факторы, влияющие на урожай, были научно обоснованы.

Ключевые слова: капельное орошение, эвапотранспирация, метод Пенмана ФАО, хлопчатник, водопотребление, норма полива, агрометеорологические показатели, экономия водных ресурсов, урожайность.

Introduction

Water scarcity is one of the most pressing challenges in arid and semi-arid regions, particularly in the agricultural sector of the Fergana Valley in Uzbekistan, including the Andijan region. Traditional surface irrigation methods—such as open canals and furrows—result in significant water losses due to evaporation, infiltration, and runoff. Moreover, these methods contribute to soil salinization, compaction, erosion, and a reduction in soil fertility and crop yields. Under such conditions, efficient use of available water resources and maximizing productivity per unit of water used have become critical needs.

In recent years, subsurface drip irrigation (SDI) has emerged as a promising water-saving technology worldwide. This method delivers water directly to the root zone of plants, significantly reducing evaporation losses, preserving soil structure, and creating optimal moisture conditions for plant growth.

This study was conducted under the specific soil and hydrogeological conditions of Andijan region, characterized by meadow-gray, medium sandy loam soils and groundwater levels ranging from 2.0 to 2.5 meters. The main objective of the research was to assess the effectiveness of subsurface drip irrigation on irrigation scheduling, seasonal water requirements, and water use efficiency.

The relevance of the study lies in its practical potential to:

- Reduce river water consumption for irrigation;
- Increase crop productivity per unit (m^3) of water used;
- Ensure sustainable cotton production under conditions of limited water resources;
- Improve the reclamation status of soils and maintain agro-ecological stability.

In addition, the research applied the Penman method, as recommended by FAO, to estimate crop evapotranspiration. Based on this, a scientifically grounded irrigation regime was developed for cotton cultivation using innovative and water-saving approaches.

Methods

The study was conducted in meadow-gray soils with medium sandy texture under conditions of groundwater levels at 2.0–2.5 m. The determination of irrigation norms and number of irrigations was based on soil moisture deficits and crop biological requirements, using S.N. Ryzhov's soil moisture formula:

$$m=\left(W_{ЧДНС}-W_{ФАК}\right)100\,Jh+к$$

Where:

$W_{ЧДНС}$ - soil's field capacity (% by weight)

$W_{ФАК}$ - actual pre-irrigation moisture (% by weight)

J - soil bulk density (g/cm³)

h - effective root zone depth (m)

k - evaporation loss factor (10% of deficit)

To determine crop water consumption (evapotranspiration), the Penman method (FAO, 1984) was used due to its accuracy. Reference evapotranspiration (ET0ET_0ET0) was calculated as:

$$ET_0 = c\{wRn + (1\text{-}w)f\,(u)\,(l_a - l_d)\},$$

Where:

w - radiation weight coefficient

Rn - net radiation (mm/day)

f(u) - wind function

l_a- l_d - vapor pressure deficit

c - correction coefficient based on local weather

Actual evapotranspiration for cotton ETcrop was calculated with crop coefficient K_c:

$$ETcrop = K_c\ ET_o$$

The growth stages of cotton were divided into four phases, and corresponding crop coefficients were used based on FAO recommendations:

Initial: Kc=0.45 (25–30 days)

Crop development: Kc=0.80 (45–60 days)

Mid-season: Kc=1.15 (50–70 days)

Late-season: Kc=0.65 (30–50 days)

Results

The application of intra-soil irrigation significantly improved water use efficiency. By tailoring irrigation schedules to evapotranspiration and crop growth stages, water application could be reduced without compromising yield. The calculated seasonal evapotranspiration values allowed for precise irrigation timing and reduced the number of irrigations. Radiation, wind speed, air humidity, and temperature were effectively incorporated into the model, which showed evapotranspiration variations between 3.5–6.2 mm/day depending on the growth stage and weather conditions.

Discussion

The results highlight the advantages of intra-soil irrigation in arid climates. Water-saving was achieved by applying water directly to the root zone and minimizing evaporation losses. The FAO Penman method proved to be a reliable tool for determining irrigation needs. Crop coefficients adjusted by growth stages ensured accurate water application. The study confirms that proper irrigation management can improve crop productivity and sustainability of water resources in cotton cultivation.

Conclusion

This research demonstrates that intra-soil (drip) irrigation, when managed according to scientifically determined crop water requirements, can significantly improve water use efficiency and yield in cotton cultivation. The use of advanced evapotranspiration models and local climate data allows for more precise irrigation planning in arid regions

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