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IMPROVING COTTON PRODUCTIVITY THROUGH EFFICIENT IRRIGATION MANAGEMENT AND WATER-SAVING TECHNOLOGIES

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Abstract

Cotton is one of the most important agricultural crops and plays a significant role in the economic development of many countries, particularly those with arid and semi-arid climates. Efficient irrigation management is essential for maintaining cotton productivity, improving fiber quality, and ensuring sustainable agricultural production. This article examines the importance of irrigation in cotton cultivation, the main factors affecting crop water requirements, and modern water-saving irrigation technologies. Particular attention is paid to drip irrigation, furrow irrigation, soil moisture monitoring, and optimal irrigation scheduling during different stages of cotton development. The economic and environmental benefits of rational water management are also discussed. The application of scientifically based irrigation practices can reduce unnecessary water consumption, improve soil conditions, and increase the efficiency of cotton production.

Keywords: cotton cultivation, irrigation management, water resources, drip irrigation, furrow irrigation, soil moisture, water-saving technologies, cotton productivity, sustainable agriculture, irrigation efficiency.

INTRODUCTION

Agriculture is one of the largest consumers of freshwater resources worldwide. In countries with dry and semi-arid climatic conditions, irrigation plays a particularly important role in agricultural production. Cotton is an economically valuable crop that requires an appropriate water supply throughout its growing season to ensure normal growth, development, and high-quality fiber production. Uzbekistan has favorable conditions for cotton cultivation; however, limited water resources, high summer temperatures, and increasing soil salinity create significant challenges for agricultural producers. Therefore, improving irrigation practices and introducing modern water-saving technologies are essential for the sustainable development of cotton farming.

Water management in cotton fields should be based on the biological characteristics of the crop, soil properties, climatic conditions, and the availability of irrigation water. Excessive irrigation may cause waterlogging, nutrient leaching, and secondary soil salinization, whereas insufficient irrigation can reduce plant growth, flowering, boll formation, and final yield. The effective use of irrigation water is therefore one of the most important factors in increasing agricultural productivity and protecting natural resources.

THE IMPORTANCE OF WATER FOR COTTON DEVELOPMENT

Cotton is relatively drought-tolerant compared with some other agricultural crops. Nevertheless, sufficient soil moisture is necessary during its different growth and development

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stages. Water participates in photosynthesis, nutrient transportation, cell development, and other physiological processes. The water requirements of cotton depend on soil texture, air temperature, solar radiation, rainfall, atmospheric humidity, plant density, and the stage of crop development.

During germination and early seedling development, adequate moisture is necessary to ensure uniform plant emergence. During vegetative growth, water supports the development of roots, stems, and leaves. The flowering and boll formation stages are particularly sensitive to water stress. Insufficient moisture during these periods may lead to flower shedding, reduced boll numbers, and lower cotton yield. During the maturation stage, excessive irrigation should generally be avoided because it may delay crop maturity and complicate harvesting operations. Therefore, irrigation should be planned according to the actual water requirements of cotton plants.

MODERN IRRIGATION METHODS IN COTTON CULTIVATION

Furrow irrigation is one of the traditional and widely used methods of cotton irrigation. In this method, water flows through small channels constructed between crop rows and gradually infiltrates into the soil. Its main advantages include relatively low initial investment, simple operation, and compatibility with conventional agricultural machinery. However, furrow irrigation may result in considerable water losses through deep percolation, surface runoff, and uneven water distribution if field leveling and irrigation management are inadequate. To improve its efficiency, farmers should pay attention to furrow length, water flow rate, irrigation duration, and soil infiltration characteristics. Drip irrigation is a modern water-saving technology in which water is delivered directly to the root zone through pipes and special emitters. This method allows farmers to maintain more stable soil moisture conditions while reducing unnecessary water application.

Drip irrigation has several important advantages. It improves the efficiency of water use, provides more uniform moisture distribution in the root zone, reduces evaporation from the soil surface, and allows fertilizers to be applied together with irrigation water. Furthermore, it can reduce weed development in areas between irrigation lines. Drip irrigation is particularly beneficial in regions experiencing water shortages. However, its successful implementation requires appropriate filtration systems, regular maintenance, and investment in irrigation infrastructure.

Sprinkler irrigation is another method used in agricultural production. It distributes water over cotton fields in the form of artificial rainfall. Water is supplied through pipes and sprayed by special nozzles. This technology can provide relatively uniform irrigation when properly designed and operated. Nevertheless, its effectiveness may be reduced under strong winds and high temperatures because of evaporation losses. The selection of an irrigation method should be based on local climatic conditions, soil characteristics, water availability, and production costs.

IRRIGATION MANAGEMENT DURING DIFFERENT GROWTH STAGES. Effective irrigation management requires understanding the relationship between soil moisture and cotton development. The irrigation schedule should be adjusted according to the actual water requirements of the crop rather than following a fixed calendar.

During germination and seedling establishment, adequate moisture is necessary for seed germination and uniform emergence. Water application should prevent the upper soil layer from drying excessively. During vegetative growth, cotton develops its root system, stems, and

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leaves. Irrigation should support active plant growth without causing excessive vegetative development. The flowering stage is particularly important because water stress may negatively affect flower development and increase flower shedding. Maintaining suitable soil moisture during this period contributes to normal reproductive development.

During boll formation, sufficient soil moisture is required for boll development and fiber formation. Inadequate irrigation may significantly reduce cotton yield and negatively affect fiber quality. At the maturation stage, irrigation should be reduced or stopped according to soil moisture, weather conditions, and crop maturity. Excessive watering at this stage may delay harvesting and increase production costs.

FACTORS AFFECTING IRRIGATION EFFICIENCY. The efficiency of irrigation depends not only on the irrigation method but also on soil, climatic, and technological conditions. Soil texture is one of the most important factors. Sandy soils generally have lower water-holding capacity and require more frequent irrigation with smaller water applications. Clay soils can retain more water but may have lower infiltration rates. High temperatures and strong winds increase evapotranspiration and consequently increase crop water requirements. Therefore, climatic conditions should be considered when determining irrigation frequency and water application rates. Soil salinity is another important issue in irrigated cotton production. Excessive salt accumulation in the root zone can negatively affect water uptake and plant development. Proper irrigation management, drainage, and appropriate leaching practices are therefore necessary in saline areas.

Regular monitoring of soil moisture helps determine the appropriate time for irrigation and prevents both water stress and excessive watering.

DIGITAL TECHNOLOGIES FOR IRRIGATION MANAGEMENT. The development of digital agriculture provides new opportunities for improving irrigation efficiency. Modern technologies allow farmers to monitor field conditions and make more accurate decisions regarding water application.

Soil moisture sensors can measure the amount of water available in the root zone. Based on these measurements, farmers can determine when irrigation is necessary. Weather stations provide information about temperature, humidity, wind speed, and rainfall. These parameters can be used to estimate crop evapotranspiration and calculate irrigation requirements. Remote sensing and satellite monitoring technologies can also help assess crop conditions over large agricultural areas. They provide information about vegetation development, water stress, and variations in field conditions.

The integration of these technologies into cotton production can improve irrigation scheduling, reduce unnecessary water consumption, and increase agricultural efficiency.

ECONOMIC AND ENVIRONMENTAL BENEFITS OF WATER-SAVING TECHNOLOGIES. The implementation of efficient irrigation technologies provides several economic and environmental advantages. Reducing unnecessary water consumption helps preserve limited freshwater resources. This is particularly important in regions where agriculture depends heavily on irrigation. Maintaining optimal soil moisture can improve cotton growth and contribute to better fiber quality. Efficient irrigation management may also reduce energy consumption associated with water pumping and distribution. Furthermore, the prevention of excessive irrigation helps reduce waterlogging, nutrient losses, and secondary soil salinization. Combining modern irrigation systems with scientifically based fertilizer application can improve the overall efficiency of agricultural production.

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However, the economic benefits of each technology depend on installation costs, maintenance requirements, energy prices, water availability, and local agricultural conditions.

CONCLUSION

Efficient irrigation management is one of the key factors determining the productivity and sustainability of cotton cultivation. The appropriate selection of irrigation methods, consideration of crop water requirements, and monitoring of soil moisture are essential for achieving stable agricultural production. Drip irrigation, improved furrow irrigation, and sprinkler systems offer different opportunities for increasing water-use efficiency. The most suitable method should be selected according to soil properties, climatic conditions, economic feasibility, and available water resources. Modern digital technologies, including soil moisture sensors, weather monitoring systems, and remote sensing, can further improve irrigation scheduling and agricultural management. For Uzbekistan, where water resources are particularly valuable, the introduction of water-saving technologies and scientifically based irrigation practices is of strategic importance. Their effective application can help conserve water, maintain soil fertility, improve cotton productivity, and support the long-term development of sustainable agriculture.

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