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DEVELOPMENT OF ELEMENTS OF OPTIMAL IRRIGATION TECHNIQUES FOR OVERLAND IRRIGATION OF COTTON IN THE CONDITIONS OF BUKHARA REGION

Abstract: This article delves into the development of key elements for optimal overland irrigation techniques tailored to the specific conditions of cotton cultivation in the Bukhara region. By analyzing soil characteristics, water availability, and cotton growth stages, we aim to propose practical and readily implementable strategies to enhance water use efficiency while maintaining high yields.
Key words: irrigation techniques, water availability, cotton growth stages, water resources, economic constraints

Introduction. Cotton, a cornerstone of Uzbekistan's economy, faces a pressing challenge: maximizing yield in the face of increasing water scarcity. This is especially pertinent in the Bukhara region, where alluvial soils, traditionally conducive to cotton cultivation, are increasingly stressed due to dwindling water resources and the risk of salinization. While modern irrigation techniques like drip irrigation offer significant water savings, their adoption in the region is often limited by economic constraints and the need for infrastructural investment. Therefore, optimizing traditional overland irrigation methods becomes essential to ensure the sustainability of cotton production in Bukhara. Water-saving technologies on 642.4 thousand hectares in the country for 2017–2021, including 308.6 thousand hectares drip irrigation, 14.7 thousand hectares – sprinkler irrigation, 10.6 thousand hectares discrete irrigation system, 78.8 thousand per hectare flexible pipes and 20.9 thousand hectares film irrigation, and 208.9 thousand hectares of arable land were leveled using laser equipment, which is 15% of the total irrigated area. As a result, a total of 10 billion cub meter of water was saved in 2021, including 3.0 billion cub meter due to the introduction of water-saving technologies, which provide water for secondary crops. Water Consumer Associations was established on farms and dehkan farms. However, outdated techniques and technologies are still used to irrigate crops. In particular, irrigation of all agricultural crops, saline leaching, irrigation to create a reserve of moisture in the soil is carried out by furrow or flood irrigation. Also, the technology of growing all crops is inextricably linked with these irrigation methods. The specificity of a drip irrigation system is determined by the fact that it consists of a permanent network of pressurized water distribution. This network delivers the same amount of water to the root layer of the crop as the plant needs.

Overland irrigation, which includes furrow and basin irrigation, remains the predominant method for cotton irrigation in Bukhara due to its relative simplicity and lower initial investment costs. However, several challenges demand a shift towards more optimized practices:

Water Scarcity: Decreasing water availability in the Zarafshan River basin necessitates careful water management strategies. Salinization: Excessive irrigation and poor drainage in alluvial soils can lead to the build-up of salts in the root zone, negatively impacting cotton growth and yield.

Uneven Water Distribution: Traditional overland irrigation methods often result in uneven water distribution, with some areas receiving excess water while others remain under-irrigated.

High Evaporation Losses: Open water channels in furrow irrigation contribute to significant water loss through evaporation, especially in the arid climate of Bukhara.

Optimizing Existing Infrastructure: By refining existing furrow designs, irrigation scheduling, and water management practices, significant improvements in water use efficiency can be achieved.

Leveraging Local Knowledge: Farmers in the region possess valuable traditional knowledge of irrigation practices adapted to local conditions. Integrating scientific principles with this indigenous knowledge can lead to more sustainable solutions.

Accessibility and Affordability: Optimized overland irrigation techniques, requiring minimal additional investments, are more accessible to a wider range of farmers, promoting sustainable cotton production across various farm sizes. Developing optimal overland irrigation techniques for cotton in the Bukhara region requires a holistic approach, considering the interplay of various factors.

Texture Determination: Accurate determination of soil texture (proportion of sand, silt, and clay) is essential for designing efficient irrigation systems. Sandy soils have lower water holding capacity and require more frequent irrigation with smaller water volumes compared to clay soils.

Infiltration Rate Measurement: Measuring the rate at which water infiltrates the soil helps determine the appropriate irrigation duration and flow rates to avoid runoff and erosion. Infiltration rate can vary significantly within a field, necessitating adjustments to furrow length and spacing.

Land Leveling: Proper land leveling ensures uniform water distribution across the field, minimizing waterlogging in low-lying areas and under-irrigation in higher areas. Laser leveling technology, though an investment, can significantly improve irrigation efficiency.

Furrow Spacing and Dimensions: Optimizing furrow spacing and dimensions based on soil type, slope, and cotton row spacing is crucial for uniform water distribution. Narrower furrows are generally recommended for sandy soils to reduce percolation losses.

Furrow Length: Long furrows increase the risk of uneven water distribution due to water infiltration along the furrow length. Dividing long furrows into shorter segments using cross-slope barriers or earthen ridges can improve irrigation uniformity.

Furrow Slope: Maintaining an appropriate furrow slope ensures a steady flow of water without causing erosion. The ideal slope depends on soil type and furrow length, but generally, a slope of 0.05-0.1% is recommended for most alluvial soils.

Growth Stage-Based Irrigation: Cotton water requirements vary significantly throughout the growing season. During the initial growth stages, when root systems are shallow, more frequent irrigation with smaller volumes is necessary. As plants mature and root systems develop, irrigation frequency can be reduced, and volumes increased.

Evapotranspiration Monitoring: Evapotranspiration (ET), the combined loss of water from the soil surface and plant transpiration, is a crucial factor for determining irrigation timing and volume. Utilizing weather data and crop coefficients specific to the cotton variety, farmers can estimate ET and schedule irrigation to replenish water lost from the soil.

Soil Moisture Monitoring: Direct measurement of soil moisture using tools like tensiometers or soil moisture sensors provides real-time data on water availability in the root zone. This allows for precise irrigation scheduling, preventing both under-irrigation and over-irrigation.

Use of Forecasting Tools: Integrating weather forecasts into irrigation scheduling can help anticipate rainfall events and adjust irrigation accordingly, further improving water use efficiency.

Mulching: Applying organic mulch, such as crop residues, around the base of cotton plants can significantly reduce evaporation losses from the soil surface. Mulching also helps suppress weeds and moderate soil temperature.

Conservation Tillage: Minimizing tillage practices helps preserve soil structure, improve water infiltration, and reduce evaporation losses compared to conventional tillage methods.

Alternate Furrow Irrigation: Irrigating every other furrow and alternating in subsequent irrigations can improve water use efficiency in some soil types. This method allows for deeper water penetration with less water applied, reducing runoff and evaporation losses.

Automated Irrigation Systems: While requiring higher initial investments, automated irrigation systems equipped with soil moisture sensors and weather stations can significantly improve irrigation precision, reduce labor requirements, and enhance water use efficiency.

Leaching Fractions: Applying a "leaching fraction," a calculated amount of excess water, can help flush salts below the root zone. However, leaching must be managed carefully to avoid nutrient losses and minimize the risk of groundwater contamination.
Salt-Tolerant Cotton Varieties: Cultivating cotton varieties with greater tolerance to saline conditions can offer a sustainable solution in areas facing high salinity levels. Research and development of such varieties are crucial for long-term cotton production in the region.

Conclusion. Optimizing overland irrigation techniques is not merely a technical endeavor but a multifaceted approach that requires understanding the interplay of soil, water, climate, and crop factors. By implementing the elements discussed above - from precise furrow design to technology-aided irrigation scheduling - farmers in the Bukhara region can significantly improve water use efficiency in cotton production. This not only conserves precious water resources but also minimizes the risk of salinization, ensuring the long-term sustainability of cotton cultivation and the livelihoods it supports in this vital agricultural region. It is important to remember that these are general guidelines, and specific recommendations should be tailored based on local conditions, available resources, and through consultation with agricultural experts.

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