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MELIORATIVE REGIME IN IRRIGATION LANDS

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Abstract
Sustainable management of irrigated lands under semi-hydromorphic conditions requires optimization of the meliorative regime to prevent soil degradation, secondary salinization, and inefficient water use. This study presents the results of a three-year field experiment conducted in the Pakhtakor district (Jizzakh region) aimed at improving irrigation efficiency and soil water–salt balance through laser land leveling and the replacement of traditional distribution furrows with portable polyethylene irrigation flumes (KSN-50).
The experimental design included three replications under a pre-irrigation soil moisture regime maintained at 70–70–60% of field moisture capacity (FMC), compared with conventional furrow irrigation. Irrigation scheduling was determined using gravimetric soil moisture analysis and tensiometer monitoring at 30, 50, and 70 cm depths. General and partial water–salt balances were calculated according to established hydromeliorative methodologies.
The findings confirm that integrating precision land leveling with portable irrigation flumes significantly improves the meliorative regime, increases water-use efficiency, and ensures sustainable cotton production under irrigated conditions.

Keywords: Degradation, field moisture capacity (FMC), laser leveling equipment, distribution canal, portable irrigation flumes, yield, water-saving technology.

Introduction

Irrigated agriculture in arid and semi-arid regions plays a decisive role in ensuring food and fiber security. However, long-term anthropogenic pressure on soil cover has led to significant transformation of natural soil-forming processes. Since the mid-20th century, intensified irrigation practices without adequate drainage management have contributed to soil degradation, salinization, and changes in groundwater dynamics.

The concept of the meliorative regime refers to the regulated combination of hydromeliorative, agrotechnical, and agrochemical measures aimed at maintaining optimal soil water, salt, air, and nutrient conditions for sustainable crop production. Under semi-hydromorphic conditions—where groundwater depth ranges between 1.5 and 3.0 m—precise control of irrigation and drainage parameters becomes particularly critical.

In Uzbekistan, cotton remains a strategically important crop, requiring optimized irrigation technologies to reduce water consumption while maintaining high productivity. This study aims to evaluate the effectiveness of laser land leveling combined with portable irrigation flumes in improving the meliorative regime and water-use efficiency in semi-hydromorphic soils.

Literature Review

The concept of the "meliorative regime" was introduced into scientific use by N.M. Reshetkina [20] and further developed by A.A. Rachinsky [17], I.P. Aidarov [1], A.I. Golovanov [4], Kh.I. Yakubov [21], V.A. Dukhovny [5], K.M. Mirzajonov [12], G.A. Bezborodov [3], L.M. Rex [19], Zh.S. Mustafayev [13], O.R. Ramazanov [16], M.Kh. Khamidov [25], B.S. Serikbaev [23], R.K. Ikramov [8], A.T. Salokhiddinov [22] and others.

Meliorative regimes represent a комплекс of hydromeliorative, agrotechnical, agrochemical, and technical measures ensuring high crop yields at minimal cost under specific natural conditions. [6,7].

According to Reshetkina and Rachinsky, the optimal meliorative regime includes irrigation scheduling, drainage of irrigated lands, groundwater depth regulation, desalinization of the calculated soil layer, soil fertility improvement, and minimum water consumption per unit yield. [20,18].

Mustafayev defines the optimal meliorative regime as targeted management of soil formation processes through irrigation and drainage systems, corresponding to the maximum possible utilization of photosynthetically active radiation. [14].

D.M. Katz [10] classified meliorative regimes into three categories based on groundwater depth:
Automorphic – groundwater deeper than 5 m
Semi-automorphic – groundwater depth 3–5 m
Hydromorphic – groundwater depth 2–3 m

According to I.S. Rabochev [15], the reclamation regime is divided into three types—automorphic, transitional, and hydromorphic—which he referred to as the soil reclamation regime.

A.A. Rachinsky [17] classified reclamation regimes in arid regions into three categories: gray soils, gray meadow soils, and meadow soils.

V.A. Dukhovny [5] introduced the concept of an optimal reclamation regime, defining it as a condition in which desalinization achieved through irrigation and drainage, along with an increase in the natural fertility of irrigated lands, ensures the minimum relative cost required to increase crop yields.

N.M. Reshetkina and Kh.I. Yakubov [21] proposed four reclamation regimes based on groundwater depth: hydromorphic (1–2 m), semi-hydromorphic (2–3 m), semi-automorphic (3–8 m), and automorphic (8–10 m).

A.U. Usmanov [24] defined the reclamation regime as a multifactorial process that determines the development of soil water, nutrient, salt, air, and thermal regimes under natural conditions influenced by an engineering–agromeliorative complex. He emphasized that an optimal regime should be understood as one that requires minimal costs per unit yield, does not disturb the ecological environment, and ensures stable high productivity of irrigated lands.

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According to I.P. Aidarov and E.K. Karimov [2], an optimal reclamation regime should be characterized by minimal water exchange between the aeration zone and groundwater. They noted that such conditions occur when the groundwater level is located 0.8–1.5 m below the capillary rise limit.

Research Methodology

The soil formation conditions of the experimental field correspond to a semi-hydromorphic regime, with the groundwater table located at a depth of 1.5–3.0 m. In the study area, subsurface horizontal drainage is installed at a depth of 2–3 m, with spacing between drains of 200–205 m. Field experiments were conducted under semi-hydromorphic conditions in the "Yagona Paxta," "Metin Bardoshi," and "Yurt Yutug'i" farms of the district.

Field studies were carried out using the local cotton variety Pakhtakor-1 in three replications. The pre-irrigation soil moisture regime was maintained at 70–70–60% of field capacity (FC), while the control treatment followed the conventional irrigation regime adopted by local farmers. Investigations of drainage performance and reclamation regimes were conducted according to the methodology of Scientific Research Institute of Irrigation and Water Problems (formerly SANIIRI), based on general and partial water–salt balance schemes for irrigated lands [10].

In the control treatments, irrigation was applied through furrows, whereas in the experimental treatments, portable irrigation flumes were used, taking into account the phenological growth stages of cotton [20].

At the experimental site in Pakhtakor district (semi-hydromorphic reclamation regime), the control plot irrigated by the conventional method covered 1 ha, where all agrotechnical practices performed by farmers were monitored. An additional 1 ha plot was laser-leveled and irrigated using portable irrigation flumes instead of permanent field ditches. Thus, the total experimental area comprised 2 ha (Fig. 1).

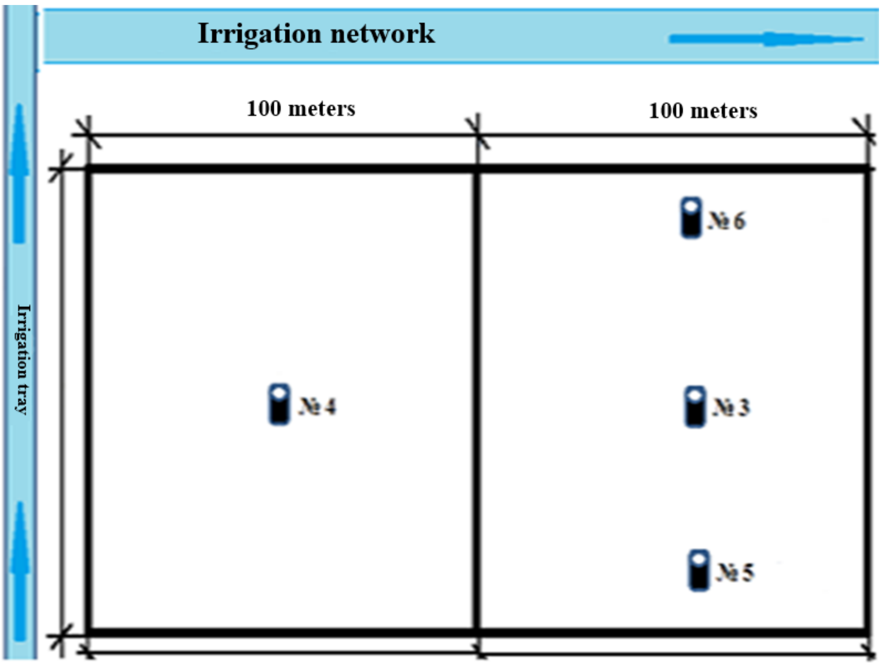

Figure 1. Experimental design scheme

Irrigation timing was determined based on soil moisture content measured by the thermostat drying method, as well as according to the readings of tensiometers installed in the field at depths of 30, 50, and 70 cm. Irrigation events were scheduled and applied accordingly [26].
To determine irrigation timing and application rates in the experimental field, the calculated soil layer varied according to the cotton growth stage: from 0–70 cm before flowering, 0–100 cm during the flowering and boll formation stages, and again 0–70 cm during the maturation stage. Irrigation was carried out depending on the soil moisture content within these respective layers.
To monitor groundwater levels in the experimental field, four observation wells with a depth of 3 m were installed. Groundwater level measurements were taken regularly throughout the entire vegetation period.

Analysis and Results

During the experimental years, the land was laser-leveled and irrigated using portable irrigation flumes (KSN-50) instead of permanent field ditches in the experimental treatments.
In the first year, cotton was irrigated three times during the growing season under a 1–2–0 irrigation scheme. The irrigation rates were 650 m³/ha for the first irrigation, 750 m³/ha for the second, and 700 m³/ha for the third irrigation. The total seasonal irrigation rate amounted to 2100 m³/ha.
In the second year, cotton was again irrigated three times under the same 1–2–0 irrigation scheme. The irrigation rates were 765 m³/ha for the first irrigation, 780 m³/ha for the second, and 705 m³/ha for the third irrigation, with a total seasonal irrigation rate of 2250 m³/ha.
In the third year, irrigation was likewise carried out three times under the 1–2–0 scheme. The irrigation rates were 650 m³/ha for the first irrigation, 730 m³/ha for the second, and 700 m³/ha for the third irrigation. The seasonal irrigation rate totaled 2080 m³/ha (Table 1).

1- Experimental Design

№	Variations	Replications	Pre-irrigation field moisture capacity, %
1	Laser land leveling with irrigation using portable irrigation flumes instead of permanent field ditches (Experimental Variation)	1	70-70-60
		2	
		3	
2	Control variation (conventional irrigation method)	1	70-70-60
		2	
		3	

The KSN-50 irrigation device was developed at the Scientific Research Institute of Irrigation and Water Problems and its production was established at the Uzbekistan–Israel joint venture SOVPLASTITAL. The flumes are manufactured from polyethylene in a semi-circular shape. Their diameters are 30 cm and 50 cm, and the section lengths are 187 cm and 220 cm, respectively. Flumes with a smaller diameter are recommended for fields with higher slopes, whereas flumes with a diameter of 50 cm are recommended for level fields.

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The KSN-50TE (portable irrigation flumes – 50 for level fields) set consists of up to 27 lightweight, interchangeable polyethylene sections that are easy to assemble. Each section has six water outlet openings arranged along its bottom length. The depth of the KSN-50 flume is H = 15 cm (diameter 30 cm), while for the KSN-50TE it is H = 25 cm (diameter 50 cm). The discharge capacity of one complete set ranges from 10 to 50 L/s, with flow rates of 0.3 to 1.0 L/s delivered to each furrow. Using one set, a farmer can irrigate up to 120 ha per year. The weight of one flume section is 5 kg, while the KSN-50TE section weighs 6.2 kg. The cost corresponds to the market price of polyethylene (Fig. 2).

Figure 2. Cotton irrigation process in Pakhtakor district using portable irrigation flumes instead of permanent field ditches.

Currently, the most widely used irrigation method on level fields is surface irrigation (furrow irrigation). In surface irrigation systems, land leveling is considered one of the primary and essential measures for improving irrigation techniques and agrotechnical practices (precision planting, mechanized inter-row cultivation, mechanized harvesting, etc.).

Figure 3. Topographic surveying and land leveling using laser equipment.

When implementing this measure on low-slope fields, minimal soil movement and minimal cutting of elevated areas are planned. To create a required longitudinal slope in the irrigation direction, a land leveler equipped with a Rugby 100LR laser system was used (Fig. 3).

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Before starting land leveling operations, the longitudinal slope (along the future furrow direction) and transverse slope (along the field ditch direction) of the planned irrigation area were determined using a level instrument. Based on the field surface relief, furrow lengths were designed taking into account minimal soil redistribution and cutting volumes. On fields leveled using laser-guided equipment, uniform soil wetting resulted in an increase in cotton yield by 0.4–0.5 t/ha, a 20% increase in labor productivity of irrigation workers, and water savings of 15–20% compared to conventional practice [27].

Due to the relatively small size of the experimental site in the district, the drainage module was determined using a simplified approach. The drainage volume during the vegetation period under the conventional irrigation regime previously applied at the Pakhtakor district experimental field was adopted based on existing general and partial water–salt balance calculations [11].

After assessing the actual reclamation status of the experimental plot, the parameters of the optimal reclamation regime for this area were calculated. The results calculated for the vegetation period are presented in Table 2.

2-Table Key elements of the general water–salt balance in the experimental plot of Pakhtakor district

Elements of balans	4-30 April		1-31 May		1-30 June		1-31 july		1-31 August	
	m^3/ga	t/ga	m^3/ga	t/ga	m^3/ga	t/ga	m^3/ga	t/ga	m^3/ga	t/ga
O_c	21	0	41	0	4	0	0	0	0	0
B_n	500	0,62	600	0,74	600	0,74	550	0,68	500	0,62
D_g	80	1,02	66	0,5	90	0,6	215	3,83	245	2,15
ET_n	364	0	743	0	704	0	1275	0	715	0
ΔW_a	-33	-	-118	-		-		-		-
h, m	1,44		1,61		1,69		1,95		2,36	
Total	1226	1,64	1552	1,24	1510	1,34	3102	4,51	1432	2,77

Based on our calculations of the water balance for the experimental plot, the following was determined: during the vegetation period, atmospheric precipitation was 66 m³/ha, applied irrigation water amounted to 2750 m³/ha, groundwater drainage into subsurface drains was 696 m³/ha, evapotranspiration from the field was 3801 m³/ha, and the change in water storage in the aeration zone was –151 m³/ha.

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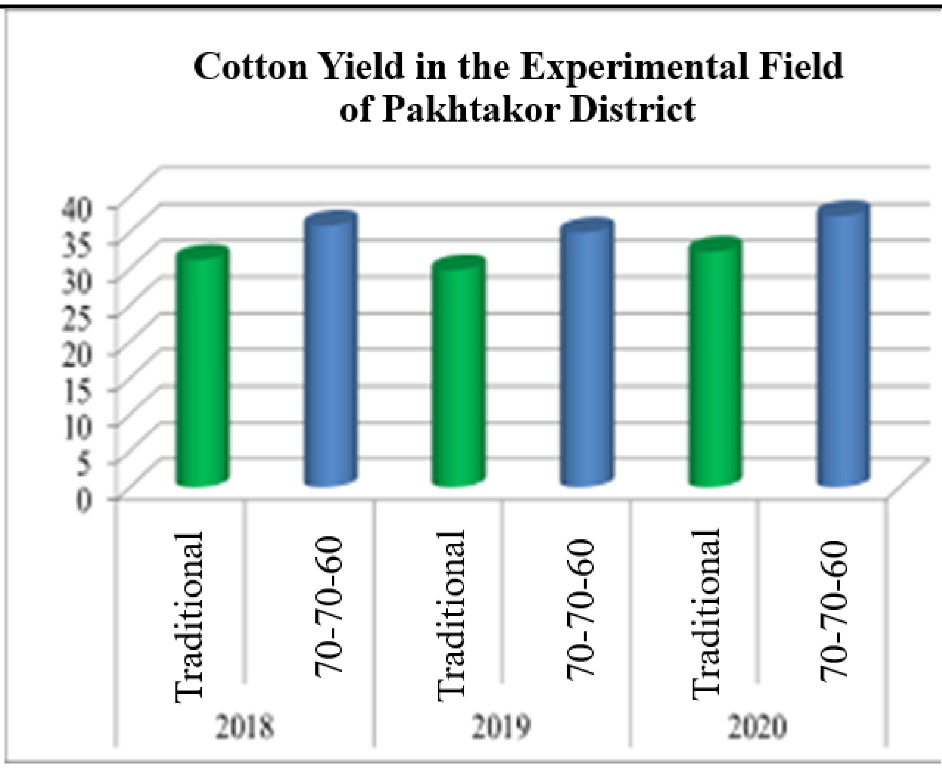

Figure 4. Cotton yield in the experimental field of Pakhtakor district (centner/ha).

Over the three-year experimental period in Pakhtakor district, the average cotton yields in the experimental treatments were 35.9, 34.9, and 37.2 centner/ha, respectively. In the control treatments, yields were correspondingly 31.2, 29.8, and 32.3 centner/ha (Fig. 4).

Conclusions and Recommendations.

Analysis of the field experiment results showed that, under the semi-hydromorphic soil conditions of Pakhtakor district, irrigation of cotton using portable irrigation flumes instead of permanent field ditches on laser-leveled land resulted in an average seasonal irrigation rate of 4145 m³/ha over three years. In the control treatments using furrow irrigation, the seasonal irrigation rate was 4490 m³/ha. The experimental treatment achieved a water saving of 16% compared to the control, equivalent to 345 m³/ha over the season. To prevent water losses through infiltration, the use of portable irrigation flumes instead of field ditches is recommended. This irrigation method not only saves water but also improves the land use efficiency, as confirmed by the study.

Cotton yield in the experimental treatments was high in the first and third years and moderate in the second year. In the control treatments, yields were moderate throughout all three years.

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