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Investigations

The Technology of Cultivating Lump Crops with Mist Sprinkling in the Conditions of the Zhambyl Region

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Abstract: Increasing water scarcity and increasing rate of livestock development in the Republic of Kazakhstan require using new water-saving irrigation methods. Using new forage crops will make it possible to use irrigation water most productively and to achieve the maximum yield with high soil-feeding capacity, while using the minimum amount of irrigation water. Therefore, the main goal of the research was developing a technology of cultivating new fodder crops with mist sprinkling. To save water with optimal water and nutrient regimes, agro technical operations for cultivating crops such as grain and new (for the southern region of Kazakhstan) sorghum and millet, as well as optimal modes of their irrigation with mist sprinkling have been developed.

Keywords: Irrigation, Water-Saving Technologies, Fine Mist Sprinkler Irrigation, Equipment, Development, New Fodder Crops, Research, Implementation

Introduction

Irrigation agriculture is one of the main factors of ensuring stability of agricultural production and food security worldwide.

Analysis of the irrigation technologies and equipment used worldwide leads to the conclusion that from the point of view of water and energy saving, one of the most promising methods is sprinkling.

Development of irrigation contributes to obtaining guaranteed amounts of production, reducing economic risks associated with crop losses due to unstable weather conditions, creating jobs for the rural population, developing localities and several other factors that ensure growth of living standards of the population (Krakovets, 1976a; Dzyubenko, 1976; Nukusheva, 2012; Possibilities of introducing intensive varieties of alfalfa into the fodder production system of the North Kazakhstan region; Fine sprinkling of crops; Crop rotation and crops layout).

The most acute water problems of the country are increasing water shortage, pollution of surface and groundwater with the existing methods of irrigation, huge excessive loss of water, problems of interstate water apportioning and the threat of water resources depletion. At present, hydro land reclaiming systems of Kazakhstan are characterized by deterioration of their ecological status and reduced technical level. This has determined deterioration of soil fertility and, accordingly, loss of agricultural irrigated land.

The absence of modern scientific and technical support for irrigated land reclamation hinders competitive production of agricultural products in the volumes sufficient for covering the needs of the domestic market and forming export resources with the aim of obtaining the leading positions in foreign markets and effective development of the water sector and water policy.

Scientific support for the rational use of water resources and development of technologies of agricultural land reclamation aims at further development of competitive agricultural production (Chichasov *et al*., 1970; Krakovets, 1976b; Nosenko and Gershunov, 1975; Zharkov, 2000; Kostyakov, 1960) in the volumes sufficient for covering the needs of the domestic market and forming export resources with the aim of obtaining the leading positions in foreign markets and effective development of the water sector and water policy of Kazakhstan.

Methods

The method of research was patent and information search in the technologies of mist irrigation of agricultural crops in the world practice. It was performed with the use of available materials from the fund of the Kazakh Scientific Research Institute of Water Economy LLP (LLP "KazSRIWE"), the scientific library of Taraz, specialized periodicals, media and online resources. The development and research of water saving technology of subsoil water irrigation of fruit plantations and onions were performed according to the methods of field experience (Dospekhov, 1985) with the use of the methods of analyzing agrochemical properties of soils (GOST 26205 -91, 26213-91 GOST, GOST 26423-85). The irrigation regime was monitored by the use of water meters and the level of soil moisture with the thermostat-weight method. The technology of cultivating fodder crops with mist irrigations was developed with scientific substantiation of the choice of fodder crops rotation with regard to the choice of varieties of fodder crops and their soil-feeding capacity. All agricultural work required by the zonal technology of cultivating agricultural crops were taken into account. The phenological and biometrical observations were made according to the standard methods.

Results

For the rational use of water in the conditions of water scarcity, a technology of cultivating fodder crops with mist irrigation has been developed. The technology was developed to be used on the agricultural lands of the Hamburg LLC in the Zhambyl region and further use at the farms of Zhambyl region.

The object of the research is located in the Zhualyn district of the Zhambyl region. The Zhualyn district is located in the South of Zhambyl region. It is one of the main agricultural areas that provide livestock and crop production for the region. The district borders the South Kazakhstan region and the Kyrgyz Republic.

Irrigated lands of the Hamburg LLP farm are located 1,000 m above sea level within the Chui valley between the spurs of the Tien-Shan, Karatau and the Kirghiz ridge.

Hamburg LLP, established in 1997, is one of the largest agricultural enterprises for growing and processing agricultural products in the Zhambyl region. To increase crop production, improve product quality and environmental safety of agricultural production, the farm uses wide-coverage, low-intensity sprinkling equipment of circular action with a central drive made in the Netherlands, as well as wide coverage front action and combined action machines and drum type irrigation machines.

The climatic conditions of the region belong to the zone of semi-provided bogara. Rainfall is 400-450 mm per year, including 100-140 mm during the period with the temperature above 10°C. The average annual temperature is +6.7°C. The hottest months are June through August (18-21°C), the coldest months are December through February (-6 to -8.9°C). The hydrothermic coefficient is about 1.0 and above. The sum of positive temperatures above 10°C is equal to 2,700-2,900°C. By the results of many years of observation, the climatic characteristics of the studied area are shown in Table 1.

The average annual relative humidity is 65%, the average number of days with relative humidity of less than 30% per year is 100-120. The average annual amplitude of air temperatures is 30°. The average annual temperature exceeds +5°C in the spring, in late March - early April. Ground frost continues until the end of May and is occasionally observed in June. Autumn colds start in October and ground frost starts in September. The frost-free period lasts on the average for 127 days. The rainfall is unevenly distributed by months. One third of the annual precipitation occurs in the spring and in the summer the precipitation is low. The number of days with snow on the average is 100. The average snow cover height is 25-35 cm. The area is dominated by the South-West and North-East winds. The strongest winds occur in the spring, when the wind speed reaches 15 m/s or higher. The greatest number of days with strong winds is observed in the autumn and in the winter (4-7 days).

By its mechanical composition, the soil is loamy, not salty: The content of easily soluble salts is 0.064-0.339%, salt lime is absent. The filtering properties of clay loams in the unsaturated zone have been defined by experimental watering according to the method of Nesterov; the average value of the water permeability is 0.17 m/day.

Groundwater on the territory of Hamburg LLP to the depth of 5 m has not been uncovered.

The described soils are mainly not eroded, however, when they are developed for irrigated agriculture, manifestations of irrigation erosion might be observed. In this respect, depending on the slope of the terrain, they are divided into soils without the risk of erosion, soils with low risk of erosion and soils with high risk of erosion. These factors should be considered when choosing the irrigation equipment for the land to be irrigated.

The technology of cultivating fodder crops with the use of mist sprinkling envisages sticking to all agro technical methods of cultivating agricultural crops under the optimum irrigation regime, as prescribed for this method of irrigation. Since irrigation is one of the main types of works in cultivating agricultural crops, the used irrigation regime should be based on the performance characteristics of the irrigation equipment and the deadlines and norms of irrigation should be set for ensuring the optimal values of soil moisture and the depth of moisturizing.

Table 1. The climatic characteristics of the studied area

Characteristics		Months I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Temperature, t°C	average	-8.9	-6.9	1.0	8.8	14.5	18.6	21.2	19.4	13.3	6.4	-0.8	-5.8	6.7
	abs. maximum	16	21	30	33	40	40	42	39	38	34	25	21	42
	abs. minimum	-38	-40	-30	-14	-7	-2	2	0	-8	-20	-42	43	-43
Precipitation, mm	average	44	48	57	61	50	25	14	6	11	31	48	52	447
	maximum	148	100	166	148	121	58	58	28	32	125	107	105	805
	minimum	3.0	1.3	7.1	18.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	206
Relative air humidity,%	average	80	81	80	69	61	54	45	44	48	61	76	80	65
	≥80%, days	11.8	9.8	9.0	3.9	1.8	0.4	0.1	0.1	0.2	3.0	8.2	11.2	59.5
	≤30%, days	0.2	0.2	2.7	7.0	11.4	16.4	24.5	24.2	22.3	14.8	3.9	0.7	128.3
Absolute humidity, Mb	3.2	3.7	5.3	7.5	9.5	10.8	10.5	9.1	6.6	5.6	4.4	3.5	6.6	
Number of days with	fog	8	8	8	2	0.7	0.1	0.1	0.1	0.3	2	7	8	44
	thunderstorms			0.6	2	5	6	3	1	0.7	0.07	0.07		18
	dust storm			0.1	0.1	0.6	0.7	1.5	1.9	2.1	2.3	0.3		9.6
	wind >15 m/s	2.1	2.8	4.0	2.4	2.8	1.5	1.1	1.4	1.5	2.3	2.2	3.3	27

The average snow cover height, cm

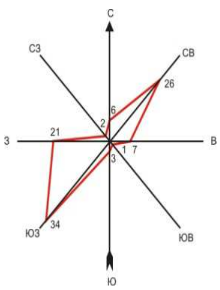
X			XI			XII			I			II			III			IV			Maximum over the winter				Stock of water, mm		
10	20	31	10	20	30	10	20	31	10	20	31	10	20	28	10	20	31	10	20	30	aver.	aver.	max	min from	max.	max.	min.
				4	4	6	10	11	12	13	13	13	15	11	11						31	60	10	60	118	30	

Dates of start and end of periods with the temperature of, days

		I	II	III	IV	V	VI	VII
Over 0ºC	12.III				242			10.XI
Over 5ºC	30.III			205		22.X		
Over 10ºC		20.IV		161		29.IX		
Without frost			9.V	127	14.IX			

Dates of snow cover appearance and disappearance and freezing capacity

Number of days per year with snow cover	Snow cover						Soil freezing capacity, cm			
	Dates of appearance			Dates of disappearance						
	early	average		late	early	average	late	average	max.	min.
100	27.IX	2.XI	14.XII	22.II	2.IV	3.V	23	56	5	



Frequency of wind directions occurrence by bearing angles and seasons as% of the annual sum of cases

Bearing angles	Spring			Summer			Autumn			Winter			
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	Year
N	3	9	9	10	11	13	8	3	1	1	1	2	6
NE	25	34	35	29	25	31	32	25	19	16	13	19	26
E	6	9	10	10	7	9	10	5	6	8	3	4	7
SE	1	1	1	2	2	1	1	1	1	1	1	1	1
S	1	2	3	4	5	3	4	4	2	2	2	1	3
SW	33	21	19	21	23	19	27	39	45	54	55	50	34
W	24	23	20	20	22	22	16	22	24	17	25	22	21
NW	7	1	3	4	5	2	2	1	2	1	0.4	2	2

Crop varieties for fodder crop rotation (TCR, 2012; FCR, 2013; Kwan *et al*., 1989; Agricultural Cultivation of Red Beet; BIP, 2014) have been selected with regard to their soil-feeding capacity for increasing productivity of irrigated lands with the use of mist sprinkling on the territory of Hamburg LLP in the Zhualy district of the Zhambyl region.

For the Northern part of the land of LLC Hamburg, with regard to the mechanical composition of the soils (light loams with pebbles below the 0-60 cm horizon), the water holding capacity of soils and the shallower depth of the plow layer, the following crop rotation has been recommended (variant 1):

Field 1: Perennial herbs
Field 2: Perennial herbs
Field 3: Perennial herbs
Field 4: Grain maize
Field 5: Maize for silage along with amaranth, sorghum and sunflower + winter crops: Blend (rapeseed, rye, overwintering peas)
Field 6: Winter crops mixture+barley for grain and milled fodder
Field 7: Millet or sorghum for hay and green fodder

For the Southern part of the land of LLC Hamburg, with regard to the mechanical composition of the soils (medium and heavy loams), the water holding capacity of soils and the deeper depth of the plow layer, the following crop rotation has been recommended (variant 2):

Field 1: Herbs

Field 2: Herbs
Field 3: Herbs + winter wheat
Field 4: Winter wheat + maize mixture for silage
Field 5: Fodder beet
Field 6: Spring a mixture of oats (Vica), canola + spring barley on for grain and milled fodder
Field 7: Sorghum or millet for hay and green fodder

The technology of cultivating fodder crops with the use of mist sprinkling was developed during formation of the crop rotation (Kalashnikov *et al*., 2012; 2013; Vaneyan and Menshikh, 2010; CKISP, 2014) on the lands of LLC Hamburg in the Zhualy district of the Zhambyl region in order to determine the possibility of using grain for silage, millet and sorghum for increasing productivity of irrigated lands. Crops for fodder crop rotation have been selected with regard to their soil-feeding capacity. Corn for silage is represented by such varieties as Hybrid VS 678 and Hybrid Donana. Millet varieties are 19586 (late-maturing) and African HHBC Tall, HHBVC Tall, HHVBC Tall and XAIAA. Sorghum varieties are sweet ICSR 93049 (India), grain Boyjugara, sweet Uzbekistan 18, grain Sereta 90 and sweet Stavropol 36.

For irrigating forage crops, modern mist irrigation equipment was used (RSGC, 1962; Aleksandrov *et al*., 1975), represented by circular TL sprinkling machines on the area of 275 hectares and by 2 drum machines on the total area of 50 hectares. Mist sprinkling irrigation ensures moisturization of the soil, the air above the soil and the above-ground parts of plants under the action of capillary forces. Such irrigation does not cause deterioration of irrigated soils structure. During irrigation, intensity of sprinkling should correspond to the infiltration capacity of the soil. Evaporation of the smallest drops during fall and of the thin film of water created on the surface of plants and soil results in higher relative humidity and lower temperature of air, soil and plants.

Irrigation machines layout and forage crops on the lands with mist irrigation are shown in Fig. 1. The field experiment has been laid out in accordance with the requirements of existing methods (Dospekhov, 1985).

Maize of varieties Hybrid VS 678 and Hybrid Donana was sown on the area of 105 hectares.

Before sorghum and millet were sown, 2 irrigation cycles had been made with a T-L circular sprinkling machine at the rate of 167 m^3/ha for creating reserve of moisture in the soil (Fig. 2).

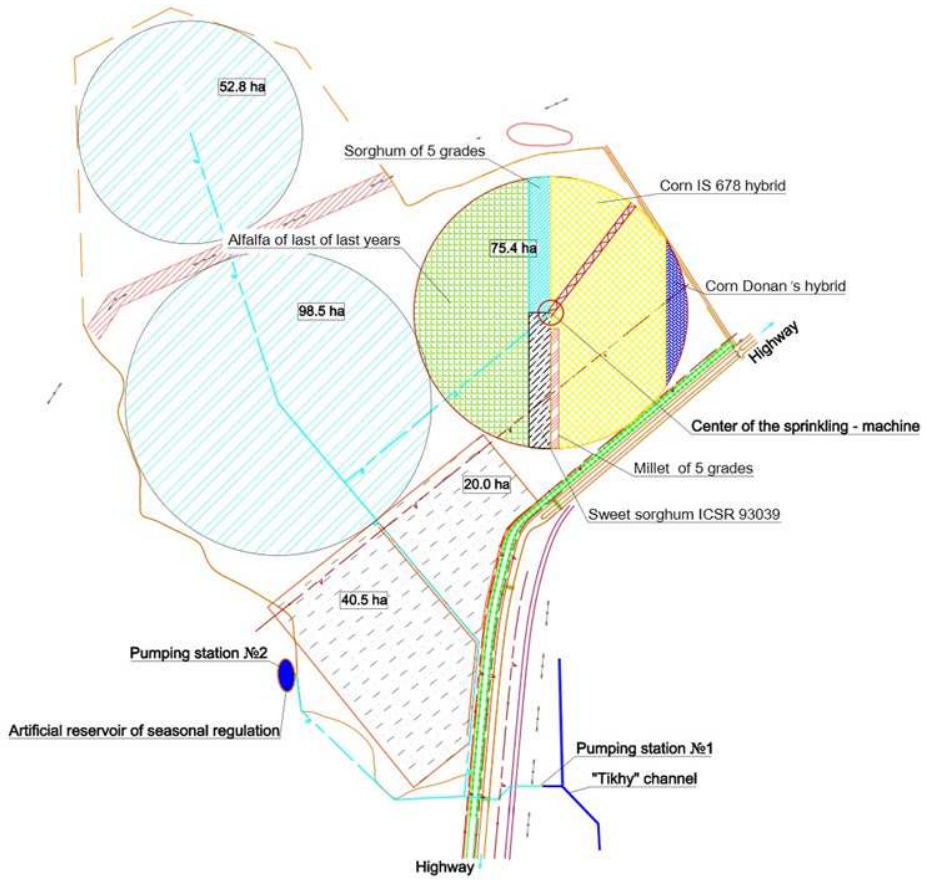


Fig. 1. Layout of sprinkling machines and forage crops

Fig. 2. Irrigation with a T-L circular sprinkling machine

Fig. 3. Sowing seeds of forage and sweet sorghum and millet

Table 2. Agrotechbical operations in crop production

	Crop					
	Maize		Sorghum		Millet	
Technological Operations	Deadlines	Quality parameters	Deadlines	Quality parameters	Deadlines	Quality parameters
Shallow plowing	3d decade of September to 1st decade of October	Immediately after harvesting the preceding crop	3d decade of September to 1st decade of October	Immediately after harvesting the preceding crop	3d decade of September to 1st decade of October	Immediately after harvesting the preceding crop
Introduction of mineral fertilizers	September to October	3 kg/ha of ammonium sulfate 3 kg/ha of superphosphate	September to October	3 kg/ha of ammonium sulfate 3 kg/ha of superphosphate		120 kg of ammophos
Boardless plowing	September to October	To the depth of 30+35 cm	September to October	To the depth of 27-30 cm	September to October	To the depth of 25-27 cm
Harrowingm	March to April	When the state of soil permits and every time after the rain	March to April	When the state of soil permits and every time after the rain	March to April	When the state of soil permits and every time after the rain
Pre-sowing Cultivation	3d decade of April	To the depth of 7-8 cm	3d decade of April	To the depth of 5-7 cm	3d decade of April	To the depth of 4-5 cm
Sowing with Introduction of Fertilizers at the rate of 60-80 kg/ha	3d decade of April to 1st decade of May	70 thousand seeds per 1 ha	3d decade of April to 1st decade of May	180 thousand seeds per 1 ha	3d decade of April to 1st decade of May	4-6 kg per 1 ha
First Cultivation	The phase of 4-5 leaves	To the depth of 7-8 cm	The phase of 4-5 leaves	To the depth of 7-8 cm	The phase of 3-4 leaves	To the depth of 5-7 cm
Weed control	May to June	In the phase of 3-4 leaves for weeds	May to June	In the phase of 3-4 leaves for weeds	May to June	In the phase of 3- 4 leaves for weeds
Second cultivation with top-dressing	The phase of 7 leaves	1.5 hwt of ammonium nitrate per 1 ha	The phase of 7 leaves	1.5 hwt of ammonium nitrate per 1 ha	The phase of 5-7 leaves	1.5 hwt of ammonium nitrate per 1 ha
First wetting		After the top layer of soil dries to 7 cm deep		After the top layer of soil dries to 7 cm deep		After the top layer of soil dries to 7 cm deep
Deep tillage	The phase of 9 leaves	Depth to be at least 30 cm	The phase of 9 leaves	Depth to be at least 30 cm	The phase of 9 leaves	Depth to be at least 30 cm
Harvesting		For silage, cobs of milky-wax ripeness		For silage in the phase of stem elongation with single cob formation		

Seeds of sugar sorghum varieties ICSR 93039 (India) were sown at the sowing rate of 8 kg/ha. Seeds of sugar and grain varieties of sorghum "Stavropolskoye 36" and "Zereta 90" (Russia), "Uzbekistan 18", "Boyjugara" were sown at the sowing rate of 8-9 kg/ha. The total planting acreage was 60 hectares. The sown millet was represented by following varieties: 19586, HBBC Tall, HHBVC Tall, HHVBC Tall, XAIAA (Fig. 3). The planting acreage of millet was 160 hectares.

A technology of cultivating maize, sorghum for silage and green fodder, millet for hay and green fodder in the South region with mist sprinkling has been developed for the conditions of the Zhambyl region with regard to the varietal characteristics of crops and to the requirements for water supply (Table 2).

Discussion

Particularities of growing sorghum in the conditions of the studied region:

- Shallow plowing after the preceding crop is performed by disc plows or harrows to the depth of 7-10 cm
- Ammonium sulfate and phosphate fertilizers are introduced before autumn plowing at the rate of at least 3 kg/ha of ammonium sulfate and superphosphate
- Board less plowing is performed to the maximum depth, but not less than 30 cm
- Early spring moisture closure with needle harrow BiG-3, followed by harrowing, is performed with the aim of preserving moisture, smoothing of the soil surface and controlling weeds after each significant rain
- Presowing cultivation is performed to the depth of 5-7 cm with simultaneous harrowing with tooth harrows
- Sorghum seed are sown into the soil warmed up to 10°C with simultaneous introduction of mixed fertilizers N16P16K16 at the rate of 60-80 kg/ha. The seeding rate for silage grains is 180 thousand per hectare
- First cultivation-tillage is performed in the phase of 4-5 leaves
- In the phase of 5-7 leaves, crops are treated with herbicides against weeds
- In the phase of 7-8 leaves, nitrogen fertilizers are
- Introduced at the rate of not less than 1.5 t/ha with simultaneous treatment of the inter-row spacing.
- Starting with the phase of 1-5 leaves, the moisture content in the top soil is continuously monitored to prevent loss of moisture from the root zone.

Watering with the use of mist sprinkling should start with regard to the depth of sowing, without exceeding it, to ensure normal development of the root system of sorghum plants and to eliminate their penetration into the deeper layers of the soil. Beside carry-over, this will make sorghum root system transfer hardly accessible forms of phosphorus into more accessible forms and pull phosphates up from the 1.5-2 m soil layer to the 30-50 cm soil layer. Considering the ability of sorghum to regrow after harvesting for silage, it can provide extra 3-5 t of green mass:

- In the phase of 9 leaves, deep tillage of the inter-row spacing is required to ensure more rapid penetration of moisture in the lower soil horizons, which contributes to facilitated penetration of sorghum plants root system into deeper soil layers, thereby increasing their erosion and drought resistance and providing the phyto-ameliorative effect on the soil and decreasing its salinity
- The time of mowing sorghum is the phase of stem elongation with single cob formation. The cutting height of 10-12 cm ensures good regrowing

*Particularities of Growing Millet in the Conditions of the Studied Regio*n

The technology of cultivating millet is similar to that of growing maize for grain, silage and green fodder, or of cultivating sweet sorghum for silage, green fodder and hay:

- Shallow plowing of the field after the previous crop is performed by disk plows or a heavy disc harrow to the depth of 7-10 cm immediately after harvesting the preceding crop (safflower, barley, bast fiber)
- Mineral fertilizers are introduced into winter tillage, which is made without shell board. Regarding fertilizers, it is recommended to introduce 1.5-2.0 kg/ha of ammonium sulfate and 1.0-1.5 kg/ha of phosphate fertilizer
- With regard to the characteristics of millet plants root system development, the depth of subsurface tillage should be at least 27-30 cm, since 80% of the roots penetrate to the depth of 40 cm and they spread to 115 cm wide
- For obtaining good harvests of millet, the maximum attention should be paid to retaining moisture during spring field works. This requires tillage with needle harrow BiG-3, which ensures knifing and leveling of the soil and weeds removal
- If fertilizers had not been introduced during main plowing, mixed fertilizers N16P16K16 should be introduced at the rate of 1-1.5 kg/ha before sowing. Tillage is to be performed to the depth of 5-6 cm
- Millet is to be sown into the soil warmed up to 10-12°C. This will be end of April - beginning of May; the sowing rate with irrigation is 4 million seeds/ha
- Preferably, sowing should be accompanied by simultaneous introduction of N16P16K16 at the rate

of not less than 60 kg/ha. Sowing should better be performed using the wide row method with the inter-row spacing of 45 cm, or in two 60+15+15 cm lines; the depth of sowing should be 3 to 8 cm, depending on the type of soil and time of sowing

- In the tillering phase, crops are treated with herbicides
- 1-2 inter-row cultivations are made for tillering the inter-row spacing and for weed control. The first treatment should be made after appearance of rows, the second treatment -in the phase of tillering. During the second treatment, corrective fertilization with microelements should be performed
- If necessary, pest control should be performed, with regard to the harmfulness threshold
- The time of harvesting is determined by the purpose of crop cultivation (for grain, for green mass, for hay)

Wetting of agricultural crops with a sprinkling machine in the area of fodder crops started based on the condition of maintaining soil moisture at the optimum level and was performed based on the prevailing climatic conditions throughout the vegetative period of plant development with reference to the main phases of plant development. Soil moisture in the active soil layer was taken as 70-85% of the nominal value.

In order to improve the physiological performance of plants and reduce the negative influence of high air temperatures in the summer (over 30°C) on their growth and development, irrigation was performed in small dosages once in 1-2 days. Observations of soil moisture in the areas for growing fodder crops showed that during the vegetation periods of plants, it was within the specified level. In the 0-30 cm layer, soil moisture was 74-88% of the nominal value, in the 0-50 cm layer -within the range between 70 and 80% of the nominal value (Fig. 4).

On the plots for growing fodder crops, growth and development of plants was monitored (Fig. 5a-c), samples of the plants were taken (Fig. 6a-b) and plant were treated with herbicide and nitrogen fertilizers.

An increased soil humidity was observed in the plots adjacent to the track of the irrigation machine (up to 94% of the nominal value), which seems to be associated with redistribution of surface moisture during irrigation of the higher areas of these plots to the lower areas with the wheel track. The irrigation norms and time of irrigation were, if necessary, adjusted based on the moisture characteristics of the soil and the requirements to it, with regard to the phases of plant development.

The results of observing fodder crops growth and development phases and the elements of agricultural operations at Hamburg LLP in the Zhualy area of the Zhambyl region are shown in Table 3.

In the plots for growing maize, silage biomass of silage maize per plant (cobs up to 1,417 g.) and the number of cobs (1-2) were determined. The weight of cobs ranged from 290 to 400 grams (Fig. 7). The number of grains in maize cobs in the milky-wax phase was counted (500-860 grains). The number of plants per 1 m^2 experimental plot was counted by the fodder crops.

Fig. 4. Observation of soil moisture

(a) (b) (c)

Fig. 5. (a) Defining millet density (b) Defining height of millet (c) Defining height of silage maize monitoring plants growth and development

(a) (b)

Fig. 6. Taking samples of plants (a) sampling millet for weighing (b) sampling sorghum for weighing

Fig. 7. Cobs of maize for silage

Table 3. Growth and development phases of maize, sorghum, millet and the elements of agricultural methods

Growth and development phases and elements of agricultural methods	Crop Maize date	Sorghum	Millet	Note
Sowing	14.05.0	24.05.0	29.05.0	
Shoots	21.05.0	05.06.0	06.06.0	
The phase of the 3d leave	15.06.0	25.06.0	23.06.0	Millet tillering
The phase of the 5th leave	29.06.0	10.07.0	31.06.0	
The phase of the 7th leave	12.07.0	23.07.0	07.07.0	
The phase of the 9th leave	23.07.0	05.08.0	14.07.0	
The phase of active stem growth	23.07.-05.08.0	10.08.0	10.08.0	
Phase of head shooting	31.07.0	27.08.0	06.09.0	
Phase of graincob formation	07.08.0			
The phase of milky ripeness	14.08.0			
The phase of milky-wax ripeness	26.08.0			
Cultivation	30.06.0			
Treatment with herbicides	15.06.0			Dezormon herbicide
2nd cultivation	15.07.0			
Top-dressing with nitrogen fertilizers	15.07.0			Ammonium nitrate 150 kg per 1 ha
Start of harvesting for the green mass	01.09.0	03.09.0	08.09.0	

The biological yield of forage crops was established by the results of measuring the weight of the plants, with regard to their number per 1 ha and after harvesting, the actual yield of forage crops was established (Table 4).

According to the results of the research, the most promising varieties in agriculture are the following: Maize hybrid Donana, millet variety HH BVC tall and HH VBC tall, grain sorghum Boyjura and sweet sorghum ICSR 93039, the yield of which was the highest among the cultivated forage crops.

With regard to the climatic characteristics of the region, for Hamburg LLP in the Zhualyn district of the Zhambyl region the bioclimatic method was used for calculating the irrigation norms for maize for silage, sorghum and millet (Table 5-7).

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Table 4. Biological and actual yield of forage crops at Hamburg LLP

Fodder crop name	Plant height, cm	Tillering coefficient	Average weight	Number of plants of 1 plant, g	Biological yield, t/ha	Actual yield, t/ha
Hybrid Maize IS 678	220	-	1,387	60,000	86.5	83.20
Maize hybrid Donana	214	-	1,417	60,000	92.3	85.00
Late-maturing millet 19586	160	4.5	130	400,000	58.9	52.00
African millet	154	3.5	150	400,000	67.3	60.00
Millet HH BVC tall	128	3.0	175	400,000	75.9	70.00
Millet HH VBC tall	100	2.5	200	400,000	85.6	80.00
Millet XAIAA	139	4.0	75	400,000	39.9	30.00
Sweet sorghum ICSR 93039	137	4.0	375	150,000	65.4	56.25
Grain sorghum Boyjugurha	146	1.0	450	150,000	72.3	67.50

Table 5. Irrigation norms for maize for silage

Estimated indicators	May			June			July			August		May-August
	II	III	I	II	III	I	II	III	I	II	III	
Air temperature, °C	14.20	15.600	17.40	18.9	20.3	20.30	22.40	20.90	20.5	19.90	18.40	
Relative air humidity, %	66.00	65.000	61.00	56.0	55.00	54.00	53.00	53.00	52.0	52.00	50.00	
Air moisture deficit	34.00	35.000	39.00	44.0	45.00	46.00	47.00	47.00	48.0	48.00	50.00	
Amount of precipitation, mm	17.50	12.500	10.00	8.8	6.3	5.60	4.90	3.50	2.4	2.10	1.50	75.0
Sum of positive temperatures, °C	85.20	256.800	430.80	619.8	822.8	1025.80	1249.80	1479.70	1684.7	1883.70	1994.10	2568.0
Active moisture transfer layer, m	0.20	0.300	0.40	0.5	0.5	0.50	0.50	0.50	0.5	0.50	0.50	
Layer increment		0.100	0.10									
Productive moisture reserves, m^3/ha	106.29	159.490	212.70	212.7	212.69	212.69	212.69	212.69	212.69	212.69	212.69	
Accretion due to layer deepening, m^3/ha		53.200	53.20									
Evaporating capacity E, m^3/ha	184.94	525.310	939.00	1,439.00	1,984.00	2,540.90	03,163.90	3,748.10	4,334.40	4,905.30	5,238.70	
Microclimatic coefficient Ko	1.00	1.000	0.90	0.90	0.90	0.80	0.80	0.80	0.80	0.80	0.80	
Biological coefficient Kb	0.61	0.640	0.67	0.74	0.81	0.87	1.02	1.07	1.03	0.96	0.86	
Total water consumption, m3/ha	112.81	336.200	566.20	958.50	1,446.40	1,768.50	2,581.80	3,208.4	3,571.50	3,767.30	3,604.20	
Irrigation norm (deficit of water consumption)	-135.50	20.713	179.50	556.80	1,030.70	1,352.80	2,145.10	2,786.7	3,153.90	3,355.60	3,207.50	3,200

Table 6. Irrigation norms for sorghum

Estimated indicators	May June			July			August			May-August
	III	I	II	III	I	II	III	I	II	
Air temperature, °C	15.60	17.40	18.90	20.30	20.30	22.40	20.90	20.50	19.90	
Relative air humidity, %	65.00	61.00	56.00	55.00	54.00	53.00	53.00	52.00	52.00	51.0
Air moisture deficit	35.00	39.00	44.00	45.00	46.00	47.00	47.00	48.00	48.00	
Amount of precipitation, mm	8.50	10.00	8.80	6.30	5.60	4.90	3.50	2.40	2.10	52.0
Sum of positive temperatures, °C	93.60	267.60	456.60	659.60	862.60	1,086.60	1,295.60	1,500.60	1,600.10	
Active moisture transfer layer, m	0.20	0.20	0.30	0.30	0.40	0.40	0.40	0.40	0.40	
Layer increment			0.10		0.10					
Productive moisture reserves, m^3/ha	102.29	102.29	158.89	158.89	215.49	215.49	215.49	215.49	215.49	
Accretion due to layer deepening, m^3/ha			56.60		56.60					
Evaporating capacity E, m^3/ha	204.22	617.87	1,118.10	1,662.90	2,219.90	2,842.90	3,427.00	4,013.30	4,298.80	
Microclimatic coefficient Ko	0.90	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.80	
Biological coefficient Kb	0.61	0.640	0.67	0.74	0.81	0.87	0.88	0.89	0.90	
Total water consumption, m^3/ha	112.12	355.890	674.24	1,107.50	1,618.30	1,978.60	2,412.60	2,857.50	3,095.10	
Irrigation norm (deficit of water consumption)	-146.20	79.605	326.36	745.64	1,199.80	1,539.10	1,988.20	2,437.00	2,680.6	2,700

Table 7. Irrigation norms for millet

Estimated indicators	May		June			July		August		May - August
	III	I	II	III	I	II	III	I	II	
Air temperature, °C	15.600	17.40	18.90	20.30	20.30	22.40	20.90	20.50	19.90	
Relative air humidity,%	65.000	61.00	56.00	55.00	54.00	53.00	53.00	52.00	52.00	51.0
Air moisture deficit	35.000	39.00	44.00	45.00	46.00	47.00	47.00	48.00	48.00	
Amount of precipitation, mm	8.500	10.00	8.80	6.30	5.60	4.90	3.50	2.40	2.10	52.0
Sum of positive temperatures, °C	156.000	330.00	519.00	722.00	925.00	1,149.00	1,358.00	1,563.00	1,662.50	
Active moisture transfer layer, m	0.200	0.20	0.30	0.40	0.40	0.40	0.40	0.40	0.40	
Layer increment				0.10	0.10					
Productive moisture reserves, m^3/ha	112.860	112.86	169.46	226.06	226.06	226.06	226.06	226.06	226.06	
Accretion due to layer deepening, m^3/ha			56.60	56.60						
Evaporating capacity E, m^3/ha	170.180	583.83	1,084.10	1,628.90	2,185.80	2,808.80	3,393.00	3,979.30	4,264.7	
Microclimatic coefficient Ko	0.900	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.8	
Biological coefficient Kb	0.610	0.640	0.67	0.74	0.81	0.87	0.88	0.89	0.9	
Total water consumption, m^3/ha	93.431	298.920	581.08	964.31	1,416.40	1,954.90	2,388.70	2,833.20	3,070.6	
Irrigation norm (deficit of water consumption)	-175.400	12.063	222.62	535.26	987.35	1,504.90	1,953.60	2,402.20	2,645.5	2,650

Conclusion

In fact, the sprinkling machine supplied 2,600 to 3,280 m^3/ha to the fields, including the duration of the growing season of forage crops. Considering water consumption for the microclimate, the irrigation gross norm ranged from 3,016 to 3,805 m^3/ha.

By the results of assessing the crop yield, crops that ensure the highest productivity, such as corn hybrid Donana, millet HH VBC tall and HH BVC tall and grain sorghum Boyjugurha and sweet sorghum ICSR 93039 can be recommended for forage crop rotation in agriculture and for the southern region of Kazakhstan.

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Author’s Contributions

Nurlan Nurmahanovich Balgabaev: Supervised this project, wrote the manuscript and final approved the manuscript.

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Aigul Eltaevna Baizakova: Performed the experiment and analyzed the data and wrote the manuscript.

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Ethics

The authors declare no conflict of interest.

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