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EVAPOTRANSPIRATION OF THE FIELD DURING CULTIVATION SUGAR BEET DEPENDING ON AGRONOMIC FACTORS IN THE SOUTH OF UKRAINE

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Sugar production to meet domestic needs and exports is an important and urgent issue. In the south of Ukraine, it is possible to increase sugar beet production by growing it on irrigated lands. The purpose of the research was to study the peculiarities of sugar beet field evapotranspiration depending on agronomic factors under irrigation in the south of Ukraine.

The main objectives of our research were to substantiate the water consumption of sugar beet cultivation at different ploughing depths, nutrition backgrounds, sowing dates and planting densities.

The field experiments were conducted in the Kherson region in the Ingulets irrigated area. The soil cover is represented by dark chestnut slightly saline medium loamy soils.

The following factors and their variants were included in the experimental design:

Factor A – ploughing to a depth of 20-22 cm and 28-30 cm

seeding rate of germinating seeds: 6, 9 and 12 million seeds/ha.

Factor B – fertiliser background: no fertiliser, N150P150K60, 40t/ha + manure

N150P150K60, Manure 40 t/ha.

Factor C – sowing dates: the first term – at a soil temperature of 6-8°C at the depth of seed placement (4-5 cm); the second – ten days after the first term, the third – 20 days after the first term;

Factor D – plant density: 90, 110 and 130 thousand/ha

In our experiments, depending on the factors studied, the share of soil moisture in total water consumption ranged from 8.6 to 23.3%, useful precipitation – from 30.8 to -35.7 and irrigation – from 45.6 to 55.7%, i.e. irrigation takes the first place in sugar beet water consumption, precipitation – the second and the smallest share belongs to soil moisture.

When comparing the nutrition backgrounds, it can be noted that the smallest share of soil moisture in sugar beet water consumption was observed in the variants on the background of applying only mineral and organic fertilizers at the third sowing term, and the largest share – on fertilized backgrounds at the first sowing term.

Based on the results obtained, it can be concluded that the total water consumption of the field during sugar beet cultivation ranged from 4128 to 5044 m3/ha. These figures were higher in the first sowing term, and the lowest in the third sowing term. The share of participation in water consumption was as follows: irrigation rate – 47.8-54.4%, useful precipitation – 32.4-34.9 and soil moisture – 10.7-19.6%.

Key words: *Sugar beet, evapotranspiration, soil moisture, useful precipitation, irrigation, agronomic factors.*

Минкін М.В. Евапотранспірація поля при вирощуванні буряків цукрових залежно від агротехнічних факторів в умовах Півдня України

Виробництво цукру для забезпечення внутрішніх потреб і експортних поставок є важливою й актуальною проблемою. На Півдні України збільшити виробництво цукрових буряків можливо за рахунок вирощування їх на зрошуваних землях. Метою досліджень було вивчення особливостей евапотранспірації поля буряку цукрового залежно від агротехнічних факторів при зрошенні в умовах Півдня України.

Основними завданнями наших досліджень було обґрунтувати водоспоживання вирощування цукрових буряків за різних глибин оранки, фонів живлення, строків їх сівби та густоти насадження.

Польові досліди проводилися в Херсонській області в зоні Інгулецького зрошуваного масиву. Ґрунтовий покрив представлений темно-каштановими слабо солонцевими середньо суглинистими ґрунтами.

У схему досліду були включені наступні фактори і їх варіанти:

Фактор А – оранка на глибину 20-22см та 28-30 см

норма висіву схожих насінин: 6; 9 і 12 млн. шт / га.

Фактор В – фон живлення: без добрив, $N_{150}P_{150}K_{60,}$ Гній 40т/га +

$N_{150}P_{150}K_{60,}$ Гній 40 т/га.

Фактор С – строки сівби: перший строк – при температурі ґрунту на глибині загортання насіння (4-5 см) – 6-8°С; другий – через десять, третій – через 20 днів після першого строку;

Фактор Д – густота стояння рослин: 90, 110 та 130 тис./га

У наших дослідах залежно від досліджуваних факторів, частка ґрунтової вологи у сумарному водоспоживанні коливалася від 8,6 до 23,3%, корисних опадів – від 30,8 до -35,7 і зрошення – від 45,6 до 55,7%, тобто перше місце у водоспоживанні цукрових буряків займає зрошення, друге – опади і найменша частка належить ґрунтовій вологі.

При порівнянні фонів живлення можна відмітити, що найменша частка участі у водоспоживанні цукрових буряків ґрунтової вологи спостерігалась у варіантах на фоні внесення одних мінеральних і органічних добрив за третього строку сівби, а найбільша частка – на удобрених фонах за першого строку сівби.

На основі отриманих результатів можна зробити висновки, що сумарне водоспоживання поля при вирощуванні буряків цукрових коливалось від 4128 до 5044 м^3/га. Більш високими ці показники були за першого строку сівби, а найменші – за третього строку сівби. Частка участі у водоспоживанні розташувалася так: зрошувальна норма – 47,8-54.4%, корисні опади – 32,4-34,9 і ґрунтова волога – 10,7-19,6%.

Ключові слова. *Буряки цукрові, евапотранспірація, ґрунтова волога, корисні опади, зрошення, агротехнічні фактори.*

Statement of the problem. Sugar production to meet domestic needs and exports is an important and urgent problem. In the south of Ukraine, sugar beet production can be increased by growing it on irrigated land. The objectives of modern agriculture are to make the most productive use of all agricultural land to obtain high, high-quality and sustainable yields, create the necessary conditions for systematic reproduction and improvement of soil fertility, rational use of natural and production resources, taking into account optimization of water and nutrient regimes, soil and environmental protection in general.

Unlike some other crops, sugar beet production is much more dependent on climatic factors. In recent years, sugar beet production has declined significantly due to high temperatures and changes in precipitation, so there is a growing need for additional research to minimize the impact of climate factors. Regardless of the degree of adaptation of agricultural plants to the climate and the level of technology used, annual fluctuations in climate variables determine the level of production.

Statement of the problem. Sugar beet is one of the crops that consume water economically. This phenomenon is explained by their biological characteristics: their transpiration coefficient is 400-500, they have a well-developed root system; a long growing season ensures good use of summer precipitation and photosynthesis is carried out during dry periods and at high temperatures. Despite this, sugar beet is very sensitive to irrigation. They rank first among agricultural crops in terms of payback of irrigation and provide high net profit.

The aim of the research was to study the peculiarities of sugar beet field evapotranspiration depending on agrotechnical factors under irrigation in the south of Ukraine.

The main objectives of our research were to substantiate the water consumption of sugar beet cultivation at different plowing depths, nutrition backgrounds, sowing dates and planting densities.

Field experiments were conducted in the Kherson region in the Ingulets irrigated area. The soil cover is represented by dark chestnut slightly saline medium loamy soils.

The following factors and their variants were included in the experimental design:

Factor A – plowing to a depth of 20-22 cm and 28-30 cm

seeding rate of similar seeds: 6; 9 and 12 million pcs/ha.

Factor B – fertilizer background: no fertilizers, N150P150K60, Manure 40t/ha +N150P150K60, Manure 40 t/ha.

Factor C – sowing dates: the first term – at a soil temperature at the depth of seed placement (4-5 cm) – 6-8°C; the second – ten days, the third – 20 days after the first term;

Factor D – plant density: 90, 110 and 130 thousand/ha.

Analysis of recent research and publications. The production of sugar beet roots in Ukraine is insufficient. Irrigation efficiency depends on the sugar beet growing zone. For example, when sugar beet was grown in the steppe zone of Ukraine, the increase in root crop yield was 45.6 t/ha, sugar harvest – 6.59, and in the forest-steppe zone, respectively, 21.0 and 3.30 t/ha [1]. Some scientists believe that irrigation should not be started before the rows close, because the lack of moisture at this time stimulates the growth of the root system in depth. In dry years, irrigation at the rate of 20 mm/ha can contribute to the uniform and accelerated emergence of plants. Also, the same scientists note, the moisture content in the arable layer should not be allowed to fall below the capillary breakdown moisture content (CBMC) for a long time. According to [2], watering should be stopped 15-20 days before harvesting.

Sugar beets require different amounts of water during the growing season. Thus, according to [2], if the entire growing season (from May 15 to October 15) is divided into three equal parts (50 days each), the ratio of water consumption by sugar beet plants for evaporation in each of them is approximately 1:9:3. Scientists of the Institute of Agriculture of the southern region of the UAAS recommend that during the sugar beet growing season 5-7 irrigations with an irrigation rate of 4000-5000 m^3/ha in dry years, 4-6 irrigations with an irrigation rate of 3500-4200 in medium dry years, 4-5 irrigations with an irrigation rate of 2300-3500 in medium wet and humid years, 2-3 irrigations with an irrigation rate of 1400-2000 m^3/ha, and a water consumption coefficient of 112-115 m^3/t.

Gorobets A.M., Pastukh M.O., and others note that under the intensive irrigation regime of sugar beet (70% during the growing season), the irrigation rate is 2900 m^3/ha, and under the water-saving regime (70% of the first irrigation period and a 20% reduction in irrigation rates in the second and third periods) it was 2400 m^3/ha, the water consumption coefficient, in turn, is 76.8 and 77.6 m^3/t, and the yield is 57 and 53.1 t/ha, respectively. In his opinion, the total water consumption of sugar beet was provided by precipitation only by 20%, by 15% – by soil moisture and by 65% – by irrigation water [5].

Fertilizers contribute to a more rational use of water. For the formation of one ton of root crops, depending on the crop rotation, the water consumption coefficient in the variants with fertilizers was 124-129, and without fertilizers – 171-231 m^3 /t, which is 38-80% more [3,4]. Buts O.V. and Filonenko S.V. believe that the irrigation regime of sugar beet is determined by the background of its nutrition. For example, without irrigation, when 30 t/ha of manure + N100P100K50 were applied, fertilizers did not significantly affect the yield, and the following yield increase was obtained on irrigation variants: at 60% NW – 2 t/ha, at 70% – 3.3 and at 80% NW – 4.8 t/ha. When fertilizer rates were doubled, a similar pattern was observed [6, 7, 8].

Summary of the main research material. The results of our research showed that during the cultivation of sugar beet, the total water consumption, depending on the factors studied, ranged from 4128 to 5044 m^3/ha (Table 1). The fertilizer background and plowing depth did not significantly affect the total water consumption. This indicator was mainly influenced by the timing of sowing and thickening of plants. The lowest total water consumption in our experiments – 4128-4418 m^3/ha – was obtained when growing sugar beet, which was sown in the third term with a plant density of 90 thousand plants per hectare, and the highest – from 4671 to 5044 m^3/ha at the first sowing term and plant density of 130 thousand plants per hectare.

Table 1

Evapotranspiration of sugar beet field depending on the studied factors, m^3/ha

Fertilizer background	Sowing date	Plant density, thousand/ha		
		90	110	130
Plowing to a depth of 20-22 cm				
Without fertilizers	First	4662	4803	4853
	Second	4795	4862	4903
	Third	4418	4439	4493
$N_{150}P_{150}K_{60}$	First	4949	4989	5044
	Second	4736	4794	4836
	Third	4144	4172	4200
Manure 40t/ha + $N_{150}P_{150}K_{60}$	First	4876	4890	4965
	Second	4455	4525	4586
	Third	4293	4311	4350
Manure 40t/ha	First	4614	4684	4735
	Second	4509	4579	4624
	Third	4192	4258	4301
Plowing to a depth of 28-30 cm				
Without fertilizers	First	4637	4685	4721
	Second	4873	4936	4966
	Third	4155	4172	4191
$N_{150}P_{150}K_{60}$	First	4651	4716	4755
	Second	4659	4677	4689
	Third	4128	4232	4165
Manure 40t/ha+ $N_{150}P_{150}K_{60}$	First	4667	4738	4792
	Second	4631	4668	4700
	Third	4305	4632	4415
Manure 40t/ha	First	4576	4628	4671
	Second	4446	4493	4509
	Third	4201	4137	4177

In the second term of sowing, depending on the depth of plowing, the total water consumption decreased compared to the first term in the variants of planting density of 90 thousand/ha by 0.8-9.5%, 110 thousand/ha by -0.8-8.1 and 130 thousand/ha by

-1.4-8.3%, in the third term this decrease was, respectively, by 5.5-19.4, 2.3-19.6 and 8.0-14.1%. Comparing the first sowing term with the second, it can be noted that without fertilizers, the total water consumption was higher than in the first sowing term, and on fertilized backgrounds, this figure was higher in the first sowing term.

An increase in the number of plants per hectare from 90 to 110 thousand was observed at almost all sowing dates, it increased the total water consumption, and its growth was even greater when the number of plants per hectare increased from 90 to 130 thousand. In our opinion, this can be explained by the fact that the more plants per hectare, the more they use soil moisture.

Tables 2 and 3 show the calculations of the share of soil moisture, useful precipitation and irrigation in sugar beet water consumption depending on the factors studied.

Table 2

The share of soil moisture, irrigation and useful precipitation in total water consumption depending on the studied factors (on the background of plowing by 20-22 cm)

Sowing term	Plant density, thousand/ha	Share of participation, %			Total water consumption, m^3/ha
		soil moisture	useful precipitation	irrigation	
1	2	3	4	5	6
Without fertilizers					
First	90	17,0	33,7	49,3	4662
	110	19,4	32,7	47,9	4803
	130	20,3	32,3	47,4	4853
Second	90	20,1	31,9	48,0	4795
	110	21,2	31,5	47,3	4862
	130	21,9	31,2	46,9	4903
Third	90	14,6	33,4	52,0	4418
	110	15,0	33,2	51,8	4439
	130	16,0	32,8	51,2	4493
On the background $N_{150}P_{150}K_{60}$					
First	90	21,8	31,7	46,5	4949
	110	22,4	31,5	46,1	4989
	130	23,3	31,1	45,6	5044
Second	90	19,1	32,3	48,6	4736
	110	20,1	31,9	48,0	4794
	130	20,8	31,6	47,6	4836
Third	90	8,9	35,6	55,5	4144
	110	9,5	35,4	55,1	4172
	130	10,1	35,1	54,8	4200
On a background of 40 t/ha of manure + $N_{150}P_{150}K_{60}$					
First	90	20,6	32,2	47,2	4876
	110	20,9	32,1	47,0	4890
	130	22,1	31,6	46,3	4965

Закінчення табл. 2

1	2	3	4	5	6
Second	90	14,1	34,3	51,6	4455
	110	15,4	33,8	50,8	4525
	130	16,5	33,4	50,1	4586
Third	90	12,1	34.4	53,5	4293
	110	12,4	34,2	53,4	4311
	130	13,2	33,9	52,9	4350
On a background of 40 t/ha of manure					
First	90	16,1	34,0	49,9	4614
	110	17,4	33,5	49,1	4684
	130	18,3	33,2	48,5	4735
Second	90	15,1	33,9	51,0	4509
	110	16,3	33,4	50,3	4579
	130	17,2	33,1	49,7	4624
Third	90	9,9	35,2	54,9	4192
	110	11,4	34,6	54,0	4258
	130	12,2	34,3	53,5	4301

In our experiments, depending on the factors studied, the share of soil moisture in total water consumption ranged from 8.6 to 23.3%, useful precipitation – from 30.8 to -35.7 and irrigation – from 45.6 to 55.7%, i.e. irrigation takes the first place in sugar beet water consumption, precipitation – the second and the smallest share belongs to soil moisture.

When comparing fertilization backgrounds, it can be noted that the smallest share of soil moisture in sugar beet water consumption was observed in the variants on the background of applying only mineral and organic fertilizers at the third sowing term, and the largest share – on fertilized backgrounds at the first sowing term.

Table 3

Share of participation in total water consumption of soil moisture, irrigation, useful precipitation depending on the studied factors (on the background of 28-30 cm plowing)

Sowing term	Plant density, thousand/ha	Share of participation, %			Total water consumption, m^3/ha
		soil moisture	useful precipitation	irrigation	
1	2	3	4	5	6
Without fertilizers					
First	90	16,5	33,9	49,6	4637
	110	17,4	33,5	49,1	4685
	130	18,0	33,3	48,7	4721
Second	90	21,4	31,4	47,2	4873
	110	22,4	31,0	46,6	4936
	130	22,9	30,8	46,3	4966

Закінчення табл. 3

1	2	3	4	5	6
Третій	90	9,1	35,5	55,4	4155
	110	9,5	35,4	55,1	4172
	130	9,9	35,2	54,9	4191
On the background $N_{150}P_{150}K_{60}$					
First	90	16,8	33,8	49,6	4651
	110	17,9	33,2	48,9	4716
	130	18,6	33,0	48,4	4755
Second	90	17,8	32,8	49,4	4659
	110	18,1	32,7	49,2	4677
	130	18,3	32,6	49,1	4689
Третій	90	8,6	35,7	55,7	4128
	110	10,8	34,9	54,3	4232
	130	9,4	35,4	55,2	4165
On a background of 40 t/ha of manure + $N_{150}P_{150}K_{60}$					
First	90	17,1	33,6	49,3	4667
	110	18,3	33,1	48,6	4738
	130	19,2	32,8	48,0	4792
Second	90	17,3	33,0	49,7	4631
	110	18,0	32,8	49,2	4668
	130	18,5	32,6	48,9	4700
Третій	90	12,3	34,3	53,4	4305
	110	18,5	31,8	49,7	4632
	130	14,5	33,4	52,1	4415
On a background of 40 t/ha of manure					
First	90	15,4	34,3	50,3	4576
	110	16,4	33,9	49,7	4628
	130	17,1	33,6	49,3	4671
Second	90	13,9	34,4	51,7	4446
	110	14,8	34,1	51,1	4493
	130	15,1	33,9	51,0	4509
Третій	90	10,1	35,1	54,8	4201
	110	8,8	35,7	55,5	4137
	130	9,6	35,3	55,1	4177

The share of useful precipitation in total water consumption, according to the data obtained, was 30.8-35.7%. Moreover, as can be seen from the table, the highest share of precipitation in total water consumption is observed at the third sowing date and plant density up to 90 thousand/ha, and the lowest – at the first sowing date and plant density up to 130 thousand/ha. In our opinion, higher rates of participation in total water consumption with fewer plants can be explained by the fact that in these variants more

moisture evaporates from the soil surface, and with a higher plant density, the soil is practically covered by the leaves of the crop.

The largest share in sugar beet water consumption is irrigation, which varies from 45.6 to 55.7% depending on the factors studied. The lowest share of irrigation in sugar beet water consumption was obtained in the variants of the first sowing term with a plant density of 130 thousand/ha, and the highest – in the third sowing term and sugar beet thickening to 90 thousand plants per hectare.

Conclusions. Based on the results obtained, it can be concluded that the total water consumption of the field during the cultivation of sugar beet ranged from 4128 to 5044 m^3/ha. These figures were higher in the first sowing term, and the lowest in the third sowing term. The share of participation in water consumption was as follows: irrigation rate – 47.8-54.4%, useful precipitation – 32.4-34.9 and soil moisture – 10.7-19.6%.

These studies encourage further research on the evapotranspiration of irrigated crop rotation fields due to changing climatic conditions.

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