NORWEGIAN JOURNAL OF DEVELOPMENT OF THE INTERNATIONAL SCIENCE

№69/2021

Norwegian Journal of development of the International Science

ISSN 3453-9875

VOL.1

It was established in November 2016 with support from the Norwegian Academy of Science.

DESCRIPTION

The Scientific journal “Norwegian Journal of development of the International Science” is issued 24 times a year and is a scientific publication on topical problems of science.

1000 copies

Norwegian Journal of development of the International Science

Iduns gate 4A, 0178, Oslo, Norway

email: publish@njd-iscience.com

site: http://www.njd-iscience.com

CONTENT

AGRICULTURAL SCIENCES

BIOLOGICAL SCIENCES

EARTH SCIENCES

MEDICAL SCIENCES

PHARMACEUTICS

PHYSICAL SCIENCES

TECHNICAL SCIENCES

MOISTURE SUPPLY AND WATER CONSUMPTION OF CROPS OF HYBRIDS OF CORN AT VARIOUS WAYS OF WATERING IN THE CONDITIONS OF THE SOUTH OF UKRAINE

Repilevsky D.
Applicant for higher education degree of Doctor of Philosophy
Ivaniv M.
Candidate of Agricultural Sciences, Associate Professor, Acting Head of the Department of Crop and Agricultural Engineering,
Kherson State agrarian and economic University, Kherson, Ukraine

Abstract

Modern methods of irrigation are considered as a key factor in the intensification of technologies for growing grain corn. The productivity of the crop as a result of the optimization of the water regime increases from 100 to 300% in comparison with non-irrigated conditions. The aim of the research was to study the effect of sprinkler irrigation, drip irrigation and subsurface irrigation on the yield of grain corn.

Keywords: hybrid, maize, FAO group, water consumption, sprinkling, drip irrigation, ground irrigation.

Introduction. Many years of scientific research and production experience show that with the optimization of all components of the irrigated agriculture system, it is possible to obtain consistently high yields of crops annually. Thus, due to the improvement of water and nutrient regimes of the soil at a high technological level of agriculture, it is possible to increase the yield by 2-3 times, and in dry years - by 4-5 times [1-3].

A significant component of the agricultural system is the method of watering, which, along with improving the moisture content of plants, enhances the action of other factors in the direction of increasing yields and increasing profits. In addition, it is important to study the characteristics of water consumption of plants, because these experimental data can be used to optimize artificial moisture by supplying the required amount of water during periods of maximum demand (in the so-called "critical periods" of plant growth and development) [4-6].

In modern practice of irrigated agriculture there are three main methods of irrigation:

Sprinkling - watering by sprinkling is that water is sprayed over the surface of plants in the form of fine droplets, thus creating a complete imitation of rain. Irrigation by sprinkling allows to keep soil structure.

Drip - the essence is to use pipes that run underground or above it and supply water in metered portions directly to the root zone of plants using special drips. Drip irrigation causes minimal water consumption, as it allows plants to consume the received moisture completely, it allows to save essentially not only on water resources, but also on fertilizers and the electric power. This method maintains optimal soil moisture, promotes active plant growth and helps accelerate crop ripening.

Underground - is realized by direct supply of water to the root system of plants with the help of special humidifiers. Pipes with irrigation devices are installed at a small depth under the soil layer, which determines the name of this type of irrigation. Such a system is very convenient, as it does not interfere with various works on the site with vegetation and does not change the structure of the earth's surface, but it is not very popular due to the high cost and complexity of installation [7, 8].

Materials and methods. The experiments were carried out according to the thematic research plan of the Kherson State Agrarian and Economic University on the assignment "Implementation of the technology of growing major agricultural crops." Field experiments were carried out in the Agrobusiness agrofirm of the Kakhovsky district of the Kherson region, located in the South Steppe agroecological zone and within the range of the Kakhovka irrigation system. The soil of the experimental site is southern middle loamy chernozem.

The moisture content of the soil was determined by the thermostat-weight method on two repetitions of the experiment. Soil samples were taken layer by layer every 10 cm to a depth of 0-50 cm in the interphase periods of corn plants when determining the timing of irrigation and 0-100 cm for calculating the total water consumption of corn. The determination was repeated four times.

The total water consumption of corn for individual interphase periods and for the entire growing season was determined by the water balance method according to the formula:

$$E = M + O + \left(W_h - W_к\right), \text{ where}$$

E - total water consumption for the calculation period, m3 / ha;

M - irrigation rate, m3 / ha;

O - precipitation for the growing season, m3 / ha;

Wh - moisture reserve in 0-100 cm layer of soil on the stairs, m3 / ha;

Wk - moisture reserve in 0-100 cm layer of soil during harvesting, m3 / ha.

Precipitation was recorded according to the data of the agrometeorological station "Askania Nova", with the adjustment of their amount in accordance with the indicators of the soil rain gauge, which was installed directly on the experimental sites.

The coefficient of water consumption was determined by the formula:

$$K_E = \frac{E}{У}$$

K_E - water consumption coefficient for the growing season, m^3/t;

E - total water consumption, m^3/ha;

У - grain yield, t/ha.

The irrigation rate was calculated from the moisture deficit of the calculation layer according to the formula of A.N. Kostyakova:

m = 100 x v x h x (βnv - $β_ф$), where,

m - irrigation rate, m^3/ha;

v - volume mass of soil, t/m^3;

h is the depth of the moistened soil layer, m;

βnv - soil moisture, respectively HB, % by weight of dry soil;

βf - actual soil moisture before watering, % by weight of dry soil.

To establish the rate of response of maize hybrids to technological conditions, the effect of different irrigation methods on grain yield was studied: irrigation by sprinkling with the Zimmatic unit; drip irrigation; subsoil irrigation with a level of pre-irrigation soil moisture of 80% HB in the soil layer 0-50 cm Control - natural moisture. Repeat four times, the sown area of the plot of the second order - 75 m^2, accounting - 50 m^2.

Agricultural techniques for growing maize hybrids in the experiments were generally accepted for the southern region of Ukraine. Predecessor - Soya. The experiments were conducted in accordance with generally accepted methods in 2018-2020. Mathematical processing of research results was carried out by the method of analysis of variance using the Agrostat computer software package [9, 10].

The purpose of the study. The aim of our research is to determine the response of maize hybrids of different FAO groups to different irrigation methods.

Results and discussion. Total water consumption is a complex indicator that reflects the amount of water used by the crop for transpiration and formation of biological mass of plants, as well as for physical evaporation from the soil. Total water consumption is not a constant indicator, it varies considerably depending on the weather conditions of the growing season, the moisture content of plants, the level of agricultural technology, etc. [11-13].

Our observations in 2018-2020. It was shown that the total water consumption of crops varies depending on the hybrid composition.

On average, for FAO hybrid groups, the maximum total water consumption of maize plants - 6024 m^3/ha was set for hybrids of the middle-late group. According to factor B (irrigation method), the highest indicator is set for the subsoil irrigation method - 7198 m^3/ha (Table 1).

The maximum indicator of total water consumption in a layer of 0-100 cm, on the average for 2018–2020 years – 7198 m^3/ha is established in the middle-late group of hybrids for underground irrigation.

Table 1

Total water consumption of maize hybrids of different FAO groups and components of its balance (average for 2018–2020)

Watering method	total water consumption, m^3/ha	components of water consumption balance					
		moisture is used from soil reserves		rain		irrigation rate	
		m^3/ha	%	m^3/ha	%	m^3/ha	%
hybrids FAO 180–190							
Without watering, control	2829	1250	44,2	1579	55,8	0	0,0
drip irrigation	4169	840	20,1	1579	37,9	1750	42,0
sprinkling	4307	898	20,8	1579	36,7	1830	42,5
underground irrigation	4594	895	19,5	1579	34,4	2120	46,1
group average	**3975**	**971**	**26,0**	**1579**	**41,0**	**1900**	**43,5**
hybrids FAO 250–290							
Without watering, control	2899	1320	45,5	1579	54,5	0	0,0
drip irrigation	4554	855	18,8	1579	34,7	2120	46,6
sprinkling	4812	883	18,3	1579	32,8	2350	48,8
underground irrigation	5011	872	17,4	1579	31,5	2560	51,1
group average	**4319**	**983**	**25**	**1579**	**38,0**	**2343**	**48,8**
hybrids FAO 320–350							
Without watering, control	2929	1350	46,1	1579	53,9	0	0,0
drip irrigation	5748	909	15,8	1579	27,5	3260	56,7
sprinkling	5942	993	16,7	1579	26,6	3370	56,7
underground irrigation	6114	955	15,6	1579	25,8	3580	58,6
group average	**5183**	**1052**	**24,0**	**1579**	**33,0**	**3403**	**57,3**
hybrids FAO 420–430							
Without watering, control	3045	1380	45,3	1665	54,7	0	0,0
drip irrigation	6827	912	13,4	1665	24,4	4250	62,3
sprinkling	7029	984	14,0	1665	23,7	4380	62,3
underground irrigation	7198	963	13,4	1665	23,1	4570	63,5
group average	**6025**	**1060**	**22,0**	**1665**	**31,0**	**4400**	**62,7**

It is also noted that the maximum amount of water used to form a unit of yield from soil reserves is observed in the control version without irrigation.

We have determined that for the cultivation of maize hybrids without irrigation, water consumption of hybrids occurs due to precipitation and soil moisture reserves in different ways depending on the FAO group. Thus, on average over the years of research, on crops of hybrids of medium-ripe and mid-late maturity groups, the total water consumption of corn from the soil layer 0-100 cm was 5183, 6024 m^3/ha, and early-ripe and middle-early groups - 3974, 4319 m^3/ha and significantly depended on precipitation fell during the growing season.

The share of precipitation in hybrids of early-ripening and middle-early groups in the balance of total water consumption was 41.9 and 38.6%, in middle-ripening and middle-late hybrids of corn - 32.4 and 28.0%, respectively.

During the cultivation of maize on irrigation, the total water consumption of medium-ripe (FAO 320-350) and medium-late (FAO 420-430) hybrids over the years of research has doubled compared to control plots and amounted to 5935 and 7018 m^3/ha, respectively.

At the same time, the irrigation rate in the total water consumption of medium-ripe and medium-late hybrids accounted for an average of 57.3 and 62.7%. The use of soil moisture reserves decreased by 30.5 and 31.9% compared to crops of hybrids of the same maturity groups without irrigation.

Analysis of the structure of the total water consumption of maize hybrids for the study period 2018-2020 years. Shows that the specific weight of soil moisture from the soil layer 0-100 cm was 44.2-46.1% in areas without irrigation, 13.4-20.8% in irrigation; the share of precipitation without irrigation - 53.9-55.8%, on irrigation - 23.1-37.9%, the share of irrigation - 42.0-63.5%. That is, the main part of the total water consumption is irrigation water.

It should be noted that even after irrigation, the amount of precipitation during the growing season is significant - 23.1-24.4% of the balance of the total water consumption of medium-ripe and medium-late hybrids of corn. Thus, with a high level of natural moisture supply, the need for irrigation of corn decreases.

Irrigation efficiency is determined and evaluated through a water consumption ratio that shows how much moisture is used to produce 1 ton of corn grain. Improving the conditions of moisture supply leads to a decrease in the coefficient of water consumption of maize hybrids (table 2).

Table 2

Water consumption rate, drought tolerance rate and payback of irrigation water for maize hybrids of different FAO groups depending on irrigation methods (average for 2018–2020)

Hybrids (factor A)	The method of watering (factor B)	yield, t/ha	coefficient water consumption, m^3/t	coefficient drought resistance	payback irrigation water growth yields grain, kg/m^3
DN Palanok (FAO 180)	Without watering, control	5,06	571,5	-	-
	drip irrigation	10,24	393,5	0,490	2,96
	sprinkling	9,64	446,4	0,529	2,50
	underground irrigation	10,11	440,1	0,497	2,38
	group average	8,76	470,5	0,509	**2,61**
DB Lada (FAO 190)	Without watering, control	5,43	609,7	-	-
	drip irrigation	10,09	399,9	0,466	2,66
	sprinkling	9,48	446,9	0,496	2,21
	underground irrigation	9,88	454,2	0,481	2,09
	group average	8,72	485,5	0,481	2,32
group average FAO 180–190		**8,74**	**478,0**	**0,495**	**2,47**
DN Galatea (FAO 250)	Without watering, control	2,96	1017,2	-	-
	drip irrigation	11,36	400,2	0,255	3,96
	sprinkling	9,98	474,0	0,289	2,97
	underground irrigation	10,67	476,9	0,279	3,01
	group average	**8,74**	**630,5**	**0,272**	**3,32**
DN Svityaz (FAO 290)	Without watering, control	2,99	1010,1	-	-
	drip irrigation	11,58	397,7	0,255	4,05
	sprinkling	10,39	460,1	0,282	3,15
	underground irrigation	11,23	439,1	0,258	3,22
	group average	8,88	622,6	0,269	3,47
group average FAO 250–290		**8,81**	**626,6**	**0,270**	**3,40**
Askania (FAO 320)	Without watering, control	2,65	1113,7	-	-
	drip irrigation	15,46	372,4	0,172	3,93
	sprinkling	13,91	429,6	0,196	3,34

	underground irrigation	14,23	425,8	0,187	3,23
	group average	11,56	585,4	0,185	3,50
DN Bulat (FAO 350)	Without watering, control	2,73	1080,8	-	-
	drip irrigation	15,27	382,4	0,182	3,85
	sprinkling	13,55	440,8	0,207	3,21
	underground irrigation	14,11	434,8	0,197	3,18
	group average	11,42	634,6	0,195	3,53
group average FAO 320–350		**11,49**	**610,0**	**0,190**	**3,52**
Primorski (FAO 420)	Without watering, control	2,01	1561,5	-	-
	drip irrigation	17,14	395,8	0,114	3,56
	sprinkling	16,08	427,7	0,121	3,21
	underground irrigation	16,62	427,1	0,118	3,20
	group average	12,96	703,1	0,118	3,32
DN Rava (FAO 430)	Without watering, control	2,00	1594,2	-	-
	drip irrigation	17,27	393,0	0,111	3,59
	sprinkling	16,33	420,9	0,117	3,27
	underground irrigation	16,73	422,8	0,114	3,22
	group average	13,08	707,7	0,114	3,36
group average FAO 420–430		**13,02**	**705,4**	**0,116**	**3,34**
LSD 05, t/ha factor A		0,14			
factor B		0,16			
AB interaction		0,18			

According to the indicators of total water consumption and yield of maize hybrids, the coefficient of water consumption of crops per unit of yield was established. According to factor A (hybrid), the lowest water consumption ratio, on average over the years of research, was observed in the hybrid Askania (FAO 350) - 372.4 m^3/t, hybrids DN Palanok (FAO 180) - 393.5 m^3/t, hybrid DN Rava (FAO 430) - 393.0 m^3/t. The maturity group of the hybrid had almost no effect on the water consumption ratio. The minimum values of this indicator for factor B (irrigation method) - 391.9 m^3/t were recorded on drip irrigation, which is 677.9 m^3/t less than in the control version without irrigation.

The water consumption rate of maize hybrids in the control variant is much higher than for irrigation. This difference is especially noticeable when growing mid-late hybrids. On average, for all irrigation methods, the water consumption coefficient in all studied hybrids decreased moderately with the growth of the FAO group and was the lowest in FAO hybrids 320-430 Askania, DN Bulat, Primorsky, DN Rava (409.3–419.3). The lowest indicators of the water consumption coefficient were observed in drip irrigation, especially in hybrids with a longer growing season, which is primarily due to the level of their yield.

Indicators of the coefficient of water consumption of maize hybrids indicate an increased level of efficiency in the use of moisture for the formation of 1 ton of grain under drip irrigation using maize hybrids of intensive type on underground irrigation. With natural moisture supply, early-maturing maize plants (FAO 180-190) are most efficiently used.

An indicator such as the payback of irrigation water by the additional grain harvest due to irrigation is also quite important (see table 2).

On the average for three years of researches on all hybrids with carrying out vegetative waterings this indicator made from 3,026 kg/m^3 in underground irrigation to 3,675 kg/m^3 on drop irrigation that testifies to prospects of use of a drop method of watering.

To establish the relationship between the payback of irrigation water by the increase in grain yield, kg/m^3 and the grain yield of maize hybrids of different maturity groups, a correlation calculation was performed. By processing the obtained data, it was established that there is a close interaction between the indicator "irrigation water payback" and "hybrid yield". The correlation coefficient was r = 0.571. This indicates that the technology of growing corn under irrigation should take into account the genotype of the hybrid and the corresponding methods of watering.

This indicates the need to grow maize hybrids on irrigated lands of the relevant FAO groups. For natural moisture, it is necessary to use hybrids with high drought resistance. The drought resistance coefficient of such hybrids should be in the range of 0.4-0.5 (see table 2). Such hybrids can provide grain yield without watering in the range of 3-5 t/ha and have a maturity group for FAO 180-250.

It should also be noted that the payback of irrigation water by an additional increase in grain yield increased in hybrids with a longer growing season.

Conclusions. On the basis of the conducted researches it is confirmed that irrigation, in a complex with other agricultural receptions, is the key factor of intensification of growth processes and formation of productivity of crops of grain corn.

Studies have shown that the maximum total water consumption in the layer is 0-100 cm, on average for 2018-2020 – 7198 m^3/ha in the middle-late group of hybrids for groundwater irrigation.

The lowest average water consumption rate over the years of research - 391.9 m^3/t was on drip irrigation, which is 677.9 m^3/t less than in the control version without irrigation.

It was found that on average over three years of research on all hybrids with vegetative irrigation, the payback rate of irrigation water ranged from 3.0263 kg/m^3 in groundwater irrigation to 3.675 kg/m^3 on drip irrigation.

When growing maize hybrids with a longer growing season, the payback of irrigation water increased in comparison with early-maturing and middle-early groups.

REFERENCES:

1. Lavrynenko Yu. O., Hozh O. A., Vozhegova R. A. Productivity of corn hybrids of different FAO groups depending on microfertilizers and growth stimulants under irrigation in the south of Ukraine. Agricultural science and practice. 2016. № 1. P. 55–60. doi.org/10.15407/agrisp3.01.055.

2. Barlog P., Frckowiak-Pawlak K. Effect of Mineral Fertilization on Yield of Maize Cultivars Differing in Maturity Scale. Acta Sci. Pol. Agricultura. 2008. №. 7. P. 5–17.

3. Romashchenko M., Shatkowski A., Zhuravlev O. Features of application of the "Penman–Monteith" method for conditions of a drip irrigation of the Steppe of Ukraine (on example of grain corn). Journal of Water and Land Development. 2016. No. 31. Pp. 123–127. DOI: 10.1515/jwld-2016-0043.

4. Vozhehova R.A., Kokovikhin S.V., Lavrynenko Y.O., Lykhovyd P.V., Biliaeva I.M., Drobitko A.V., Nesterchuk V.V. Assessment of the CROPWAT 8.0 software reliability for evapotranspiration and crop water requirements calculations. Journal of Water and Land Development. Polish Academy of Sciences (PAN) in Warsaw. 2018. № 39 (X – XII). P. 147–152. http://www.degruyter.com/view/j/jwld DOI: 10.2478/jwld-2018-0070.

5. Gadzalo Y.M., Vozhegova R.A., Kokovikhin S.V., Bilyaeva I.M., Drobitko A.V. Scientific substantiation of technologies of corn cultivation on irrigated lands taking into account hydrothermal factors and climate change. Irrigated agriculture. Kherson: Helvetica. 2020. № 73. 21–26. https://doi.org/10.32848/0135-2369.2020.73.3.

6. Marchenko T.Yu. Innovative elements of cultivation technology of corn hybrids of different FAO groups in the conditions of irrigation. Natural sciences and modern technological solutions: knowledge integration in the XXI century: collective monograph. Lviv; Torun : Liha-Pres, 2019. P. 137–153. DOI: 10.36059/978-966-397-154-4/135-152.

7. Shatkovsky A.P., Zhuravlyov O.V., Melnichuk F.S., Ovchatov I.M., Yarosh A.V. Influence of irrigation methods on the productivity of corn. Crop and soil science. 2020. Vol. 11, №4. p. 34–42. doi.org10.31548 / agr2020.04.034.

8. Ushkarenko V.O., Nikishenko V.L., Goloborodko S.P., Kokovikhin S.V. Dispersion and correlation analysis of the results of field experiments: a monograph. Kherson: Aylant, 2009. 372 p.

9. Ushkarenko V.O., Vozhegova R.A., Goloborodko S.P., Kokovikhin S.V. Methods of field experiment (Irrigated agriculture). Kherson: Green DS, 2014. 448 p.

10. Nosko B.S., Patika V.P., Tarariko O.G. and others. Ways to increase soil fertility in modern conditions of agricultural production (recommendations). K.: Agrarna nauka, 1999. 111s.

11. Averchev O.V., Lavrynenko Y.O., Mikhalenko I.V., Ivaniv M.O. Biometric indicators of maize hybrids and their relationship with grain yield under different methods of irrigation and moisture in the arid steppe of Ukraine. Taurian Scientific Bulletin. 2020. № 111. P.3–13.

12. Averchev O.V., Ivaniv M.O., Lavrynenko Y.O. Indices of yield and effective productivity in maize hybrids of different FAO groups under different methods of irrigation and moisture in the arid steppe of Ukraine. Taurian Scientific Bulletin. 2020. № 114. P.3–12. https://doi.org/10.32851/2226-0099.2020.114.1.