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EFFICIENCY AND ECONOMIC EVALUATION OF DIFFERENT METHODS OF IRRIGATION IN GROWING CORN (*ZEA MAYS* L.)

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Abstract

The paper aimed to study the effectiveness of corn cultivation under different irrigation methods on the experimental field of the Askanian State Agricultural Research Station, which is located in the semi-arid, steppe, arid climate zone of the Southern Steppe of Ukraine, in the Kakhovsky irrigated massif. The investigation pointed out the effectiveness and provided an economic assessment of the use of different irrigation methods in corn cultivation. Two methods of irrigation (sprinkling and subsoil drip irrigation) were studied, with the maintenance of the humidity of the soil layer 0–50 cm at the level of 80% LMC and corn hybrids of different maturity groups. Under subsoil drip irrigation, the irrigation rate was lower on average by 24% than when sprinkled, on the other hand, the yield was higher on average by 40.9%, which significantly affected the cost price of the obtained corn grain. Subsoil drip irrigation yielded a net profit of 62% higher than sprinkler irrigation. and the profitability accordingly increased by 78.8%.

Key words**:** *corn, hybrid, sprinkling, drip irrigation, yield*

INTRODUCTION

One of the most important tasks of the agricultural industry is to obtain the greatest profit, reduce the cost price and increase the profitability of growing agricultural crops. In contrast to this is the expansion of the area of agricultural land and the continuous intensification of agriculture, which leads to increasingly strong negative consequences for the ecology of the planet. Therefore, in today's context, one of the most promising ways to increase the profitability of agricultural production is the scientific development and wide implementation of resource-saving technologies [11, 14].

The south of Ukraine is the territory of risky agriculture, where due to lack of moisture, farmers can suffer significant losses, or even completely lose their harvest [8, 9]. Therefore, irrigation in this region is a necessary component for the sustainable development of agriculture. One of the main means of reducing cost, increasing productivity is possible due to the increase of irrigated areas under surface and subsoil drip irrigation, which is considered a resource-saving method of irrigation [4, 13].

The most widespread method of irrigation in the Southern region of the country is sprinkler irrigation. Drip irrigation is widely used in the cultivation of vegetable products, but the research results below have shown that this is a very promising method of irrigation for row crops as well [12]. In many countries of the world, instead of surface drip irrigation, when drip lines are located on the surface of the soil, underground drip irrigation is increasingly used. The peculiarity of this

irrigation method is that water is brought to the field using perennial pipes with drippers, which are laid under the surface at a depth of 30-50 cm.

The impact of drip irrigation on the productivity of various corn hybrids has been studied in many countries of the world. Such experiments conducted in the experimental garden of the Faculty of Agriculture, Teuku Umar University, Meulaboh, West Aceh in Indonesia on various hybrids of sweet corn showed that the use of drip irrigation practically does not affect the plants in the first month of vegetation, but already on the 45th day such the watering method led to an increase in leaf length by almost 20% [5].

Studies of the influence of different watering intervals using drip irrigation on the yield and quality of corn silage conducted in Southeastern Anatolia region in Turkey indicate a positive effect of maximally frequent watering with a small irrigation rate [7].

Despite the fact that subsoil drip irrigation is a relatively new method of irrigation, it is quite widely covered in scientific works around the world. Lysimeter studies carried out on winter wheat plants indicate a decrease in evapotranspiration when using subsoil drip irrigation by 26% compared to traditional irrigation methods, and by 15% compared to surface drip irrigation [1, 10]. A field experiment conducted in Pals (Baix Ter, Girona, Spain) during the cultivation of Onice rice variety showed that when laying drip tapes at a depth of 0.15 m and carrying out two irrigations per day, the lowest water losses for percolation into the lower soil layers can be achieved [3].

Research carried out in the USA on the possibility of increasing the productivity of modern corn hybrids due to the use of subsoil drip irrigation together with increasing the density of plant stands showed high prospects for such an approach. However, the change in irrigation intensity had a minor effect on corn yield (within 2–3%) [6]. In India, a study was conducted with the possibility of evaluating the yield level of sweet corn under different irrigation water management strategies. Among the many considered parameters were various irrigation methods. The results of the study indicate that the use of subsoil drip irrigation allows to increase the yield of corn grain compared to sprinkling by 22.69% without the use of mulch, and by 8.47% with mulching [2].

With the aim of researching different irrigation regimes when growing corn on subsoil drip irrigation, a number of experiments were conducted at Haymana Research and Training Center of Agricultural Faculty at Ankara University, in Central Anatolia Region of Turkey. The results were quite predictable. With an increase in the irrigation rate, the yield of corn also increased significantly. However, when the irrigation rate was reduced by 30%, the grain yield decreased by only 10% [2].

The analysis of the results of recent studies showed that the influence of subsoil drip irrigation on the productivity of corn depends on the soils and climatic features of the place of the experiment. Therefore, for the conditions of the south of Ukraine, it is necessary to conduct detailed studies of this issue. The analysis of literary sources shows that Ukrainian scientists consider the economic efficiency of corn cultivation with sprinkler and drip irrigation. However, scientific and practical works on the study of the influence of subsoil drip irrigation on the economic efficiency of corn cultivation for the soil and climatic conditions of southern Ukraine were not conducted.

The aim of the study was to study, analyze and establish the effectiveness of the application of excellent methods of irrigation in the cultivation of corn for grain and to provide an economic assessment.

MATERIALS AND METHODS

The research was carried out at the experimental field of the Askanian Atate Agricultural Research Station in the village of Tavrychanka, Kherson region (46°33'12"N; 33°49'13"E; 39 m above sea level), located in the steppe zone of Southern Ukraine, Kakhovsky irrigated massif, during 2019–2020.

The soil on the site is dark chestnut. The humus horizon is dark gray up to 35 cm thick and has a lumpy granular structure. It contains a significant amount of root remains. The transitional horizon has a coarse-grained or lumpy-prismatic structure, light chestnut color. It contains carbonates in the form of white stars. The humus content is 2.3%. The content of the main nutrients: N (mineral) – 30–45 mg/kg, P_2O_5 – 45–55 mg/kg, K_2O – 400–550 mg/kg. The parent rock is represented by loess, which lies at a depth of about two meters.

Irrigation by sprinkling was calculated to maintain the humidity of the soil layer 0–50 cm at the level of 80% of the lowest soil moisture content (HB). On subsoil drip irrigation, soil moisture was maintained within 80% HB. The subsoil drip irrigation system had the following parameters: a drip tape with a diameter of 16 mm with a wall thickness of 16 mil laid at a depth of 35 cm. The distance between the tapes is 70 cm, the distance between the emitters is 25 cm. The output of the emitter is 1.1 l/h. Corn was sown with a seeder with a row spacing of 70 cm. The seeding rate was 82,000 pieces. per hectare. The rate of application of mineral fertilizers was $N_{120}P_{60}$ and was applied in two stages: the first – under cultivation in the form of amphos, the second - before sowing in the form of UAM.

Factor A in the experiment was the methods of irrigation: subsoil drip irrigation and sprinkling using a front sprinkler. Factor B - corn hybrids of different maturity groups: Stepovyy – FAO 190, Meotida – FAO 190, Khotyn – FAO 250, Askania – FAO 320, Getera – FAO 420 and Arabat – FAO 430.

Statistical processing of experimental data was carried out to help program security AgroSTAT, XLSTAT and Statistica (v. 13).

RESULTS AND DISCUSSIONS

The use of subsoil drip irrigation made it possible to reduce the irrigation rate in 2019 from 3,600 m^3/ha to 2,610 m^3/ha. In 2020, this figure for sprinkling was 2,700 m^3/ha, and for subsoil drip irrigation – 2,160 m^3/ha. This saving of irrigation water had a significant impact on the cost of the obtained corn grain.

The use of drip irrigation made it possible to significantly increase the productivity of corn, with the highest yield in the Getera hybrid - 14.17 t/ha, while with sprinkler irrigation - 9.69 t/ha (Table 1).

Table 1. Productivity and economic efficiency of corn cultivation on average for 2019-2020

irrigation method (A)	Hybrid (B)	Yield, t/ha	The cost of the obtained products, €/ha	Expenses per 1 ha, €	Notional net profit, €/ha	Cost of 1 t of seeds, €	Profitability level, %
Sprinkling	Stepovyy	8.62	1,637.80	517.90	1,119.90	60.08	216.2
	Meotida	8.97	1,704.30	519.18	1,185.13	57.88	228.3
	Khotyn	9.07	1,723.30	518.78	1,204.53	57.20	232.2
	Askania	9.65	1,833.50	519.20	1,314.30	53.80	253.1
	Getera	9.69	1,841.10	519.28	1,321.83	53.59	254.6
	Arabat	9.33	1,772.70	517.75	1,254.95	55.49	242.4
	Average	**9.22**	**1,752.12**	**518.68**	**1,233.44**	**56.34**	**237.8**
Subsoil drip irrigation	Stepovyy	12.31	2,338.90	469.48	1,869.43	38.14	398.2
	Meotida	12.23	2,323.70	469.83	1,853.88	38.42	394.6
	Khotyn	12.50	2,375.00	469.85	1,905.15	37.59	405.5
	Askania	13.14	2,496.60	470.30	2,026.30	35.79	430.9
	Getera	14.17	2,692.30	470.83	2,221.48	33.23	471.8
	Arabat	13.60	2,584.00	469.83	2,114.18	34.55	450.0
	Average	**12.99**	**2,468.42**	**470.02**	**1,998.40**	**36.28**	**425.2**
LSD_{05}	A	0.840					
LSD_{05}	B	0.545					

Note: The cost of 1 ton of grain–190 €/t.
Source: Own results.

The lowest productivity was shown by the Stepovyy hybrid in the version with sprinkler irrigation - 8.6 t/ha. The use of subsoil drip irrigation showed an increase in productivity by 3.77 t/ha compared to sprinkling.

This growth of the Yield is caused by the fact that drip irrigation allows you to carry out many waterings with small rates and maintain a more uniform level of moisture in the root layer of the soil.

Also, subsoil drip irrigation systems showed greater adaptability to the climatic conditions of the region. Meteorological conditions during the years of the study were quite typical for Southern Ukraine. The amount of precipitation during the corn growing season in 2019 was 180.0 mm, and in 2020 – 213.5 mm. The main part of precipitation fell in the form of heavy downpours, between which there were long periods without rain. Thus, irrigation was stopped for some time after rains for 5–6 days, and then resumed. However, due to the peculiarities of the sprinkling technology, some areas of the field received moisture several days later than it was necessary. With drip irrigation, thanks to the flexible schedule of moisture supply to the fields, this problem was avoided.

Therefore, the use of subsoil drip irrigation allows to simultaneously increase the yield of corn and reduce the cost of the obtained products. By reducing the irrigation rate, it was possible to reduce production costs by €48.66 per hectare. Profit from one hectare increased by €764.96. Thus, on subsoil drip irrigation, the profitability of corn grain production increased by 78.8%.

For late-ripening hybrids, production costs were approximately the same as for early-ripening ones, and the net profit increased due to increased productivity. Thus, the difference between the cultivation of the steppe hybrid - FAO 190 and the hybrid Arabat - FAO 430 on sprinkler irrigation was 8.2%, and on subsoil drip irrigation - 10.4%.

CONCLUSIONS

The use of subsoil drip irrigation when growing corn for grain in the Southern Steppe of Ukraine made it possible to reduce the irrigation rate by an average of 24%, which led to a decrease in production costs by 9.4%. On the contrary, productivity increased by an average of 40.9%. Subsoil drip irrigation yielded a net profit of 62% higher than sprinkler irrigation. Production costs decreased by 9.4%, and profitability accordingly increased by 78.8%.

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