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STUDY THE ENVIRONMENTAL PERFORMANCE OF TWO TECHNOLOGIES OF FERTILIZATION AND IRRIGATION ON GRAIN MAIZE

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Abstract. *The synergistic effect of irrigating and fertilizing corn for grain has been the subject of years of research. Grain maize shows its biological potential by properly combining irrigation, nutrient fertilization and other factors of the agro-technical complex of activities. In order to achieve the objectives of the study, the following variants are laid: In some furrows are fertilized and in the adjacent watering; In the same furrows are fertilized and irrigated; Non-irrigation option.The size of the test plots is 70 m2 (length of 10 m, 5 irrigation and 5 non-irrigation furrows) and soil type meadow cinnamon soil (Gleyic Hromic Luvisols). Nitrogen fertilizer is fed three times at 1/3 - before sowing, before sowing and after the first watering with a total of 120 kg/ha in the 1st year and 180 kg/ha of active substance in the 2nd year of the field experiment.The aim of this study is a comparative analysis of two technology solutions for fertilization and irrigation of maize grain. Studied the distribution of nitrogen in the soil profile and the level of contamination of the effluent. The analysis of both technologies for irrigation and nutrition with nitrogen grain maize in irrigation fertilization (traditional technology) and without fertilization furrows (new technology) seeks to establish the ecological relevance of each of them. Assays were performed in method for simultaneous determination of ammoniacal and nitrate nitrogen in the soil. Water samples of irrigation water were analyzed for nitrogen, the samples were taken at the beginning of irrigations; of effluent irrigation for both variants are taking an average sample of irrigation furrows in the beginning in the middle and at the end of the flow in them. It was found that only the first watering and irrigation fertilized furrows has substantial exports of both mineral and nitrate nitrogen in the effluent. Most nitrate nitrogen is exported in irrigation furrows and fertilized at a higher fertilization rates.*

Key words: *maize, irrigation, fertilization, yield, nitrogen*

INTRODUCTION

Global warming is a problem for all crops. Tigchelaar et al. (2018) examine how an increase in average global temperature is likely to increase yield volatility worldwide. For each degree of increase in average global temperature, yields are expected to decrease by an average of 7.4% for corn, 6.0% for wheat, 3.2% for rice and 3.1% for soybeans (Zhao et al., 2017).

The synergistic effect of irrigating and fertilizing corn for grain has been the subject of years of research. Grain maize shows its biological potential by properly combining irrigation, nutrient fertilization and other factors of the agro-technical complex of activities. The level of fertilization affects the biometric parameters of maize (Petrovska et al. 2010).

Changing the content of ammonium and nitrate nitrogen in the soil profile is a complex and dynamic process (Slavov, 2000; Halvorson et al. 2005; Stoyanova et al. 2010a). Nitrate accumulation depends mainly on nitrogen fertilization, its consumption by plants and, to a large extent, on the intensity of irrigation.

In a study (Stoyanova et al. 2010b), it was found that irrigation regime of maize for grain influences the content of mineral nitrogen in the soil horizon. Under non-irrigation conditions, the amount of nitrogen is higher in the surface layer 0-40 cm. Under irrigation conditions, the mineral nitrogen content is higher in the deeper layers 80-100 cm. A number of studies in the world and in our country have proven the influence of water deficit on the productivity of corn (Dagdelen et al. 2008: Stoyanova et al. 2010c, Bazitov, 2014).

However, the costs of fertilizer and irrigation water are an essential part of the cost of production. On the other hand, the use of high fertilizer rates in combination with intensive irrigation can lead to pollution of wastewater and groundwater with nitrates and disturb the ecological equilibrium of the environment (Badzhov, 1969; Koteva, 1993; Slavov, 2000).

A number of developments (Popova, 2000; Popova et al., 2005; Popova, 2008a, Ivanova et al., 2011; Popova et al., 2014) Have found the influence of irregular distribution of irrigation water and nitrogen fertilizers on yields, the environment through the application of the CERES-NC model and others. In this way, the results of the models can be reduced to production conditions, which proves their practical applicability.

The purpose of this study is to draw a parallel between the two irrigation and nourishing technologies of corn maize for irrigation in manure (traditional technology) and non-fertilized furrows (new technology) and to establish the environmental and economic feasibility of each.

MATERIAL AND METHODS

In order to achieve the objectives of the study, the following variants are laid: In some furrows are fertilized and in the adjacent watering; In the same furrows are fertilized and irrigated; Non-irrigation option.

Characteristics of the test area

The size of the test plots is 70 m2 (length of 10 m, 5 irrigation and 5 non-irrigation furrows) and soil type meadow cinnamon soil (Gleyic Hromic Luvisols). Nitrogen fertilizer is fed three times at 1/3 - before sowing, before sowing and after the first watering with a total of 120 kg/ha in the 1st year and 180 kg/ha of active substance in the 2nd year of the field experiment. The whole fertilizer rate is applied to the irrigation variants and the non-irrigation rate is sowed. Soil samples for testing the nitrogen content are taken at the beginning, during and at the end of the growing season at depths of 0-40, 40-70 and 70-100 cm. in irrigation furrow, it was also irrigation furrow in irrigation variants, and in dry in furrow, it was either. The assays are performed by a procedure for the simultaneous determination of ammonia and nitrate nitrogen in the soil.. Water samples to test nitrogen content are taken: from the irrigation water at the beginning of the irrigation; of effluent for irrigation two options taken random sample of five irrigation furrows in the beginning in the middle and at the end of the flow in them.

The irrigation variants maintain optimum soil moisture with three irrigations and irrigation rates of 700 to 1000 m^3/ha. In the 1st year it is moderately dry and in the 2nd year it is medium humid.

Soil characteristics

In terms of humus content, the soil falls to the average reserves of 3.75% (humus in% to absolutely dry soil) for the 0-20 cm layer and an average of 1.97% for the 20-40 cm layer. The FC is 27%, the meadow-cinnamon soil fading ratio is about 18-19%, the porosity is 47% and the volume weight is 1.45. It has been shown that soil salts accumulate in the boundary between the carbonate and humus layers. It follows that, when irrigating, the active soil layer should be limited to 80 cm. Thus, in order to obtain the ascent of the accumulated salts to the surface layers, it is necessary to calculate a irrigation rate that will moisten the soil layer up to 80 cm.

The irrigation rate is determined on the basis of the established maximum field moisture content (MFM). For this soil type, the MPV is found to be 27%, ie. at a given depth of the active soil layer for wetting up to the MFM, it is necessary to realize a watering of 95 m3. The meadow-cinnamon soil wilt ratio is about 18-19% and the volume weight is 1.45.

The soil type is characterized by high absorption capacity, which is a prerequisite for irrigation with a large irrigation rate in a shorter time. Due to its high molecular capacity, high moisture content, absorption and favorable density of soil horizons, the lateral spread covers a large radius and reaches up to 1.5 m depending on the plow layer.

RESULTS AND DISCUSSION

The maize irrigation was done with Moto Pump Unit and Flexible Polyethylene Pipelines. Irrigation pipes were perforated with holes 22 mm arranged with a minimum slope providing a uniformly flowing irrigation streams with a size 0.6 l / s, in which were carried out following irrigation rates:

In the 1st year of the field study realized three irrigations: 1st watering - m = 884 m3/ha; 2nd watering - m = 975 m3/ha; 3rd irrigation - m = 772 m3/ha. In the 2nd year of the field survey, three waterings were realized: 1st watering - m = 920 m3/ha; 2nd watering - m = 1030 m3/ha; 3rd watering - m = 670 m3/ha;

Mineral nitrogen content in soil profile

At the beginning of the growing season in the first year (Table 1) the content of mineral nitrogen in the top soil layer (0 - 40 cm) is 14.03 mg/1000g and is significantly lower than in the subsequent layers - 0 - 70 and 70 - 100 cm (56.36 and 48.92 mg/1000g). When fertilizing with a lower fertilizer rate, the mineral nitrogen content at the end of the growing season for the 0-40 cm layer is from 22.13 to 32.62 mg/1000g for irrigation and is significantly higher than at the beginning (14.03 mg/1000g). In the non-irrigation version, the content of mineral nitrogen at the end of the growing season is even higher - 40.77 mg/1000g. In irrigation variants, as a rule, the content of mineral nitrogen decreases in depth of the soil profile. The deviation from this rule is in the variant irrigation furrows for non-irrigation furrows, where its content increases in depth - from 22.13 to 28.54 mg/1000g.

In the second year (Table 2), at the beginning of the growing season, the content of mineral nitrogen was lowest in the layer 0 - 70 cm, and in the layer 70 - 100 cm higher than those in the layer 0 - 40 cm, but the values were small differences. At the end of the growing season, the content of mineral nitrogen was significantly higher in the 0-40 cm layer (31.36 mg/1000g) compared to the following depths of 14.00 and 11.76 mg/1000g.

For irrigation variants, the content of mineral nitrogen is higher for the layer 0 - 40 cm in the case of irrigation in fertilized furrows for irrigation furrow and ridge, and in the variant irrigation in non-fertilized furrows for irrigation furrow and irrigation furrow. For non-irrigation furrows of irrigated fertilization, mineral nitrogen is highest (28.00 mg / 1000g) in the 40-70 cm layer, and for irrigation-irrigation furrows it is highest for 70-100 cm (27.44 mg / 1000g).

Nitrogen content in soil profile

The nitrate nitrogen data show significant movement in the soil profile (Tables 1 and 2), but it is not the same in both fertilization rates and in both irrigation, comb and irrigation furrows. At the beginning of the growing season, the nitric nitrogen (NO3) content was significantly increased (about 3 times) in depth of the soil profile. At the end of the growing season, in the non-irrigation variant, the NO_3 content of the topsoil (0-40 cm) is up to twice as high as for the 40-70 and 70-100 cm layers.

Table 1.

Content of nitrogen in the soil profile at the beginning and end of vegetation, 1st year

Depth	Location	Ammonium Nitrogen	Nitrate nitrogen	Mineral Nitrogen
cm		mg/1000g	mg/1000g	mg/1000g
Without irrigation		Start of growing season		
0-40		78.04	6.99	14.03
40-70		44.26	12.81	56,36
70-100		33,78	15,14	48,92
		End of growing season		
0-40		31,35	9,32	40,77
40-70		19,8	8,15	27,95
70-100		10,48	13,98	24,46
Watering in fertilized furrows		End of growing season		
0-40	Watering furrow	25,63	5,82	31,45
40-70		13.98	8.15	22.13
70-100		15.14	8.15	23.29
0-40	Ridge	24.46	5.82	31.28
40-70		16.89	6.99	23.88
70-100		19.22	7.57	26.79
0-40	No-watering furrow	18.64	3.49	22.13
40-70		20.97	9.32	30.29
70-100		25.63	2.91	28.54
Watering in no-fertilized furrows		End of growing season		
0-40	Watering furrow	19,8	10,48	30,28
40-70		11,65	16,31	27,96
70-100		13,98	12,81	27,79
0-40	Ridge	18,64	10,48	29,12
40-70		9,32	8,15	17,47
70-100		10,48	5,82	16,3
0-40	No-watering furrow	25,63	6,99	32,62
40-70		15,72	5,82	21,54
70-100		16,31	8,15	24,46

In year 1 the fertilizer rate is 120 kg/ha of active substance. At the end of the growing season, irrigation in irrigated furrows (Var.1) determines the nitrate content in depth of the soil profile for irrigation furrow, ridge and irrigation furrow (Table 1). In the irrigation furrow, the values of (NO3) are higher than those of the ridge and the irrigation furrow, and in the furrow itself, higher for the upper layer is 0 - 40 cm. At combing, the values of (NO3) are highest in the plow layer and decrease substantially in depth. In the non-irrigation groove, the values of (NO3) are slightly different for the upper two layers, but less than those for the 70-100 cm layer.

When irrigated with irrigated furrows (Var. 2), the nitrate content in the depth of the soil spring is as follows: in the irrigation furrow (NO3) it is evenly distributed in depth, with only lower values for the upper layer. At the crest values increased in depth, but the differences are small. For the non-irrigation groove, the values for the layers 0-40 and 70-100 cm are the lowest in both variants, and for 40-70 cm they are higher and are in the order of those in the irrigation furrow and comb.

In year 2, the fertilizer rate was 180 kg/ha of active substance (Table 2). At the end of the growing season, when irrigated with irrigated furrows (Var.1), the following nitrate content is determined in depth of the soil profile for the irrigation furrow, ridge and non-irrigation furrow: At this fertilizer rate the nitrate nitrogen values for irrigation furrow, comb and irrigation grooves are close to each other in depth of soil profile. In the irrigation furrow they increase slightly and in the ridge and the irrigation furrow they decrease in depth of the soil profile. Only the 0-40 cm layer in the non-irrigation groove (NO3) has significantly higher values.

For irrigation in fertilized furrows (Var. 2), the nitrate content in the depth of the soil spill is as follows: In the irrigation furrow, the values of (NO3) decrease in depth of the soil profile. In the case of the ridge these values also decrease, but for the layer 0-40 cm they are 3 times higher than those at the following depths. In the non-irrigation groove, the values increase in depth, but are close to each other.

Table 2.

Content of nitrogen in the soil profile at the beginning and end of vegetation, 2nd year.

Depth	Location	Ammonium Nitrogen	Nitrate nitrogen	Mineral Nitrogen
cm		mg/1000g	mg/1000g	mg/1000g
Without irrigation		Start of growing season		
0-40		21.28	5.6	26.8
40-70		11.76	10.08	21,84
70-100		14,56	13,44	28,00
		End of growing season		
0-40		18,48	12,88	31,36
40-70		6,16	7,84	14,00
70-100		5,60	6,16	11,76
Watering in fertilized furrows		End of growing season		
0-40	Watering furrow	12,88	11,2	23,2
40-70		7,84	6,16	14,00
70-100		11,76	8,96	20,72
0-40	Ridge	21,84	30,24	52,08
40-70		11,2	11,76	22,96
70-100		7,84	7,84	15,68
0-40	No-watering furrow	15,68	8,96	24,64
40-70		17,36	10,64	28,00
70-100		12,32	11,20	23,52
Watering in fertilized furrows		End of growing season		
0-40	Watering furrow	16,80	8,96	25,76
40-70		11,20	10,08	21,28
70-100		15,68	11,76	27,44
0-40	Ridge	33,60	12,32	45,92
40-70		21,28	10,08	31,36
70-100		14,56	10,08	24,64
0-40	Watering furrow	34,16	21,84	56,00
40-70		16,24	10,08	26,32
70-100		7,84	11,20	19,04

Analysis of the results for nitrogen content in irrigation and effluent (Tables 3 and 4) shows that the ammonium nitrogen content in irrigation water is 5 - 10 times lower than nitrate.

During the 1st test year, no significant differences were found in the nitrate content of the irrigation and waste water of the two irrigations. This is most likely due to the fall of 73 mm of rain in June and 12 mm a few days before the first watering.

Table 3.

Ammonium, nitrate and mineral nitrogen content in irrigation and effluent, 1st year

Variant	Ammonium Nitrogen, ***mg/l***	Nitrate nitrogen ***mg/l***	Mineral Nitrogen ***mg/l***
I Watering			
Irrigation water	-	11,182	11,182
Watering in fertilized furrows	0,348	11,414	11,762
Watering in non-irrigation furrows	0,232	11,414	11,646
II Watering			
Irrigation water	0,582	11,648	12,230
Watering in fertilized furrows	0,582	11,648	12,230
Watering in non-irrigation furrows	0,582	11,94	12,522

Table 4.

Ammonium, nitrate and mineral nitrogen content in irrigation and effluent, 2nd year

Variant	Ammonium Nitrogen, ***mg/l***	Nitrate Nitrogen ***mg/l***	Mineral Nitrogen ***mg/l***
I Watering			
Irrigation water	1,28	14,56	15,84
Watering in fertilized furrows	3,15	16,31	19,46
Watering in non-irrigation furrows	1,28	15,03	16,31
II Watering			
Irrigation water	0,58	11,53	12,11
Watering in fertilized furrows	1,05	12,23	13,28
Watering in non-irrigation furrows	1,05	12,23	13,28
III Watering			
Irrigation water	1,68	15,12	16,80
Watering in fertilized furrows	1,68	15,12	16,80
Watering in non-irrigation furrows	1,68	15,12	16,80

In the second year of the study, higher values of 1.75 mg/l of the nitrates exported were registered during irrigation in the fertilized furrows at the first irrigation. When irrigated with furrows, nitrates are exported about 4 times less - 0.47 mg/l. In the second irrigation, the nitrates exported are 0.7 mg/l and are the same when irrigated in fertilized and non-fertilized furrows. In the third irrigation, the amount of nitrates exported in both variants is zero.

Mineral nitrogen exports are the most significant 3.62 mg/l at the first irrigation for the irrigated fertilizer irrigation option and 0.47 mg/l for the irrigated irrigation irrigation. In the second irrigation, the export is the same for both options and is 1.17 mg/l. Mineral nitrogen is not exported during the third irrigation. At the higher fertilization rates and irrigation furrows netoreni distribution of nitrate nitrogen in the soil profile is more uniform than in the lower fertilization rates. Values, however, are higher.

Most nitrate nitrogen is exported when watering in fertilized furrows and higher fertilization rates. Only in the first watering and watering in fertilized furrows has a substantial export both the mineral and the nitrate nitrogen in the effluent.

CONCLUSIONS

As a result, the displayed field experience can be drawn the following conclusions:

When irrigation in fertilized furrows nitrate in depth of the soil layer is evenly distributed in depth, only the top layer has a slightly lower values.

In irrigation and fertilization each other furrow is found that in the irrigation furrow values (NO_3) are higher than those at the ridge and furrow irrigated, and within the groove are higher for the upper layer 0-40 cm. In irrigated furrow values (NO_3) have a small difference of the above two layers, but are less than those of the layers of 70-100 cm.

The content of mineral nitrogen in the effluent is the highest after the completion of first watering irrigation in fertilized furrows. When irrigation furrows netoreni quantity of exported nutrient is much less.

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