Nitrates Movement in Conditions of Every-Furrow and Alternate-Furrow Irrigation and Fertilization

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Introduction

At the attempts to increase food production by means of application of nitrogen fertilizers some new problems have been recognized. Excessive amounts of N leave agricultural fields and cause losses through leaching of NO_3 into surface and ground waters. Deep water percolation and chemical leaching is a recognized environmental problem with furrow irrigation. Furrow irrigation is commonly used in arid and semi-arid zones to supply crops with water. Furrow-irrigated maize has been identified as a major contributor to groundwater nitrate pollution (WYLIE et al., 1994). ARTIOLA, 1991 found as much as 40% of the available NO_3-N lost from the root zone from one 300 mm irrigation on a clay soil. Alternate furrow irrigation (AFI) was hypotesised as a method to increase water use efficiency and decrease chemical leaching compared with every-furrow irrigation (EFY) (FISCHBACH and MULLINER, 1974; MUSICK and DUSEK, 1974; CRABTREE et al., 1985. In same time they reported small yield losses for different crops for AFI compared with EFI system.

From 1996 we study water and nitrate nitrogen present in root zone and the losses beyond to root zone in aim to maintain agricultural practices consistent with sustainable development.

Material and methods

The problem was studied on leached cinnamonic soil in Sofia region. Chemical characteristics of studied soil (0-30 cm): humus – 1.80%; N total 0.114 %; pH_{KCl} –5.2. Two lysimeters (20 m^2 each) have been use in the investigation in 1997: the first one with the separate irrigation and fertilization furrows (alternate furrow irrigation - AFI) and the second with the common used technology - fertilization and irrigation in every furrow (every furrow irrigation - EFI). Maize was used as test crop. Good yields on studied soil are related with irrigation due to the relatively low water holding capacity and the rapid drainage. Fertilizer N - 200 kg.ha^{-1} as ammonium nitrate - was surface applied in two portions - 3/4 in whole lysimeter surface and 1/4 in non irrigated furrow for AFI; for EFI 3/4 in whole lysimeter surface and 1/4 in every furrow. Initial surface application of fertilizer permitted that the main part of fertilizer was situated in the rows when the furrows were made. Nitrates movement was observed to 90 cm depth in soil and on the bottom of lysimeters (2 m) in drainage water. In 1998 the study was carried out in four lysimeters - two AFI with 200 and 400 kg N ha^{-1} and two EFY with the same rates of fertilization.

Results and discussions

Investigations results show changes in inorganic nitrogen concentrations down soil profile and in N-NO_3 in lysimetric water. The best aeration due to the lower precipitations in 1997 compared as 1996 (KOUTEV et al., 1997), ensure better conditions to the nitrification of ammonium nitrogen. That is why N-NO_3 leaching down the soil profile is more significant in 1997. Longer period of our study in 1998 is the other reason of higher nitrates leaching in 1998 than in 1997.

The results from 1997 (*Table 1*) show that NO_3-N leaching from the treatment AFI - 9.22 kg ha^{-1} is higher than nitrate nitrogen leaching from the treatment EFI 6 kg ha^{-1}. Nitrate nitrogen concentrations in drainage water on the bottom of lysimeters (2 m) were higher during entire sampling period in the treatment EFI. In same time water losses from AFI were higher than in EFI treatment, which explain the contradictory results as compare to the theoretical approaches (increase of nitrates leaching instead of decrease in AFI treatment). The soil texture and the low water holding capacity permitted in AFI treatment, (where the water was applied in two times smaller surface) that water flow down soil profile was more important than in EFI treatment. In the same time an insignificant decrease of maize grains yield was observed in the treatment alternate-furrow irrigation - 7540 kg ha^{-1}, as compared to 7690 kg ha^{-1} for the EFI treatment. Similar results were obtained in 1998. Non significant decrease in yield was obtained for EFI and AFI treatments fertilized with 200 kg N ha^{-1}. Most significant decrease was obtained for treatments fertilized with 400 kg N ha^{-1} compared with treatments with 200 kg N.ha^{-1} (*Table 2*).

Changes in inorganic nitrogen content (NH_4 and NO_3) in soil profile down to 90 cm show nitrification and leaching of nitrates out of this zone for 5-20 days after fertilizer application for both treatments – AFI and EFI (*Table 3*). The insignificant part of nitrogen leached out of 2 meters zone, 3-5% of applied and the rapid leaching nitrogen out of 0-90 cm zone show a non evaluated important movement of nitrogen out of maize root

Table 1: **Water balance and N-NO_3 leaching in 2 m depth**

	Water inflow, L m^{-2}	Water outflow, L m^{-2}	N-NO_3 leaching N kg ha^{-1}
	1997 (16.05-30.08.97)		
AFI-200	315	63.2	9.22
EFI-200	315	38.5	6.00
	1998 (04.01-22.09.98)		
AFI-200	688	114.7	19.04
EFI-200	718	58.9	12.97
AFI-400	688	96.5	21.94
EFI-400	718	54.7	8.95

Table 2: **Maize yields, kg ha^{-1}**

Year	N kg ha^{-1}	AFI	EFI
1997	200	7540	7690
1998	200	8820	8610
1998	400	9940	9100

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Table 3: **Ammonium and nitrate N content in the soil profile, mg N kg^{-1}**

Date of sampling	Depth cm	AFI treatment						EFI treatment			
		$N\text{-}NH_4$			$N\text{-}NO_3$			$N\text{-}NH_4$		$N\text{-}NO_3$	
		irrig. furrow	row	dry furrow	irrig. furrow	row	dry furrow	furrow	row	furrow	row
07.05.97	0-30	9	7	6	1	2	2	9	8	1	1
	30-60	7	7	9	1	0	2	9	9	0	0
	60-90	8	8	9	0	3	0	8	8	0	0
05.06.97*	0-30	9	19	9	2	20	2	15	36	20	44
	30-60	4	16	4	8	24	8	23	24	9	8
	60-90	4	12	4	1	18	1	8	21	6	1
21.07.97	0-30	12	10	11	9	17	6	7	11	7	33
	30-60	11	9	9	7	14	0	5	4	14	15
	60-90	7	2	6	2	15	1	4	3	3	6
14.08.97*	0-30	11	28	55	2	14	17	27	18	3	18
	30-60	15	25	16	1	14	14	18	24	3	4
	60-90	17	31	16	2	6	2	14	12	1	9
19.08.97	0-30	5	7	10	3	4	8	10	10	8	6
	30-60	3	6	5	2	4	5	5	4	3	2
	60-90	4	5	4	2	4	3	5	5	3	3
01.12.97	0-30	11	8	2	4	5	1	10	12	2	2
	30-60	2	8	8	6	8	1	9	9	10	13
	60-90	4	10	3	14	4	4	6	11	17	15

zone in 90-200 cm zone. Next year investigations must be aimed in optimization of nitrogen nutritional regime of plants and avoiding important nitrogen losses from root zone.

Conclusions

The studied technology did not show significantly different results for maize yields but show significant difference of nitrates leaching between treatments. The low amounts of leached nitrates out of 2 m zone (3-5% of applied fertilizer) are not important hazard for the underground waters. Studied soil characteristics are not favorable to optimal nitrogen transformations. In acid soil nitrification is inhibited mainly in conditions of excessive water supply. In this case important ammonium nitrogen quantities could be blocked in the surface soil layer, out of maize root zone (the case of 1996 studies). In this soil zone wet and dry conditions due to the low water retention capacity of the soil turn rapidly as depend to irrigation and climatic factors and the optimal conditions to nitrification are rare during the growing period. That is why nitrogen fertilizers must be applied in depth of 10 – 20 cm in dry furrow, to be more accessible for maize root system. To avoid nitrogen and water losses irrigation must be more frequent with lower water amounts than applied. Best results for AFI technology must be obtained in soils with heavier texture and higher water retention capacity.

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