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EFFECT OF SALINE WATER AND N-FERTILIZATION ON MAIZE PRODUCTION UNDER DRIP IRRIGATION USING TRACER TECHNIQUE

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Abstract

The study is a part of research project conducted at I.A.M. Bari, Italy and Atomic Energy Authority, Cairo, Egypt. The aim of this study is to asses the effect of saline water and N-fertilization on growth, and N-uptake by the different plant components from both soil and fertilizer using the ^{15}N-isotope as well as calculating the Nitrogen Use Efficiency (NUE) under saline irrigation practices. The experiment was performed in the greenhouse at I.A.M. Bari, Italy. The corn crop was grown with four water salinity levels (fresh water as control, water of 3 , 6 and 9 ds m^{-1}) and four nitrogen doses (Ammonium Sulphate % a.e.) 0 , 50 and 150 kg N ha^{-1}. The results of salinity / N-fertilization interactions, the data showed clearly that under saline irrigation practices, when using water with EC values up to 3 ds m^{-1}, the crop response to nitrogen is gradually increasing with successive N-application doses at rates ranging between 50 and 150 kg N ha^{-1}. The improvement in the corn growing parameter as well as its yield is to great extent related to the N-application dose rather than to salinity level opposite was the case with the 6 ds m^{-1} and 9 ds m^{-1} salinity levels. Since in this case the vegetative growth and the yield production were mainly affected by accumulated salts in the active root-zone without any significant crop response to N exceeding 100 kg N ha^{-1}, which brought about a further increase in the degree of salt accumulation in the soil.

Introduction

It is a well known fact that world resources of fresh water are getting exhausted through the increasing demand to satisfy the needs of the increasing world population therefore, the use of low water quality, such as ground water, drainage and even sea water diluted with fresh water should be considered as complementary sources for the agricultural development. In this respect, several factors have been evaluated as they limit suitability of water for irrigation purposes. These factors are chemical characteristics of water, crop species, type of soil and irrigation management.

Corn, a moderately tolerant plant, is an important strategic plant needed by most people, so it must given a great attention to be cultivated and improved. Saline irrigation water has it greatest influence on corn growth and yield when applied during the seedling stage, which is the crop's most critical growth period. At three weeks of age, the corn plant has a salt tolerance threshold of only 1 ds m^{-1}; whereas by the tassling and grain-filling stages, it can tolerate an EC up to 9 ds m^{-1} without yield loss (National corn Handbook, NCH-41).

Materials and Methods

The experiment was conducted in the greenhouse of the International Agronomic Mediterranean (IAM) Institute in Valenzano, Bari-Italy during the year 2001.

Experimental layout :

The Set-up consists of 64 lysimeters (four irrigation treatments and four nitrogen doses, each treatment was replicated four times). The lysimeter were tanks of Polyvinyl Chloride (PVC) with a volume of 0.06 m^3. The bottom of the lysimeter has holes to drain the water.

A sandy clay loam soil was brought to the greenhouse, crushed and sieved through a 5 mm. The values of chemical and physical analysis are reported in Table (1).

Four salinity levels in irrigation were used in the experiment namely 1.0 ds/m (freshwater as a control) and three, levels of saline water 3, 6 and 9 ds m^{-1}. The saline waters were prepared by mixing fresh water (1.0 ds m^{-1}) with sea water (47.0 ds m^{-1}) at appropriate ratio. The crop cultivated is maize (zea mays, .SWEET MAIZE, variety. HYBRID FIXP841 CONTRY).

Fertilization with K and P took place before sowing. P was applied at a rate of 200 kg P_2O_5 ha^{-1} and K at rate of 150 kg K_2O ha^{-1}. Nitrogen was applied at the rate 50, 100 and 150 kg N ha^{-1} as Ammonium sulphate, $(NH_4)_2SO_4$ and $(^{15}NH_4)_2SO_4$ 10 % (atomic excess) a.e. The amounts of ammonium sulphate were add through the drip irrigation system (8 times).

After complete maturity the corn plant was harvested, divided into two parts, stems with leaves and cobs, and oven dried for 48 hours at 70 °C, then the weight of each plant component was recorded.

Measurement :

- Maturity of maize plant (two parts).
- N-uptake (total nitrogen).
- ^{15}N-analysis.

Calculate of :

$$\% \text{ Ndfs} = 100 - \% \text{ Ndff}$$

$$\% \text{ Ndff} = \frac{\% \; ^{15}\text{N a.e. in plant}}{\% \; ^{15}\text{N a.e. in fertlizer}} \times 100$$

$$\% \text{ F.U.E} = \frac{\% \text{ Ndff} \times \text{total N (mg N pot}^{-1})}{\text{rate of fertilizer s added (mg} \cdot \text{N pot}^{-1})} \times 100$$

where :

% Ndff = % Nitrogen drived from fertilizer, % Ndfs = % Nitrogen drived from Soil.

% FUE = % fertilizer use efficiency.

Results and Discussion

Dry matter accumulation in shoots and grain yields of maize as affected by N gradient and salinity levels.

Data presented by Table (2) indicate the response of maize plants to salinity levels under conditions of no nitrogen fertilizer supply. Shoot dry matter was increased with 3 dS m^{-1} water irrigation, as compared with fresh water. A similar trend was detected with grain yield.

It is clear from our data, that a relative decrease in dry weight of whole plants (shoot + grain) was evidenced with increasing salinity level up to 9 dS m^{-1}, and record an average decrease of 25.1 and 33.4 % for level 6 dS m^{-1} and 9 dS m^{-1}, respectively, Table (2).

On the other hand, the total dry weight of maize plants was significantly increased with increasing N levels under different salinity treatments. In this respect, relative increase was 41.2, 79.9 and 83.2 % for 50, 100 and 150 kg N ha^{-1}, respectively.

These results show that even with a rising salinity level, the physiological behavior of maize plants was not much affected since it responded well to the additions of nitrogen fertilizer up to 150 kg N ha^{-1}. Total N uptake by shoot and grain of maize plants exposed to different salinity level and N fertilization regime.

The nitrogen uptake by shoot and grain paralleled that of dry matter accumulation, Table (2). An increase in percentage was noticed with 3 dS m^{-1} under 50 kg N ha^{-1} where the N uptake recorded +2.9 % over the fresh water treatment; opposite to that, increasing water salinity to 6 and 9 dS m^{-1} brought about a decrease in N percentage of 35.3 and 46.6, respectively.

With the other nitrogen fertilizer levels (100 and 150 kg N ha^{-1}), N uptake tended similarly to decrease with increasing salinity levels, as shown in Table (2).

The negative effect of saline water on N uptake is consistent with those recorded with wheat irrigated with lake water against tube-well water, where the N % utilization was lower in the salt-affected soils (IAEA, 1995).

A similar trend was noticed with barley plants irrigated with canal water (3.4 dS m^{-1}) and saline water (11.7 dS m^{-1}) with different rate of N fertilizer (0, 60, 120 and 180 kg N ha^{-1}) (Nagaz and Ben Mechlia, 2001). The same authors found that yield of barley responded significantly to N applications.

Nitrogen fertilizer uptake by plants (Ndff %).

Data of nitrogen derived from fertilizer (Ndff) and utilized by different parts of maize plants are presented in Table (2). The quantity of N-fertilizer derived to grains was higher than those utilized by either straw or root under fresh water and 3 dS m^{-1} water irrigation regime. With the other two water salinity treatments, Ndff quantities were lower in grain as compared to N-fertilizer utilized by straw. It means that high salinity levels (6 and 9 dS m^{-1}) had an opposite effect on N uptaken by grains from fertilizer. Generally, lower amounts of N-fertilizer were detected in the roots, indicating a mobilization of N from roots upward to the aerial parts of corn plants.

It is obvious in conclusion, that the nitrogen derived from fertilizer to the whole plant was significantly but negatively affected by increasing water salinity level. In fact, the averaged quantities of Ndff were 764.7, 571.0, 279.3 and 215.3 mg for FW, 3 dS m^{-1}, respectively.

The values of N which corn plants absorbed from the fertilizer were positively correlated to N fertilizer rates and the highest amounts were recorded with 150 kg N ha^{-1} additions.

Under no fertilizer treatment, corn plants were exclusively dependent on N derived from soil (Ndfs) as reported by Table (3).

In those treatments where N-fertilizer was supplied, the portion of N derived from the soil was generally positively correlated to N-fertilizer rates and negatively affected by water salinity increase. Clearly addition of N- fertilizers enhanced the uptake of N from soil. This proved and confirmed the phenomenon of the so-called "priming effect" of fertilizer added on soil N pool (Jenkinson et al., 1985).

The highest values of Ndfs were mostly localized in straw followed by grain, then roots. Regarding the proportions of Ndff and Ndfs, the present results are in agreement with those reported earlier by Abdel Monem et al., (1995) and Soliman et al., (1993).

Fertilizer use efficiency (FUE %) as affected by water salinity and N-fertilizer rates was calculated and presented in Fig. (1).

Data show that FUE % was high under fresh water irrigation with a trend to decrease with either increasing salinity level or N rates. At 3 dS m' salinity, FUE % was reasonably close to those recorded with the fresh water treatment. A great decline in FUE% was recorded with 6 dS m^{-1} and 9 dS m^{-1} salinity.

In light textured soils, leaching is the most common reason of N-losses (Soliman et al., 1993): in this respect, drip irrigation is preferable for supplying adequate nutrients to the plants, especially those soluble fertilizers that applied in low concentrations satisfy the plant requirement at different stages of growth resulting in increments of fertilizer use efficiency (Phewne et al., I 979).

Table 1. Chemical an physical properties of the soil.

PH	EC (ds m^{-1})	O.M %	Cations				Anions				Classification
			Ca^{++}	Mg^{++}	Na^{+}	K^{++}	$SO4^{--}$	CO_3^{-}	HCO_3^{--}	Cl^{-}	
[illegible].7	0.436	1.64	2.9	1.7	0.38	0.19	1.56	0	2.6	1.0	Sandy clay loam

Table 2. Response of maize DM and N uptake to salinity gradient.

Water	Fertilizer kg N ha^{-1}	DM g/Li				N-uptake mg/Li			
		Shoot	Grain	Total	Relative increase %	Shoot	Grain	Total	Relative increase %
F.W	0	156.3	6.5	162.8	-	512	82	594	-
	50	201.2	42.7	243.9	-	1026	858	1884	-
	100	260.2	50.5	310.7	-	1139	1212	2351	-
	150	245.6	69.5	315.1	-	1194	1981	3175	-
3 ds m^{-1}	0	160.9	12.8	173.7	7.9	491	140	631	6.2
	50	198.5	41.4	239.9	- 3.7	426	1013	1939	2.9
	100	242.0	49.1	291.1	- 6.3	1157	1052	2209	- 6.0
	150	226.5	60.6	287.1	- 8.9	1059	1364	2423	- 23.7
6 ds m^{-1}	0	116.7	10.4	127.1	- 21.9	451	112	531	- 10.6
	50	161.5	18.8	180.3	- 26.1	841	378	1219	- 35.3
	100	195.2	30.7	225.9	- 27.3	1144	479	1623	- 30.9
	150	209.2	36.9	246.1	- 21.9	982	860	1842	- 41.9
9 ds m^{-1}	0	111.4	-	111.4	- 31.6	406	-	406	- 31.6
	50	145.4	10.5	155.9	- 36.1	743	263	1006	- 46.6
	100	182.3	28.0	210.3	- 32.3	912	686	1598	- 32.0
	150	178.2	30.6	208.8	- 33.7	941	652	1593	- 49.8

Table 3. Nitrogen Ndff and Ndfs in straw and grain (mg pot^{-1}).

Water	Fertilizer kg N ha^{-1}	Straw			Grain		
		Ndff	Ndfs	Total	Ndff	Ndfs	Total
F.W	0	-	512	512	-	82	82
	50	247	752	999	243	515	758
	100	285	854	1139	496	716	1212
	150	385	809	1194	501	693	1194
3 ds m^{-1}	0	-	492	491	-	140	140
	50	166	760	926	334	679	1013
	100	231	926	1157	347	705	1052
	150	201	858	1059	422	942	1364
6 ds m^{-1}	0	-	451	451	-	112	112
	50	135	706	841	76	302	378
	100	183	961	1144	95	384	479
	150	157	825	982	163	697	860
9 ds m^{-1}	0	-	406	406	-	-	-
	50	104	639	743	45	218	263
	100	127	785	912	117	369	486
	150	131	810	941	114	542	652

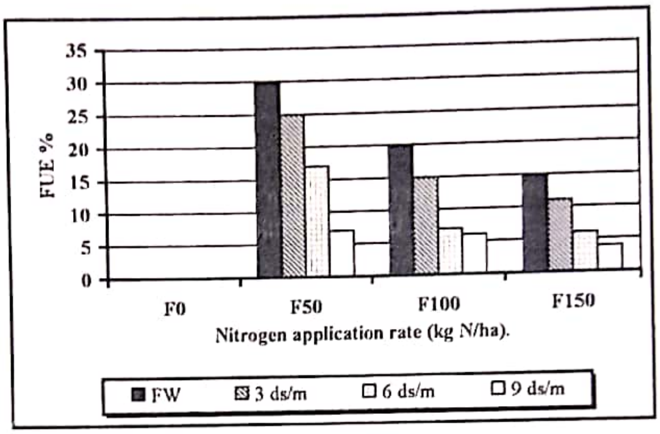

Figure 1. The interaction between N-fertilizer and different saline water. Fertilizer Use Efficiency (FUE %).

Conclusion

Salinity / N-fertilization interactions, the data showed clearly that under saline irrigation practices, when using water with EC values up to 3 ds m^{-1}, the crop response to nitrogen is gradually increasing with successive N-application doses at rates ranging between 50 and 150 kg N ha^{-1}. The improvement in the corn growing parameter as well as its yield is to great extent related to the N-application dose rather than to salinity level opposite was the case with the 6 ds/m and 9 ds/m salinity levels. Since in this case the vegetative growth and the yield production were mainly affected by accumulated salts in the active rootzone without any significant crop response to N exceeding 100 kg N ha^{-1}, which brought about a further increase in the degree of salt accumulation in the soil.

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