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EFFECT OF INTEGRATED MINERAL AND ORGANIC NITROGEN APPLICATIONS ON CROP PERFORMANCE

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Abstract

Field experiments were conducted to evaluate the effects of integrated organic and mineral fertilization through drip irrigation (fertigation) on nitrogen and water use efficiencies by maize and bean grown on a sandy soil. Fertilization treatments: (a) 120 kg N/fed and 20 kg N/ fed for maize and bean respectively were applied to the soil through fertigation either in 100% mineral form (ammonium nitrate), 100% organic form (Chicken manure extract) or mixtures of organic and mineral fertilizers by the proportions: 75% mineral + 25 %organic; 50 % mineral + 50% organic and 25 % mineral + 75 % organic. (b) The same fertilization treatments as in (a) plus a supplement addition of 50 L/ fed of humic substances (Hu). Increasing the mineral content in fertilizer mixtures had a positive effect on the yield of both maize and bean. The highest yield was realized with the plants that received the fertilizer mixture 75% mineral + 25 % organic. Addition of Hu with the 100% mineral fertilization further increased the yield of the two crops. Nitrogen use efficiency (NUE expressed as kg yield/kg N) increased with increasing the mineral content in the fertilizer mixtures. Highest values were realized with the plants that received the fertilizer mixture 75 % mineral + 25 % organic. Increasing the mineral content in fertilizer mixtures had a positive effect on values of irrigation water use efficiency (WUE expressed as kg yield/m^3 water) recording 0.76 kg/ m^3 and 0.79 kg/ m^3 for maize grain and bean seeds respectively; both were realized with the plants that received the fertilizer mixture 75% mineral + 25% organic.

Keywords: *fertigation; maize; nitrogen; water use efficiency*

Introduction

Due to the limitation of further expansion of irrigated land in most countries, a large part of the future food requirements will need to be covered by a more efficient use of irrigation water and fertilizers. One of the most important challenges facing sustainable agriculture is to provide crops with an optimal quantity of water and nutrients throughout the growing season in the most efficient manner possible. Fertigation is considered the best answer to this challenge, whereby both water and fertilizers are delivered to crops simultaneously through the irrigation system. Scheduling fertilizer applications on the basis of needs reduces nutrient losses compared to conventional application methods that depend on the soil as a reservoir for nutrients. The method of fertilizer application also improves the use efficiency of nutrients (Zotarelli et al. 2009). Well-balanced fertigation program will satisfy the exact needs of the plant as they change along the season, increase efficient use of water and fertilizers, increase yield, protect the environment and sustain irrigated agriculture**.**

The fertigation technique is used mainly with N, P and K mineral fertilizers, whereas, little data have been reported concerning the fertigation using organic fertilizers.

Therefore, the present investigation was conducted to study the effect of fertigation involving mineral and organic fertilizers applied through drip irrigation on growth, yield and yield quality of maize and bean plants cultivated in a sandy soil.

Materials and Methods

The experimental part of this work aimed principally at evaluating the effects of integrated organic and mineral fertilization through irrigation (fertigation) on different crops cultivated in a virgin sandy soil.

Grains of maize and seeds of faba bean were obtained from the Field Crops Research Institute, A.R.C, Ministry of Agriculture, Giza, Egypt; seeds of faba bean were inoculated with the proper rhizobia before sowing. Drip irrigation system with fertilizer distribution equipment was used. Emitter discharge was 1.6 Lh^{-1} at 1.0 bar operating pressure and 30 cm spacing between emitters. Calculated irrigation water requirements were 2860 m^3 fed^{-1} for maize and 1425 m^3 fed^{-1} for faba bean (fed = 4200 m^2).

Fertilization:

1) Control treatment: soil without any fertilizer added to the soil through fertigation.

2) Fertilizers added to the soil through fertigation:

a) Mineral fertilizer (120 kg N/fed) for maize (250 kg/fed 20 : 20 : 20 fertilizer + 210 kg/ fed ammonium nitrate 33.5% N) and 20kg N/fed for faba bean (100 kg fed^{-1} 20 :20 :20 fertilizer).

b) Organic fertilizer - chicken manure extract (100% ChM) at the rate of 120 kg N/ fed^{-1} for maize and 20 kg N fed^{-1} for faba bean.

c) Mixtures of chicken manure extract and the mineral fertilizers by the following ratios:

75% ChM + 25 % NPK ; 50% ChM + 50 % NPK; 25 % ChM + 75 % NPK

d) The same fertilization treatments in (c) + 50 L fed^{-1} of humic substances.

Results and Discussion

Integrated fertilizer application through irrigation affected positively the vegetative characteristics of both maize and bean plants. Fertigation with different combinations of NPK+ChM mixtures plus holmic substances produced more vigorous shoots compared to the corresponding combinations without holmic substances. These results are in accordance with those of Medina et al. (2004); Singer et al. (2004). Abd-El Mageed et al. (2006) and Roy et al. (2006).

Yield and yield attributes

Integrated mineral/organic fertigation positively affected the yield of maize and bean with different magnitude. Increasing the mineral content in fertilizer mixtures had a positive effect on the yield of both maize and bean, where the higher yield was realized with the plants that received the fertilizer mixture 3/4 mineral + 1/4 organic. Addition of Hu with the fertilization treatment NPK 100% in mineral form further increased the yield of the two crops. Combinations of mineral/organic fertigation had positive effects on maize straw and grains and also on bean straw and seeds. Increasing the mineral content in fertilizer mixtures had a positive effect on the grain yield of maize, where the higher yield was realized with the plants that received the fertilizer mixture 3/4 NPK + 1/4 ChM. The effect of addition of Hu was less evident. However, with increasing the proportion of the mineral content in the fertilization dose, a positive but not significant effect was noticed due to the addition of Hu with the mixture. Ertan (2007) studied the effect of foliar and soil fertilization with humic acid on tomato and found that both foliar and soil HA treatments positively affected fruit characteristics including fruit diameter, fruit height, mean fruit weight and fruit number per plant. According to Selim *et al.* (2009), application of humic substances through drip irrigation enhanced potato tubers yield, starch content and total soluble solids. Taha *et al.* (2006) concluded that humic substances gave the highest values of available nutrients, yield and nutrient uptake by wheat plant grown on different Egyptian sandy soils.

Humic substances have been shown to increase the uptake of nitrogen by plants, and to increase soil nitrogen utilization efficiency (Yusuf et al. 2009). It can also enhance the uptake of potassium, calcium, magnesium and phosphorus (Arancon *et al.* 2006).

Water and nitrogen use efficiency

Increasing the mineral content in fertilizer mixtures had a positive effect on the value of water use efficiency (WUE). The highest values were realized with the plants that received the fertilizer mixture 3/4 NPK + 1/4 ChM. Addition of Hu with the fertilization treatment NPK 100% in mineral form had insignificant effect on values of water use efficiency of both maize and bean plants. El-Gindy and Abdel Aziz (2003) reported that the highest value of WUE was (1.3 kg/m^3) for corn crop under drip irrigation system. The drip irrigation saved about 20.3% from water requirement compared to sprinkler irrigation system. Zotarelli et al. (2009) evaluated the interaction between N-fertilizer rates and irrigation scheduling on yield and irrigation water use efficiency (IWUE). The surface drip irrigation treatment required 15-51% less water when compared to conventional treatments.

Also, increasing the mineral content in fertilizer mixtures had a positive effect on the values of nitrogen use efficiency (NUE). The highest value for maize grain yield (17.9 kg kg^{-1}N),

Table 1: Water use efficiency (Kg/m^3) by maize and bean

Treatments	Maize			Bean		
	Biomass	Straw	grains	Biomass	Straw	grains
Control	1.665	1.399	0.266	1.576	1.282	0.294
NPK	3.325	2.662	0.663	2.675	2.062	0.613
3/4NPK + 1/4ChM	3.665	2.956	0.709	3.230	2.527	0.703
1/2NPK + 1/2ChM	3.324	2.679	0.645	2.870	2.114	0.756
1/4NPK + 3/4ChM	3.240	2.641	0.599	2.804	2.204	0.600
ChM	2.815	2.259	0.556	2.420	1.807	0.613
NPK + Hu	3.394	2.728	0.666	2.702	2.090	0.612
3/4NPK + 1/4ChM + Hu	3.846	3.088	0.758	2.992	2.204	0.788
1/2NPK + 1/2ChM + Hu	3.410	2.784	0.626	2.831	2.175	0.656
1/4NPK + 3/4ChM + Hu	3.281	2.643	0.638	2.529	2.000	0.529
ChM + Hu	3.225	2.642	0.583	2.478	1.924	0.554

Table 2: Nitrogen use efficiency (Kg kg^{-1}N) by maize and bean

Treatments	Maize			Bean		
	Biomass	Straw	grains	Biomass	Straw	Grains
Control	-	-	-	-	-	-
NPK	79.233	63.433	15.800	190.700	147.00	43.700
3/4NPK + 1/4ChM	87.350	70.458	16.892	230.350	180.200	50.150
1/2NPK + 1/2ChM	79.217	63.842	15.375	204.650	150.750	53.900
1/4NPK + 3/4ChM	77.192	62.925	14.267	199.900	157.150	42.750
ChM	67.108	53.850	13.258	170.850	128.850	42.000
NPK + Hu	80.185	64.447	15.738	183.081	141.601	41.480
3/4NPK + 1/4ChM + Hu	90.876	72.965	17.911	202.707	149.347	53.360
1/2NPK + 1/2ChM +	80.565	65.785	14.780	191.828	147.398	44.430

Hu						
1/4NPK + 3/4ChM + Hu	77.527	62.456	15.071	171.344	135.424	35.920
ChM + Hu	76.195	62.415	13.780	167.927	130.387	37.540

and for bean seed yield (53.4 kg kg^{-1}N) was realized with the plants that received the fertilizer mixture 3/4 NPK + 1/4 Ch.M. Addition of Hu with the fertilization treatment NPK 100% in mineral form had insignificant effect on values of water use efficiency of both maize and bean plants. Neilsen et al., (2002) and Neilsen and Neilsen (2006) showed that scheduling of irrigation with fertigation in high density apple orchards improved the efficiency of fertilizer used by 10 to 38 percent. In this respect, Thomas et al. (2003), with cauliflower and broccoli grown on sandy loam or finer soils and fertigated through subsurface drip irrigation concluded that yield and quality, N uptake in the above ground biomass and N use efficiency were significantly affected. The nutrient-uptake efficiency with mineral-nutrient applications through the irrigation stream, according to (Mustafa et al., 2006 , Akimasa and Uehara 2007) ,was increased substantially.

Conclusion

It has been established that integrated mineral and organic fertilization through irrigation (fertigation) increased the measured vegetative growth parameters, yield, nutritional status and both water and nitrogen use efficiency by maize and faba bean plants compared to sole application. Positive effects were recorded using mixtures of different organic and mineral proportions. Therefore, it is recommended to apply the fertilizer as mixture of the two forms taking into consideration the soil type, the irrigation system under use and also the economical factor.

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