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EFFECT OF FERTILIZATION TYPE ON THE CONCENTRATION OF AMMONIUM ION AND NITRATE IN THE RHIZOSPHERE OF *ZEA MAYS* L.

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Abstract

An experiment was conducted to study the effect of the application of mineral, organic and biofertilizers and their interaction on the concentration of ammonium ion and nitrate in yellow maize rhizosphere. The study was conducted at the Department of Soil and Water Resources College of Agriculture / University of Al-Qadisiyah during the agricultural season 2018-2019 in plastic pots. The Complete Randomized Design was used (C.R.D). Two levels of mineral fertilizer (urea) (0 and 250) kg.N.h^{-1} were used, and two levels of biofertilizer (*Azospirillum brasilense*) namely (application, without application). Yellow maize seeds of the cultivar bihooth(106) were planted on July 13^{th,} 2018 in soil. Ammonium and nitrate ion were estimated in soil during plant growth periods (40, 70, 100) days of planting. The application of mineral fertilizers, organic fertilizers and biofertilizers and their interactions led to a significant increase in the amount of ammonium ion and nitrates in the rhizosphere and in the bulk soil during the time periods (40, 70, and 100) days of planting. The interaction between the mineral fertilizer (250) kg.N.h^{-1} and organic fertilizer (10) tons.h^{-1} and bio-fertilizer resulted in the highest amount of ammonium and nitrate. Single fertilization, the highest ammonium and nitrate ion availability in both rhizosphere and bulk soil were with mineral fertilization during 40 days of planting compared to organic and bio fertilization (less availability ratios). These values decreased during the period (70 and 100) days of planting, in contrast to organic and fertilization, whose values increased in the two above periods. Mineral fertilization (N) at 40 days of planting with all forms applied either single or interfering with the other fertilizers used in the study led to a significant increase in the concentration of ammonium and nitrates in the soil of rhizosphere and bulk soils. High nitrate ion values compared with ammonium ion values under all treatments both in and the rhizosphere and bulk soils for all studied durations.

Keywords: Ammonium ion, nitrate, maize, nutrient availability, bulk soil, rhizosphere

Introduction

Most soils of agricultural importance in arid and semi-arid areas suffer from low organic matter content. Under these conditions, there is a significant decrease in biomass and in the availability of many of the necessary materials in the soil, which are important for plant nutrition and productivity. Since nitrogen is one of the main plant nutrients important in the production process, it must be available and other nutrients for plant growth. In order to sustain soil productivity and preserve its fertility, it is necessary to continue applying chemical fertilizers, which are now a high-cost input into the production process, as well as the potential for pollution caused to the environment during irrational use. Organic nitrogen makes up more than 95% of soil nitrogen, while the mineral form is less than 5%. Ammonium and nitrate ions are essential ions to supply the plant with this element, Jarallah (1998). Most of the nitrogen in the soil is organic and is not available for direct absorption from plant roots and must first be mineralized to $NH4^+$ or $NO3^-$ to be available for plants, Ali *et al.*, (2014); Khaeim HM (2013).

The movement of nitrogen in soil depends on the nature of the applied nitrogen fertilizers, as the movement of ammonium ion in the soil is low compared to nitrates. The depth of movement depends on the cation exchange capacity (CEC) of the soil, and the proportion of fertilizer application, Boman and Obreza (2002). Therefore, the ammonium ion in the soil is subjected to several processes such as the process of oxidation of ammonium to nitrate (nitrification), which is affected by several factors, including ammonia tension, soil pH, soil organic matter

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(increase C/N) as well as soil bestowal, in addition to the processes of volatilization and stabilization. Ammonium ion stabilization occurs in the soil and becomes unavailable for plants. Ammonium fixation is influenced by a number of factors including soil texture, soil temperature and moisture, Kafkafi (2004); Hussein Khaeim *et al.*, (2019). Nitrogen in the form of nitrates resulting either from nitrogen fertilizer application or resulting from the process of converting ammonium to nitrate in the soil to continuous washing processes away from the roots of the plant. Nitrates are the most laundered form of non-catchment by colloids in the soil, because they are repulsed with clay surfaces and moved away from the colloidal soil solution and thus easy to move when heavy rain and irrigation water are available, rye (2005).

Mineral fertilizers play a major role in increasing crop production provided there is a balance in fertilizer application. Insufficient application lead to delayed maturation as well as an effect on crop quality and excessive and unbalanced quantities can adversely affect yield and quality, Anon (2004); Bushra Jeber *et al.*, (2019). The use of organic fertilizers in agriculture to increase the soil content of organic matter and improve its physical and chemical properties and also encourages the activity of microorganisms and thus improve the properties of soil fertility and productivity. The use of organic and biofertilizers reduces the pollution of the environment resulting from the continuous use of chemical fertilizers and improves the quality of the crop at the same time, Zoghbi *et al.*, (2007). Therefore, the world has recently turned to the use of modern fertilizer technologies to reduce pollution problems and attention to bio-organic farming technology. Organic fertilizers and beneficial microorganisms are used to improve the quantity and quality of agricultural production, Zaki and Abdel Halim (2007). In the last two decades, the use of biofertilization has spread to different parts of the world, including the Middle East.

Biofertilizers are instrumental in improving soil fertility because of their ability to process nutrients on a continuous basis and can cover or meet part of the needs of treated plants. This contributes to reducing the use of chemicals and environmental pollution and is relatively cheap food sources as alternatives to chemical fertilizers, Wua *et al.*, (2005). This is one of the microorganisms that stabilize atmospheric nitrogen in the soil is the bacteria *Azospirillum ssp* and increase its absorption by the plant as well as its secretion of growth-promoting substances such as gibberellin and cytokinin and hormone, IAA also works to increase the absorption of water and plant nutrients such as potassium and phosphorus, Mehnaz (2015). The success of the fertilizer used as a vaccine in addition to the medium of plant growth depends on the efficiency of the organism used, the compatibility of the microorganism with the plant host, the competitiveness of the organism with the existing microorganisms in the

Table 1: Chemical and physical properties of the soil before planting.

Trait		Value	Unit	Reference
Reaction Degree (pH) (1:1)		7.6	---	Page *et al.*, (2982)
Electrical Conductivity (EC) (1:1)		3.2	DesiSmens.M^{-1}	
Cation exchange capacity (CEC)		23.73	Cml.charge.kg^{-1}.soil	Savant, (1994)
Carbonate minerals		230	g.kg^{-1}	Page *et al.*, (2982)
Organic matter		11.37		Black, (1965)
Cationic dissolved ions	Ca^{2+}	25.45	Cml.charge.L^{-1}	Page *et al.*, (2982)
	Mg^{2+}	13.44		
	Na^{1+}	40.58		Jackson, (1958)
Negative dissolved ions	SO_4^{2-}	17.95		Black, (1965)
	HCO_3^{1-}	16.8		Jackson, (1958)
	CO_3^{-2}	Nill		---
	Cl^-	41.56		Jackson, (1958)
Available Nitrogen	$N\text{-}NH^+_4$	22.18	Mg. kg^{-1}	Black, (1965)
	$N\text{-}NO_3$	19.33		
Available phosphorous		16.30	Mcg.m^{-1}	Page *et al.*, (2982)
Available potassium		164.40		Black, (1965)
Bulk Density		1.36		
Soil Separators	Sand	270	g.kg^{-1}	
	Loam	540		
	clay	190		
Texture type		Silt Loam		

soil, and the number of microorganisms already present in the rhizosphere, Al-Shibini, (2006).

Based on the purpose of the research to study the effect of mineral, organic and bio-fertilization and its interactions on the concentration of ammonium ion and nitrate in the maize rhizosphere in different growth periods (40, 70 and 100) days of planting.

Materials and Methods

This study was carried out at the College of Agriculture / University of Al-Qadisiyah during the agricultural season 2018-2019 using plastic containers with a capacity of (20) kg. The soil was air-dried, milled and passed through a sieve (4 mm) in diameter.Seeds of yellow maize of cultivar of Bihooth (106) were planted. Potassium sulfate fertilizer (50%) at the level of (100) kg $K2O.h^{-1}$ and triple superphosphate fertilizer at the level of (200) kg. h^{-1} were applied. The experiment was designed according to Complete Random Design (C.R.D). Eight experimental treatments were used, including the control with four replicates. The soil samples were taken before planting, air dried, milled and passed through a sieve with a diameter of (2) mm. Some physical and chemical properties were estimated in accordance with the methods in Jackson (1958), Black (1965); and Page *et al.* (1982) as shown in Table (1). Soil samples were taken for each experimental unit of the rhizosphere and bulk soils after the (40, 70 and 100) days of planting to estimate the ammonium ion in the soil using the microjeldal device according to the Bremner (1965) method described in Black (1965).

The results were statistically analyzed using the Statistical Analysis System (SAS) (2012) in the data analysis to study the effect of mineral fertilization, organic fertilization, and bio fertilization and their interactions. Significant differences between the means were compared with the least significant difference (LSD) and at the significant level of (0.05).

Results and Discussion

Fig. 1 presents the relationship between ammonium and nitrates in the rhizosphere and bulk soil. The application of all fertilizer increased the concentration of ammonium and nitrate ions in general. The nitrate concentration in all measurement periods increases the concentration of ammonium ion in both of the rhizosphere and bulk soils. This may be due to the plant's dependence on the absorption of nitrogen in the form of ammonium. This is due to its fixation on clay minerals and the surfaces of mineral and organic colloids on the one hand and to having a positive charge, which leads to the holding on the metal surfaces and thus reduces the movement on the other hand.

Nitrate is compensated from outside the rhizosphere (for the low range between nitrate values in and outside the rhizosphere). This is due to the speed of the movement of the nitrate ion on the one hand and the fact that the negative ion, on the other hand, increases the speed of transition to the rhizosphere. This decrease is also due to the consumption of nitrogen by biota and absorption by the plant. In addition, the speed of ammonium conversion to nitrate, which is the most mobile form of nitrogen, is

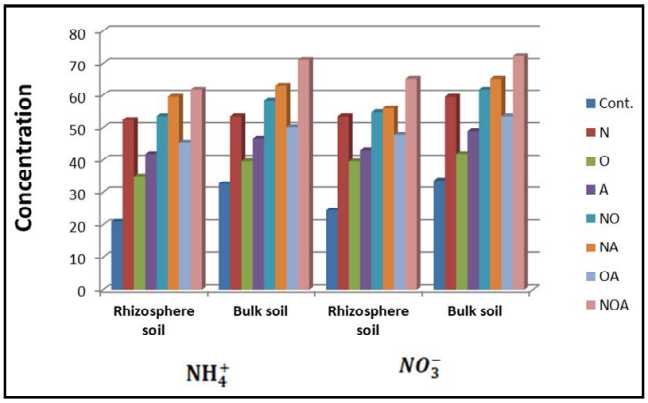

Fig. 1: The relationship between ammonium and nitrates ions in the soil after (40) days from planting.

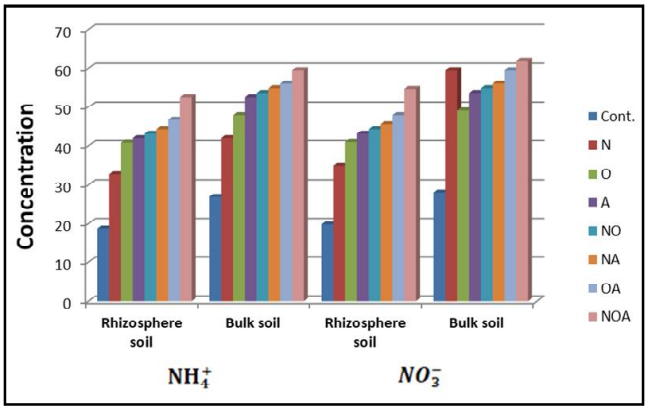

Fig. 2: The relationship between ammonium and nitrates in the soil after (70) days of planting.

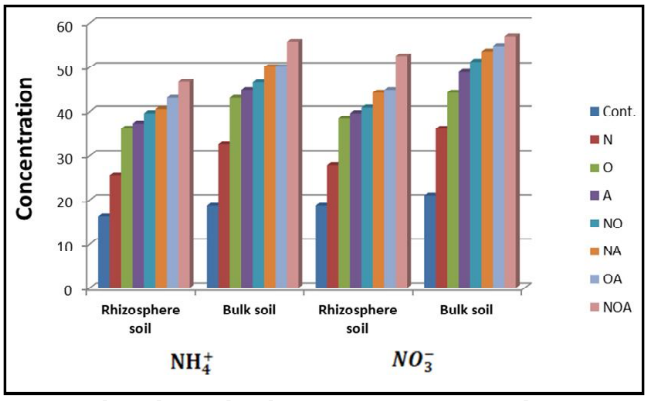

Fig. 3: The relationship between ammonium and nitrates in the soil after (100) days of planting.

easy to wash with irrigation water. This is consistent with Ritter *et al.,* (1991); Nelson and Huber, (2001) reported that one of the most common processes in which nitrates are lost is irrigation with water washed away from the roots. The concentration of ammonium ion and nitrate in the rhizosphere is lower than in bulk soil. This is due to the consumption of nitrogen in the root region and its accumulation outside the root area as a result of its absorption by the plant as well as to increase the microorganisms in the root area, including those that work to oxidize nitrogen and convert it to nitrate by nitrification process. This is consistent with Smalla *et al.,* (2001) that the numbers of nitrogen oxidizing bacteria are increasing in the root zone compared to the area far from the roots of the plant. The concentration of ammonium and nitrate ions gradually decreased during measurement periods and the order was as follows:

40 days > 70 days > 100 days

The relationship between ammonium and nitrate ions in the rhizosphere and bulk soils at 40 days of cultivation is observed in Fig. 1. The mineral fertilization (N) in all forms of application, whether a single application or in combination with the rest of the fertilizers used in the study resulted in an effect on the increase in the concentration of ammonium and nitrates in the soil and rhizosphere and bulk soils. The increase in the ammonium ion concentration may due to the 46% N available of urea fertilizer used as a mineral fertilizer, in addition to increasing the activity of organisms in the decomposition of organic matter and nitrogen fixation. When nitrogen fertilizers are applied, the amount of nitrites and nitrates accumulated increases and this is consistent with what Jokela, (1992) and Bronson *et al.,* (1992).

Results in Fig. 2 presents the relationship between ammonium and nitrates ions in the rhizosphere and in bulk soils after (70) days of planting. The interaction of bio-fertilizer (A) with the other fertilizer treatments used in the study resulted in an effect on increasing the concentration of ammonium ion and nitrate in the rhizosphere and bulk soils. This is due to the passage of (70) days of the agriculture period led to the growth and activity of microorganisms and thus led to increased stabilization of atmospheric nitrogen.

Results presented in Fig. 3 shows the relationship between ammonium and nitrate in the rhizosphere soil and bulk soils after (100) days of planting. The persistence of biofertilizer (A) persists when applied individually or in combination with the fertilizer treatments used in the study to increase the concentration of ammonium ion and nitrate in the rhizosphere soil and beyond compared with other treatments and the persistence of nitrate ion over ammonium ion. A gradual reduction of ammonium and nitrate ions in mineral fertilization (N) is observed as the measurement period progresses with respect to plant age or decreases gradually with time and takes the following order:

40 days > 70 days > 100 days

This is due to the diminution of nitrogen fertilizer concentrations to be depleted by plants or by washing and entering other pathways within the nitrogen cycle in nature such as representation in the bodies of microorganisms, Jansson and Person (1982).

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