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MINERAL, ORGANIC AND BIO-FERTILIZERS EFFECT ON THE CONCENTRATION OF NITRATE ION IN THE RHIZOSPHERE OF *ZEA MAYS L.* CROP

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Abstract

This field trial was conducted in the Department of Soil Science and Water Resources College of Agriculture University of Al-Qadisiyah during the agricultural season of 2018-2019 in plastic pots. The study was designed in accordance with Complete Random Design (C.R.D). Two levels of mineral fertilizer (urea) (0 and 250) kg.N. h^{-1} and two levels of organic matter (poultry residue) (0 and 10) tons.h^{-1} and two levels of biofertilizer (*Azospirillum brasilense*) namely (application, without application) were used. Seeds of yellow maize of the cultivar (106) were planted on the 13th of July 2018. Nitrate ion in soil during plant growth periods (40, 70 and 100) days of planting was estimated to study the effect of mineral, organic and biofertilizers and their interaction on nitrate ion concentration in the maize plant rhizosphere. The treatment of mineral fertilizer in combination with organic fertilizer and biofertilizer (NOA) achieved the highest concentration of nitrates (65.33, 54.66 and 52.50) mg.kg^{-1} in the rhizosphere and (72.33, 61.83 and 57.16) mg.kg^{-1} in bulk soil for the time periods (40, 70 and 100) days of planting, respectively. Using each kind of fertilization itself, nitrate ion availability was higher in the rhizosphere and in bulk soil with mineral fertilization during 40 days of planting compared to organic and bio fertilization (lower availability ratios). These values decreased during the period (70 and 100) days of planting, in contrast to organic and bio fertilization, whose values increased in these periods.

Key words: Maize, rhizosphere, bulk soil, nitrate availability, biofertilizer.

Introduction

Egamberdieva *et al*., (2011) identified rhizosphere as a soil part with physical and chemical properties affected by the growth and activity of roots or soils affected by the plant root system or environment in which roots secrete large amounts of metabolism to keep up with these radical changes, Nihorimbere *et al*., (2011); Khaeim, H.M. (2013). The secretions of the roots and the secretions of microorganisms create a favorable environment for plant growth and increase the availability of most nutrients. Urea is the source of available nitrogen for the growth of bacteria, fungi and plants and the fact that urea solid nitrogen fertilizer most used in agriculture is one of the most important sources of nitrogen. The roots of the plant absorb urea from the soil solution energetically and there are a number of enzymes help in the representation of urea after absorption, including urease and urea amidoliz, while the hydrolysis of urea produces ammonia and carbon dioxide and is made through the urease, Witte, (2011); Hussein M. Khaeim *et al*., (2019).

Organic matter is defined as a combination of complex compounds in different states of decomposition or stabilization, Barker and Pilbeam, (2007); Hussein Khaeim, (2019). When organic matter is applied to the soil with less than 1% nitrogen, a mineral nitrogen source must be applied in order to accelerate the decomposition process otherwise the decomposition period may take several months. This period must be passed before planting to ensure that nitrogen deficiency symptoms do not appear on the cultivated plant, Miller and Miller, (2000). Most of the applied organic nitrogen will be mineralized when suitable nitrification conditions are available (often available) and when nitrogen is converted to nitrate then it will be lost. Organic sources are that they are generally slowly available, depending on the degree of their decomposition and nutrient content. This is not in a big amount compared to mineral fertilizers. This reduces the negative impact of incorrect application to high-availability

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mineral fertilizers and high nutrient content, Badawy, (2008); Bushra Jeber *et al.,* (2019).

Kumar *et al*., (2013) noted that biofertilizers are organisms that contain organisms applied to seeds or to the soil in the rhizosphere that stimulates plant growth and increase nutrient availability in addition to their role in reducing mineral fertilizers and are considered environmentally friendly and non-polluting, producing healthy food. Plant Growth Promoting Bacteria (PGPB) of the genus *Azosperlum* have many mechanisms through which azosperlim can exert a positive effect on plant growth, which may include multiple effects including synthesis of plant hormones, N2 stabilization, nitrate availability efficacy and promotion of nutrient uptake from soils, Komy-EL and Hesham, (2004); Muneer Saeed M. Al-Baldawy *et al.,* (2019).

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

Materials and Methods

This study was carried out in the College of Agriculture, University of Al-Qadisiyah. The soil was dried, milled and sifted through a sieve diameter of holes (4 mm) for the purpose of planting in pots and then was placed into 20 kg and prepared for planting. The experiment was designed according to the Complete Randomized Design (C.R.D). Eight experimental treatments were used, including a comparison treatment with four replicates. Treatments were randomly distributed to the experimental units, bringing the number of units to 32. Yellow maize seeds of the cultivar of Bihooth (106) were planted on July 13^{th,} 2019. Five seeds were placed per each pot and after 15 days of planting the seedlings were rugged out to a single plant per pot.

Fertilizers were applied before planting including potassium sulfate fertilizer (50%) was applied at the level of (100) kg.$K_2O.h^{-1}$ and triple superphosphate fertilizer at the level (200) kg.h^{-1}. The soil samples were taken before planting, air dried, milled and passed through a 2 mm diameter sieve and some physical and chemical properties were estimated using the methods in Jackson (1958), (1965); Black, Page *et al*., (1982) and shown in table 1. Soil samples were taken for each experimental unit of the rhizosphere and bulk soil during the (40, 70 and 100) days of planting to estimate the nitrate ion in the soil using the microcouldal device according to the Bremner, (1965) method described in Black, (1965).

Data were statistically analyzed by using Statistical Analysis System- SAS, (2012) in analyzing the data according to the Complete Random Design (CRD) to study the effect of mineral fertilization (N) and organic fertilization (O) and bio fertilization (A). Bio and their interactions. Significant differences between the mean were compared with the least significant difference (LSD) and the significant level of 0.05.

Results and Discussion

The results in table 2 indicate the effect of the application of mineral, organic and biofertilizers and their interactions on the nitrate ion concentration in the soil. Their application resulted in a significant increase in the nitrate ion concentration of the rhizosphere and bulk soils after 40 days of planting. Mineral fertilization in combination with organic fertilization and bio-fertilization (NOA) resulted in the highest concentration of nitrate (65.33 and 72.33) mg.kg^{-1} in the rhizosphere and bulk soils with an increase of (166.65 and 113.80)% compared to the control treatment that resulted in the least concentration of nitrate ion (24.50 and 33.83) mg.kg^{-1} in the rhizosphere and bulk soils, respectively. This because of the application of urea fertilizer, which prepares nitrogen for soil and microorganisms, which encourages the

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

Trait		Value	Unit	Reference
Reaction Degree (pH) (1:1)		7.6	-------------------	Page *et al*., (1982)
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*., (1982)
Organic matter		11.37		Black, (1965)
Cationic dissolved ions	Ca^{2+}	25.45	Cml.charge.L^{-1}	Page *et al*., (1982)
	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	$N-NH_4^+$	22.18	Mg. kg^{-1}	Black, (1965)
	$N-NO_3^-$	19.33		
Available phosphorous		16.30	Mcg.m^{-1}	Page *et al*., (1982)
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		

Table 2: Nitrate concentration (mg.kg^{-1}) in both of rhizosphere and bulk soils after 40 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	24.50	33.83
Mineral fertilizer	N	53.66	59.50
Organic fertilizer	O	39.66	42.00
Bio-fertilizer	A	43.16	49.00
Mineral + organic fertilizers	NO	54.83	61.83
Mineral + bio-fertilizers	NA	56.00	65.33
Organic + bio-fertilizers	OA	47.83	53.66
Mineral+ organic+ bio-fertilizers	NOA	65.33	72.33
	LSD 0.05	*13.548	

growth of these organisms, in addition to that the fertilizer is rich with nutrients, especially the main ones (Table 4).

Urea exposed to the processes of mineralization and decomposition and thus increase nitrate availability in the soil. This is consistent with Siddig *et al*., (2006). Mineral fertilization increased nitrate availability more than organic fertilizer in the rhizosphere and bulk soils (53.66 and 59.50) mg.kg^{-1} Nitrate Organic Fertilization (39.66 and 42.00) mg.kg^{-1}. This increase in the concentration of nitrate ion (-NO_3) in the soil was due to the application of nitrogen fertilizer in the form of urea fertilizer (rapid decomposition), which contains (46% N) and the conversion of ammonium to nitrates after the nitrification process. Thus, the mineral fertilizer will be converted directly to nitrate with the help of microorganisms compared to organic fertilizer, which is a relatively slow-release fertilizer and bio-fertilizer. Nitrogen-fixing organisms need time to grow and then processing nitrates. This is consistent with Ali *et al*., (2002) that the application of nitrogen fertilizer increases nitrate formation in the soil. There were no significant differences between mineral fertilization and bio fertilization where the value of bio fertilization was (43.16 and 49.00) mg.kg^{-1} in the rhizosphere and bulk soil, respectively. This because of the increased activity of nitrogen-fixing by *A. brasilens* in the soil when nitrogen is present at an appropriate level and is used as an energy source, Abbasia and Yosra, (2012).

Table 3, presents the effect of the application of mineral, organic and bio-fertilizers and their interactions on the nitrate ion concentration in the rhizosphere and bulk soils after 70 days of the planting date. The results of statistical analysis showed significant differences at the 0.05 level. All treatments outperformed the control. The highest nitrate concentration in bulk and rhizosphere soils was at mineral fertilization in combination with organic and bio-fertilization (NOA), which resulted in (54.66) mg.kg^{-1} in rhizosphere soil (61.83) mg.kg^{-1} in bulk soil and increased rates (175.64 and 120.82)% compared with the control treatment, which resulted in the least values of (19.83 and 28.00) mg.kg^{-1} in the rhizosphere and bulk soils, respectively.

The application of mineral fertilizer in combination with organic fertilizer and bio-fertilizer improves soil properties and increases the concentration of minerals, especially nitrogen. No significant differences were observed between the individual fertilizer types, but the highest concentration of nitrate was with bio fertilization, where the nitrate concentration was (43.16) mg.kg^{-1} in the rhizosphere soil. The increase in nitrogen availability in the soil is because of the ability of *Azosperm* to decompose the organic matter in the soil as well as its ability to stabilize atmospheric nitrogen. In bulk soil, the highest concentration of the nitrate ion shown with mineral fertilizer application. The nitrate concentration was (59.50) mg.kg^{-1}. This may be due to the adoption of the plant to obtain nitrogen in the form of ammonium, table 6 and confirms that there is no withdrawal of nitrate from bulk soil. This is because of the fact that nitrogen fertilizer provides more available nitrogen than is proven by soil biologists and these results are consistent with, Sage and Monson (1999); Akdeniz *et al*., (2006); Sadoun and Dahri, (2011).

Table 3: Nitrate concentration (mg.kg^{-1}) in both of rhizosphere and bulk soils after 70 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	19.83	28.00
Mineral fertilizer	N	35.00	59.50
Organic fertilizer	O	41.00	49.00
Bio-fertilizer	A	43.16	53.66
Mineral + organic fertilizers	NO	44.33	54.83
Mineral + bio-fertilizers	NA	45.50	56.00
Organic + bio-fertilizers	OA	47.83	59.50
Mineral+ organic+ bio-fertilizers	NOA	54.66	61.83
	LSD 0.05	*10.581	

Table 4, presents the effect of the application of mineral, organic and bio-fertilizers and their interactions on the concentration of nitrate ion in the rhizosphere and bulk soils 100 days after planting. The results of statistical analysis showed significant differences at the 0.05 level. All treatments

Table 4: Nitrate concentration (mg.kg^{-1}) in both of rhizosphere and bulk soils after 100 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	18.66	21.00
Mineral fertilizer	N	28.00	36.16
Organic fertilizer	O	38.50	44.33
Bio-fertilizer	A	39.67	49.00
Mineral + organic fertilizers	NO	40.83	51.33
Mineral + bio-fertilizers	NA	44.33	53.67
Organic + bio-fertilizers	OA	45.00	54.83
Mineral+ organic+ bio-fertilizers	NOA	52.50	57.16
	LSD 0.05	*10.272	

outperformed the control treatment.

The highest nitrate concentration in the rhizosphere and bulk soils was shown with mineral fertilization in combination with organic fertilization and bio-fertilization (NOA), which resulted in (52.50) mg.kg^{-1} in rhizosphere and (57.16) mg.kg^{-1} in bulk soil and increased rates (181.35 and 172.19)% compared with the control treatment that resulted in the least nitrate ion concentration in this period amounted to (18.66 and 21.00) mg.kg^{-1} in the rhizosphere and in the bulk soils, respectively. This because that the urea fertilizer contains 46% available nitrogen as well as the significant role of organic matter in increasing the numbers of *Ososperm* and activated and increase its activity in nitrogen fixation and thus increase the amount of nitrogen in the soil. Bio fertilization resulted in a significant increase compared to mineral fertilization and the nitrate concentration was (39.66 and 49.00) mg.kg^{-1} in the rhizosphere and bulk soils, respectively. These results are consistent with Arti *et al*., (2014); Kumar, (2010) who found that the application of bio-fertilizers leads to the increase of some nutrients (nitrogen, phosphorus and potassium).

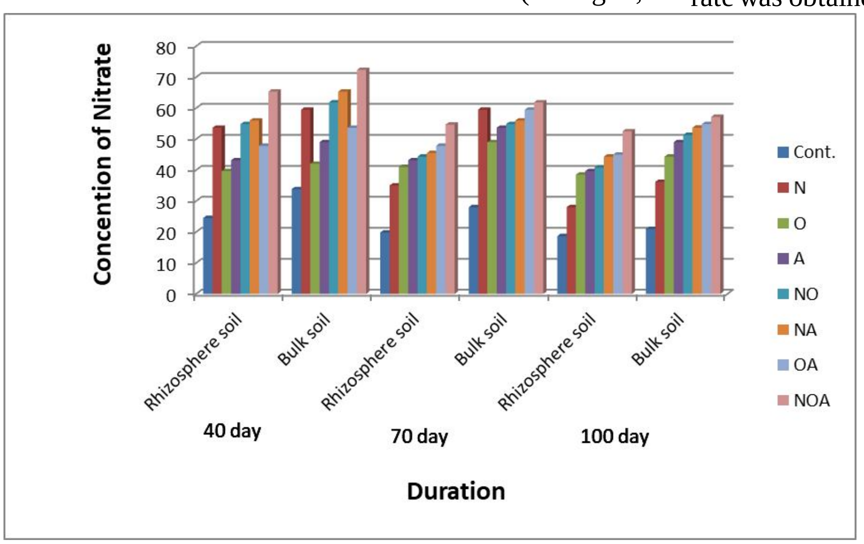

Fig. 1: Effect of mineral, organic and bio-fertilizer on nitrate ion concentration in maize rhizosphere (*Zea mays* L.).

Organic fertilizer presents a significant increase in the nitrate ion concentration (38.50) mg.kg^{-1}. No significant differences were observed between bio fertilization and organic fertilization in rhizosphere and bulk soils. This shows the importance of bio-organic fertilization in dispensing a quantity of nitrogen fertilizer to preserve the environment and human health by improving the quality of agricultural production as well as reducing production costs, Vessey, (2003); Majidian *et al*., (2006) and with Shevananda, (2008); Afifi *et al*., (2003) demonstrated the importance of bio-organic fertilization in reducing nitrogen fertilizer use by up to 50% without significant effect on yield.

From the results in tables 2, 3 and 4, the concentration of nitrates continued to decrease with measurement periods (40, 70 and 100) days in both rhizosphere and bulk soils for all treatments. The decrease was more pronounced at 100 days because of the absorption by plants or nitrate washing. This is consistent with Abu Tubaikh, (2019) found that the larger the size of the plant with age the increase the need for nutrients and thus will increase its absorption of nutrients, including nitrogen in addition to washing and volatilization, which leads to the reduction of nitrates in the soil with time as a result of the continuation of these processes. This is consistent with Ngimsh, (2012) that the amount of nitrate decreases overtime during the 10, 20, 30, 40 and 50 days intervals from the application of the fertilizer. The highest nitrate rate was obtained in the first period and began to decrease to the last period. This because of the nitrate depletion by plant roots, the process of reversing nitrification, biological representation by soil microorganisms and continuous washing. It also agrees with Attia's results (2005), which reported an increase in nitrate concentration one week after nitrogen fertilizer application to the soil and decreased after three weeks. This is confirmed by Patra *et al*., (2002); Patra *et al*., (2009) showed that the gradual decrease in the nitrogen aggregation in the root zone was similar to that outside the root zone (42.21, 47.31 and 39.21) mg.kg^{-1}, respectively. The highest amount of nitrite and nitrate in the first period and began to decline gradually down to the last period but in quantities exceeding what is in the area of the root ocean and this is due to the activity of biological operations in the root zone.

The overlap in fertilizer application increased nitrate concentration as shown in tables 2, 3, 4 and fig. 1. Nitrate is the most laundered form because it is not caught by the colloidal granules in the soil to be repulsed with the surface of the clay away to the soil solution away from the colloidal surface and thus easy to move. This because that nitrogen consumption by microorganisms in the root zone and its uptake by the plant as well as biomass activity in the root zone leads to shifts between nitrogen forms, which increases the susceptibility of soil loss, Grant *et al*., (2001). Nitrogen in the form of nitrates resulting from applied nitrogen fertilizers or from the process of converting ammonium to nitrate in the soil is also subjected to continuous washing processes away from plant root areas, Frye, (2005).

Based on the above results, we find that there is a balance between the amount of nitrate ion located in the rhizosphere and bulk soils. This ion transferred from bulk soil to the rhizosphere soil. This is due to the proliferation and speed of movement of the nitrate ion because it is a negative ion, which reduces its hold on the surfaces of colloids and the amount was higher than the ammonium ion in all studied periods of oxidation of the ammonium ion by nitrification.

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