Plant Archives Volume 20 No. 1, 2020 pp. 1284-1288 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

FERTILIZER TYPE EFFECT ON THE CONCENTRATION OF AMMONIUM ION INTO THE RHIZOSPHERE OF *ZEA MAYS* L.

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Abstract

This pots study was conducted in the Department of Soil Science and Water Resources, College of Agriculture, University of Al-Qadisiyah during the agricultural season 2018-2019. It aimed to investigate the effect of mineral, organic and biofertilizers and their interaction on the concentration of ammonium ion into the rhizosphere area of *Zea mays L.* Complete Random Design (C.R.D) was used. The study included the use of two levels of mineral fertilizer (urea) (250) kg.N.h^{-1}, two levels of organic matter (poultry residue) (0 and 10) tons.h^{-1}, and two levels of biofertilizer (*Azospirillum brasilense*) namely (application, without application). Maize seeds of the cultivar (106) were planted on Jun 13th 2018. Ammonium ion was estimated in soil during plant growth periods (40, 70 and 100) days of planting. Results that the treatment of mineral fertilization in combination with organic fertilization and bio-fertilization (NOA) resulted in the highest concentration of ammonium ion (61.83,52.50 and 46.80) mg.kg^{-1} into the rhizosphere and (71.16,59.50 and 56.00) mg.kg^{-1} in bulk soil for the time periods (40, 70 and 100) days of planting, respectively. Using individual fertilization, the highest ammonium ion availability in the rhizosphere and bulk soils was shown with mineral fertilization during 40 days of planting compared to organic and bio fertilization (lower availability ratios). These values were decreased on the periods of (70 and 100) days of planting unlike organic and biofertilizers, which their values increased during these periods.

Key words : Bulk soil, rhizosphere, ammonium ion, ammonium availability, maize.

Introduction

Yellow maize is an important cereal crop in food. It is widely cultivated in the world. Maize is very important in many industries such as oil and biofuels, animal feed such as cattle and poultry, starch, glues, asbestos, ceramics and plastic, Mengel and Kirkby (2001); Bushra Jeber, *et al.* (2019). Nitrogen is the most important marital in plant nutrition. It plays an essential role in plant cell growth, development and division, and protein and amino acid formations. Nitrogen comes first in terms of the amount needed by the plant, so its availability in the soil during the stages of plant growth, especially at the stage of tillering and elongation of plant growth is necessary to obtain good crop productivity, Jan *et al.*, (2010); Hussen Khaeim (2019). Plants do not benefit from the organic part only after it has been transformed into inorganic forms (metallic) in the process of mineralization and in the form of ammonia compounds found on soil complexes and colloids and soil solution. Therefore, dependence on soil reserves of nitrogen alone is not productive without the application of nitrogen fertilizer. Nitrogen applications must be in different forms such as ammonium and nitrates. Transitions between these forms are in place for soil-availability nitrogen uptake by plants, Halvin *et al.*, (2005); Amran, (2005); Barker and Bryson, (2007); Hussein Khaeim (2013).

Urea fertilizer is the most nitrogen-available fertilizer in the world due to its high nitrogen content (46%), low production costs, easy storage, application to soil and its rapid decomposition in soil Selim *et al.*, (2010). Gregory (2006) defined organic matter as plant and animal material at various stages of decomposition, considering that the roots of living plants and microorganisms are part of organic soil. From this definition it turns out that the sources of organic matter vary from plant originating from the roots of plants and leaves falling on the soil surface, which is going through the stages of biological decomposition by microorganisms, and animal sources come as a result of the activities of the organisms and

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animals of the soil and cells, and tissue after death. The presence of organic residues in soil, especially vegetation, increases the rate of ammonium representation. Bio-fertilizers are natural preparations containing one or more species of non-GMO beneficial microorganisms that do not contain any harmful pesticides or chemicals. They are therefore health-safe products as well as their effective role in improving soil fertility because of their ability to release nutrients on a continuous basis, making them somewhat safe if the ideal conditions for their growth to meet the needs of treated plants. Thus, they contribute to reducing environmental pollution and are relatively inexpensive food sources as alternatives to chemical fertilizers, Mokhaimer, (2008). Taha (2007) showed that biofertilizers cannot be used as a substitute for mineral fertilizers, but rather as fertilizers that supplement mineral fertilizers. It contributes to increasing the effectiveness and efficiency of mineral fertilizers in soils with poor qualities in terms of fertility, as well as being an important means of preserving the environment, and its role in improving the quality of yield compared with the use of mineral fertilizers. Based on the purpose of the research to study the effect of mineral, organic and bio fertilization and their interactions on the concentration of ammonium ion in the rhizosphere of maize plants during different growth periods (40,70 and 100) days of planting.

Methods and Materials

The study was carried out at the College of Agriculture, the University of Al-Qadisiyah during the agricultural season 2018-2019 using plastic pots with a capacity of 20 kg soil. The soil was air-dried and milled and passed through a sieve diameter of its holes (4 mm). Maize seeds were planted into these pots. Potassium sulfate fertilizer (50%) was applied at the level of (100 kg $K_2O.h^{-1}$) and triple superphosphate fertilizer at the level of (200 kg. h^{-1}). The experiment was designed according to the Complete Randomized Design (C.R.D). Eight experimental treatments were applied, including comparative treatment with four replicates for each treatment. Treatments were randomly distributed into the experimental units, bringing the number of units to 32. 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 by the methods in Jackson (1958), Black (1965) and Page *et al.*, (1982) as presented in (Table 1). Soil samples were taken from each experimental unit of rhizosphere and bulk soils at the (40, 70 and 100) days of planting to estimate the ammonium ion in the soil using the micrococcal device according to the Bremner (1965) method described in Black (1965). The results were statistically analyzed using the Statistical Analysis System-SAS (2012) to study the effect of N (mineral fertilization), O (organic fertilization) and (A) (bio fertilization) and their interactions. Significant differences between means were compared with the least significant difference (LSD) at 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 overlap on the concentration of ammonium ion in soil. Significant increase in the concentration of ammonium ion in both 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 ammonium (61.83 and 71.16) mg. kg^{-1}. The least concentration of ammonium in this growth period was (21.00 and 32.67) mg. kg^{-1} in the rhizosphere and bulk soils, respectively. This indicates that the application of the different types of fertilizers gave significant results due to the positive effect of mineral, organic and bio fertilization. Many studies have confirmed the role of organic matter in activating the Azotobacter and thus increasing their effective numbers in the stabilization of atmospheric nitrogen and increase the secretion of phytohormones by providing the bacteria with energy, which is a prerequisite for reproduction. This confirms the importance of fertilizer integration which leads to reduced dependence on mineral fertilizers and these confirm the findings of Mahmoud, (2001). The results also present that mineral fertilization made the highest ammonium availability than other fertilizers in rhizosphere and bulk soils, where the value of ammonium ion (52.50 and 53.66) mg. kg^{-1}, while the value of organic fertilizer was (35.00 and 39.67) mg. kg^{-1} and bio-fertilizing valued at (42.00 and 46.66) mg. kg^{-1} in the soil of the rhizosphere and bulk respectively, which took the following sequence:

Mineral fertilization > Bio fertilization > Organic fertilization.

Table 3 presents the effect of the application of mineral fertilizer, organic fertilizer, and bio-fertilizer and their interactions on the ammonium ion concentration of the rhizosphere and bulk soils after 70 days of planting. The results of statistical analysis showed significant differences at 0.05 significance level. All treatments outperformed the control. The highest concentration of ammonium ion in and outside the rhizosphere resulted with the application of mineral fertilizer in combination with organic fertilizer and biofertilizer (NOA) (52.50) $mg.kg^{-1}$ into the rhizosphere soil and (59.50) $mg.kg^{-1}$ in

Table 1: Chemical and physical properties of the field soil.

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	$N-NH_4^+$	22.18	Mg. kg^{-1}	Black, (1965)
	$N-NO_3$	19.33		
Available phosphorous		16.30	Mcg.m^{-1}	Page *et al.*, (2982)
Available potassium		164.40		
Bulk Density		1.36		
Soil Separators	Sand	270	g.kg^{-1}	Black, (1965)
	Loam	540		
	Clay	190		
Texture type		Silt Loam		

Table 2: The concentration of ammonium ion in both of rhizosphere and bulk soils after 40 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	21.00	32.67
Mineral fertilizer	N	52.50	53.65
Organic fertilizer	O	35.00	39.67
Bio-fertilizer	A	42.00	46.66
Mineral + organic fertilizers	NO	53.67	58.33
Mineral + bio-fertilizers	NA	59.50	63.00
Organic + bio-fertilizers	OA	45.50	50.17
Mineral+ organic+ bio-fertilizers	NOA	61.83	71.16
	LSD 0.05	*8.609	

bulk soil and increased percentages (181.19 and 121.76) % compared with the control treatment (18.67 and 26.83) mg.kg^{-1} in the rhizosphere and bulk soils, respectively. The results show that the concentration of ammonium with the application of mineral fertilization (N) decreased to (32.66 and 42.00) mg.kg^{-1}. This may due to the fact that urea fertilizer is rapped soluble, easy to be absorbed by the plant and is quick to wash with irrigation water as well as depletion by the plant. Bio-fertilization (A) significantly made higher values than the treatment of mineral fertilization (N) as it reached (42.00 and 52.50) mg.kg^{-1} in the soils of the rhizosphere and bulk soils, while there was no significant difference between them and organic fertilization (O) in both soils. This is because of the important role of *A.brasilens* in stabilizing atmospheric nitrogen in soil, which is consistent with what Abdelaziz found (2010). The increase in organic fertilization is also due to the fact that the application of organic matter increases the activity of microorganisms, which in turn decomposes the material and increase the processing of ammonium, Nazarene (2005).

Table 4 shows the effect of the application of mineral fertilizer, organic fertilizer, and bio-fertilizer and their interactions on the ammonium ion concentration of the rhizosphere and bulk soils (100) days after planting. The results of statistical analysis showed significant differences at 0.05 level. All treatments outperformed the control treatment. The highest concentration of ammonium in and outside the rhizosphere was when mineral fertilizer applied in combination with organic fertilizer and biofertilizer (NOA) which valued at 46.80 mg.kg^{-1} in rhizosphere soil and 56.00 mg.kg^{-1} in

Table 3: The concentration of ammonium ion in both of rhizosphere and bulk soils after 70 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	18.67	26.83
Mineral fertilizer	N	32.66	42.00
Organic fertilizer	O	40.83	47.83
Bio-fertilizer	A	42.00	52.50
Mineral + organic fertilizers	NO	43.16	53.67
Mineral + bio-fertilizers	NA	44.33	54.83
Organic + bio-fertilizers	OA	46.67	56.00
Mineral+ organic+ bio-fertilizers	NOA	52.50	59.50
	LSD 0.05	*7.029	

Table 4: The concentration of ammonium ion in both of rhizosphere and bulk soils after 100 days of planting.

Fertilization Type	Treatment	Sampling area	
		Rhizosphere soil	Bulk soil
Control	Cont.	16.33	18.66
Mineral fertilizer	N	25.66	32.67
Organic fertilizer	O	36.17	43.16
Bio-fertilizer	A	37.33	45.00
Mineral + organic fertilizers	NO	39.67	46.66
Mineral + bio-fertilizers	NA	40.56	50.16
Organic + bio-fertilizers	OA	43.16	50.17
Mineral+ organic+ bio-fertilizers	NOA	46.80	56.00
	LSD 0.05	*8.863	

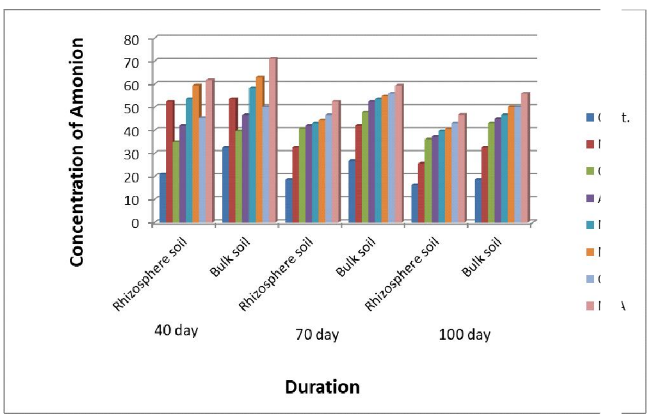

Fig. 1: Effect of fertilizer type on the concentration of ammonium ion.

the bulk soil with an increase of (186.59 and 200.11)% compared with the control treatment that resulted the least concentration of ammonium (16.33 and 18.66 mg.kg^{-1} in the rhizosphere and bulk soils, respectively. The positive effect of bio-fertilization (A) on ammonium concentration of rhizosphere and bulk soils continued to be significant compared to mineral fertilization (N). No significant difference between bio fertilization (A) and organic fertilization (O) was shown. The reason is due to the role of nitrogen-fixing bacteria in the soil in a non-coherent manner, Zaghloul (2002). This is consistent with what al-Dhafiri found (1999), which confirmed the role of Azospirilm in stabilizing atmospheric nitrogen in soil. This is probably due to the important role of microorganisms in the decomposition of organic nitrogen (proteins, amino acids, and nucleic acids) to obtain carbon and energy and release excess nitrogen in the form of ammonium ion, Alexander (1982). This represents the importance of bio-organic fertilizer in the possibility of reducing the amount of nitrogen fertilizer applied to the soil to reduce environmental pollution resulting from excessive use of mineral fertilizers, Mittal *et al.*, (2008).

The results in (Tables 2, 3, 4) and Fig. 1 show that the concentration of ammonium continued to decrease with measurement periods (40, 70 and 100) days in and bulk soil for all treatments. The decrease in ammonium ion may because of uptake absorption and loss of part of the nitrogen in the soil by volatilization, nitrification, stabilization of organic matter or clay minerals, or use by soil organisms when carbon is available as a source of energy and growth. This is consistent with what Barker and Bryson found (2007), which was more pronounced for the third phase in the measurement period (100) days. The overlap in the fertilizer application led to an increase in the concentration of ammonium, Fig. 1. The decrease in ammonium concentration in both bulk soil and in the rhizosphere indicates the transfer of this ion from bulk soil to the area of biological activity (rhizosphere) to compensate for the lack of ion in it. As shown in Fig. 1, the concentration of ammonium in rhizosphere soil was lower than that in bulk soil. This is consistent with Abu Tabikh (2019) and Duineveld *et al*., (2001) who showed that the decrease in the amount of ammonium in the root zone is due to the increased numbers of bacteria (Nitrosomonas) specialized in the biological conversion of ammonium to nitrite in the nitrification process as well as the absorption of ammonium by the plant. The amount of nitrogen-ammonium outside the root zone.

Based on what being said of the results, there is a balance between the amount of ammonium ion found in the bulk and rhizosphere soils. There is processing for this ion from bulk soil the rhizosphere soil to the rhizosphere. This is because of the tension caused by plant roots due to ion depletion as well as its representation in the bodies of microorganisms.

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