Effect of Organic and Mineral Fertilization in concentration of Soluble Potassium Inside and Outside Rhizosphere of Maize (*zea mays* L.)

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Abstract

A field experiment was carried out in a private farmer's farm located in AL-Qadisiyah/ Diwaniyah/ Daghara/ Sadr Al-Daghara area to study the effect of organic and mineral fertilizers on dissolved potassium amount inside and outside Zea maize rhizosphere. randomized complete block design (RCBD) was designed in three replicates and included two factors: the first factor with four levels of potassium sulphate which are (0, 75, 150, 225) kg K. ha^{-1} symbolized by the symbols (K_0, K_1, K_2, K_3) Respectively, and the second factor with four levels of organic matter (poultry residues) which are (0, 10, 20, 30) tons. ha^{-1} symbolized by the symbols (O_0, O_1, O_2, O_3) Respectively, the seeds of Zea maize (Zea mays L.) were cultivated in the form of lines (DKC 6120) in the form of lines on 20/7/2016.

The results showed that the addition of potassium sulphate in different levels has achieved a significant increase in the amount of soluble potassium inside and outside the soil of the root zone and for all time periods (40,70,100) days of planting and the mineral fertilizer has exceeded the organic fertilizer in increasing the amount of soluble potassium and the interaction between the highest level of potassium fertilizer 225 kg k. ha^{-1} and the highest level of organic fertilizer 30 tons. ha^{-1} (K_3O_3) achieved the highest amount of soluble potassium within the root zone which amounted to (0.131,0.163) cmol.kg $soil^{-1}$ respectively, and (0.179,0.167) cmol.kg $soil^{-1}$ outside the root zone respectively for the periods (40,70) days of planting respectively, while after 100 days of planting the interaction (K_2O_3) achieved the highest amount of soluble potassium amounted to 0.114 cmol.kg $soil^{-1}$ inside the root zone and the interaction (K_3O_3) achieved the highest amount of soluble potassium amounted to 0.159 cmol.kg $soil^{-1}$ outside the root zone and a decrease in the amount of soluble potassium and for all treatment is noticed with the increase of plant growth time.

Key words: Fertilization, soluble potassium, Rhizosphere.

Introduction

The organic material includes plant and animal residues as well as microorganisms in the soil. These substances are degraded by microorganisms when the appropriate conditions of heat, humidity and ventilation are available to produce Bio-chemical materials such as sugars, carbohydrates, organic and amino acids, oils and pigments in addition to gases and these materials are called the non-humus materials. While the humus materials are a mixture of heterogeneous and

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* Part of MSC thesis of the second author.

non-amorphous materials of dark color, and these materials can be divided according to their molecular weight and properties to humine, humic and folic acid (Ali et al., 2014). Organic matter in the soil arises from plant waste containing 60-90% moisture. While the remaining dry matter is composed of carbon, oxygen, hydrogen, and a small amount of sulfur, nitrogen, phosphorus, potassium, calcium and magnesium. Although these elements exist in small amounts but they are very important to soil fertility as the most important property of organic fertilizers is its content of major elements such as nitrogen, phosphorus and potassium (Bot and Benites, 2005). Potassium is one of the seven most abundant mineral elements in the earth's crust as the Potassium is found in large areas of the surface of the Earth's crust but is not found in the potassium ion K^+ in nature but rather is found combined with other ions (Hussein, 2007). And the Potassium represents 2.6% of the earth's crust components (Stanley, 2005). And Potassium is one of the major nutrients needed by the plant, which plays an important role in its growth and completeness of its life cycle as It is needed by all plants although it does not enter any organic compound as it is found in the free form (K^+) within plant tissues (Philippe et al., 2004). And the amount of potassium needed by the plant varies by type, class, stage of growth and quality of grains or fruits produced (Ali et al., 2014). Korb et al. (2002), Havlin et al. (2005) and Pettygrove et al. (2011) pointed that the potassium is found in the soil in four forms connected together with a direct balance relationship that determines the behavior and role and the amount of availability to the plant and these forms are soluble potassium and exchangable potassium and non-exchangable potassium and mineral potassium. one of the most potassium forms available and easily absorbed by the plant is dissolved potassium which is found soil solution in a dissolved ionic form (K^+) and is not desorbed on the surfaces of colloids and its concentration arises in the soil solution as a result of exchangable potassium hydrolysis or substitution of potassium by other cations, and usually it has a low quantity and usually it is one of the most potassium forms prone to loss as a result to washing (Mehmedany et al., 2008). Al-Samurai (2005) showed that the most important factors determining the concentration of dissolved potassium in the soil solution is the amount of exchange potassium, the soil reaction rate, the moisture content of the soil, the content of the carbonate minerals and the type and concentration of the cations in the soil solution in addition to that The processes occurring in the soil which depresses the potassium concentration in soil solution also releases potassium from the exchangable and non-exchangable form. soluble Potassium represents 10% of the available potassium, 1% of the exchange potassium and 0.01% of total potassium (Wiklander, 1954). Concentration of potassium in the soil solution suitable for plant growth should be more than (0.5) mmol. L^{-1}, which can be achieved if all adsorption sites involved in potassium fixation are saturated, and all external surfaces are occupied by potassium (IPI, 2001). The objective of the study is the effect of organic and potassium fertilization on the values of dissolved potassium inside and outside Zea Maize rhizosphere.

Materials and Methods

A field experiment was carried out in a private farmer's farm located in Qadisiyah/ Diwaniyah/ Daghara/ Sadr al-Daghara in a sedimentary soil with Silt Clay Loam for the autumn season of 2016. A sample of soil from the field was randomly selected prior to planting from the surface layer (0-30 cm) and was air-dried and tested and passed from a 2 mm diameter sieve to perform some chemical and physical analysis according the flowing methods:

- Hydrogen Potential (pH): Measured in suspension of soil: water (1:1) using the pH meter according to Page et al. (1982).
- Electrical conductivity (Ec): Measured in suspension of soil: water (1:1) using the Ec meter according to Page et al. (1982).
- Cations Exchange Capacity (CEC): Estimated using ammonium acetate and sodium acetate according to the method mentioned in Black (1965b).
- Carbonate: Estimated by equalization to 1N of Hcl and retrograde titration with 1N of NaOH according to the method mentioned in Page et al. (1982).
- Gypsum: Estimated by the method of quantitative sedimentation of acetone according to the method of Page et al. (1982).
- Organic matter: Estimated by the method of wet digestion using 1N of K2Cr2O7 according to the method of Walkly and Black mentioned in Black (1965b).
- Calcium: Estimated by titration with Na2-EDTA using Ammonium Parpuate indicator according to the method of Lanyon and Heald mentioned in Page et al. (1982).
Sodium: Estimated by the Flame photometer according to the method mentioned in Jackson (1958).
- Available Nitrogen: Estimated by using the Micro Kjeldahl according to the method of Bremner and Keeney (1965) mentioned in Black (1965b).
- Available Phosphorus: Estimated by the Spectrophotometer and with a wavelength of 882 nm according to Page et al. (1982).
- Soluble Potassium: Estimated in suspension of soil: water (1:1) according to the method proposed by Knudsen *et al.* mentioned in Page et al. (1982).
- Exchangeable Potassium: Exchangeable Potassium Extracted with Ammonium Chloride NH_4OAC at 1N Concentration After Modifying the pH of the Solution to 7 in was estimated according to Page et al. (1982).
- Total potassium: Estimated by digestion of soil samples with a mixture of 48% hydrofluoric acid, 97% sulfuric acid and pyrochloric acid using a 30 mL platinum shell with heating according to the method suggested by Jackson (1958).
- Bulk Density: Measured by Core Sample method according to Black (1965a).
- Soil texture: Measured by the pipette method mentioned in Black (1965a).

The soil of the field was prepared by making the necessary tillage, smoothening and leveling, and three main streams were opened along the field, including a subset of each plate so the field was divided into three blocks between each block and another a distance of 2m and each block was divided into 16 plates (experimental units) with an area of (3m×3m) for each experimental unit, which represents an area of $9m^2$ and left a distance of 1 m between each experimental unit and another. The experiment was designed according to the randomized complete block design (RCBD), which included two factors: the first factor with four levels of potassium sulphate which are (0, 75, 150, 225) kg K. ha^{-1} symbolized by the symbols (K_0, K_1, K_2, K_3) Respectively, and the second factor with four levels of organic matter (poultry residues) by mixing it with the soil surfce which are (0, 10, 20, 30) tons. ha^{-1} symbolized by the symbols (O_0, O_1, O_2, O_3) Respectively. and table (2) show some characteristics of organic fertilizer. The seeds of the Zea maize (*Zea mays* L.) experimental class (DKC 6120) were cultivated in 20/7/2016 In the form of lines and the distance between one line and the other 75 cm and between one pit and another 25 cm in the form of four lines in one plate and with a plant density of 53333 plant. ha^{-1}. Samples from outside and outside the rhizosphere were also taken at the periods (40,70,100) days after planting to estimate soluble potassium.

Table (1) some of the chemical and physical properties of farm soil before planting.

property		value	unit
potential of hydrogen		7.85	----
Electrical conductivity		5.3	ds. m^{-1}
cations exchange capacity		21.2	Cmol. Kg^{-1}
carbonate		219	g. Kg^{-1}
gypsum		1.06	
organic matter		10.31	
available nitrogen		39.20	mg. kg^{-1}
available phosphorus		14.52	
Calcium		1.54	Cmol. kg^{-1}
Sodium		3.15	
soluble potassium		0.075	
exchangeable potassium		0.599	
Total potassium		36.289	
Bulk Density		1.401	megg. m^{-1}
soil texture	sand	184	g. kg^{-1}
	silt	437	
	clay	379	
Texture class		Silt Clay Loam	

Table (2) Some chemical properties of organic fertilizer (poultry residues)

property	Value	Unit
Potential of hydrogen	7.31	----
Electrical conductivity	4.01	ds. m^{-1}
C/N	10.32	----
Organic Carbon	263	g. Kg^{-1}
Total Nitrogen	25.5	
Total phosphorus	14.6	
Total potassium	16.9	

Results and discussion

Soluble potassium

The amount of dissolved potassium in the soil before planting was 0.075 Cmol.Kg^{-1} and this value represents 0.2% of the total potassium, which amounted to 36.289 Cmol.Kg^{-1} Table (6) and this is close to what AL_Zubaidi (2001) and AL-Samurrai (2005) found. This amount of soluble potassium is enough to meet the need for many crops, except for potassium greedy plants such as Zea maize (Abdul Rassoul, 2007).

1. **Soluble potassium after 40 days of planting:**

Table (3) shows the effect of potassium and organic fertilization and the interaction between them on the amount of soluble potassium inside and outside the soil of the root zone after 40 days of planting. The results of the statistical analysis showed that there was a significant effect at 0.05 level to addition of potassium and organic fertilizer on the amount of soluble potassium inside and outside the soil of the root zone**,** as all levels of Potassium Fertilizer were significantly superior to control treatment (K_0O_0). This increase is natural and logical due to the addition of Potassium Fertilizer and this agrees with the findings of Abdul Rassoul (2007) and AL-Samak (2009). In addition to that all levels of organic fertilizer were superior to the control treatment and this is due to the fact that the addition of organic soil residues increases the soluble potassium in the soil solution by replacing the potassium ions K^+ on the exchange surfaces with hydrogen ion H^+ produced from dissociation of organic acids (AL-Delphi, 2013) and this agrees with the findings of Abdul Rassoul (2007). The highest average of soluble potassium inside and outside the soil of the root zone was at the addition of 225 kg K. ha^{-1} with 30 tons. ha^{-1} of organic fertilizer (K_3O_3) which gave 0.163 Cmol. Kg $soil^{-1}$ in the root zone and 0.179 Cmol. Kg $soil^{-1}$ outside the root zone and with an increase rate of (143.28,145.20)% compared with the control treatment that achieved the lowest amount of soluble potassium in this period which amounted to (0.067,0.073) Cmol. Kg $soil^{-1}$ inside and outside the root zone respectively. soluble potassium values inside the root zone were also noticed to decrease in all treatments compared to the treatments outside the root zone and this may be due to the absorption of soluble potassium from the area close to the plant's roots is higher than that for the area far from the roots at one hand, or the general increase of biological activity at the other hand, and this agrees with Rao and Takkar (2007) who found through a study about the status for potassium in soils different in their clay content planted with Zea maize crop that the samples taken from the root zone contain soluble potassium between 6.0-26.5 $mg.kg^{-1}$ while the samples taken from outside the root zone contain soluble potassium between 8.0-28.9 $mg.kg^{-1}$ and the researchers attributed this difference to the absorption of potassium by the plant. Also soluble potassium values were increasing with the increase of potassium fertilization and organic fertilization levels which its increase rates were less compared to the potassium fertilization inside and outside the root zone.

2. **Soluble potassium after 70 days of planting:**

Table (4) shows the effect of potassium and organic fertilization and their Interaction on the amount of soluble potassium inside and outside the root zone soil after 70 days of planting. The potassium and organic fertilization processes resulted in an increase in soluble potassium concentration in soil with the increase of the levels of fertilization, and the results of the statistical analysis at a significant level 0.05 showed that all the levels of potassium fertilization and organic fertilizer significantly exceeded the control treatment (K_0O_0), and that the highest level of soluble potassium inside the root zone was at the addition of 225 kg K. ha^{-1} with 30 tons. ha^{-1} of organic fertilizer (K_3O_3) which gave 0.131 Cmol. Kg $soil^{-1}$ with an increase rate of 133.92% compared to the control treatment which didn’t differ significantly from (K_2O_3) treatment which amounted to 0.129 Cmol. Kg $soil^{-1}$, while outside the root zone the highest level of soluble potassium was at the addition of 225 kg K. ha^{-1} with 30 tons. ha^{-1} of organic fertilizer which gave 0.167 Cmol. Kg $soil^{-1}$ with an increase rate of 135.21% compared to the control treatment.

Table (3) Effect of Addition of Potassium Sulphate Fertilizer and Organic Fertilizer and their Interaction in the Amount of Soluble Potassium (Cmol. Kg soil^{-1}) inside and outside rhizosphere After 40 Days of planting.

Treatment		Sampling area	
Mineral fertilization	Organic fertilization	Inside root zone	Outside root zone
K_0	O_0	0.067	0.073
	O_1	0.079	0.086
	O_2	0.088	0.094
	O_3	0.101	0.107
	Average	0.084	0.090
K_1	O_0	0.089	0.099
	O_1	0.102	0.110
	O_2	0.120	0.127
	O_3	0.134	0.144
	Average	0.111	0.120
K_2	O_0	0.101	0.113
	O_1	0.124	0.135
	O_2	0.140	0.150
	O_3	0.149	0.161
	Average	0.129	0.140
K_3	O_0	0.112	0.123
	O_1	0.138	0.153
	O_2	0.154	0.167
	O_3	0.163	0.179
	Average	0.142	0.156
Factors		$LSD_{0.05}$	
K		0.0022^*	0.0027^*
O		0.0022^*	0.0027^*
K*O		0.0045^*	0.0054^*

It is also observed that the level of potassium decreases and for all treatments for this period, which is the flowering peroid compared potassium levels during the 40 days of cultivation, due to the need of Zea maize crop to potassium during this period. As Al-Sahuki (1990) stated that Zea maize crop requires low amounts of potassium in the early stages of growing but this need increases to reach its maximum in a certain stage before male flowering phase and after 50-75 days of planting and this agrees with the findings of AL-Samak (2009) in his study on the status and behavior of potassium in soils used in cultivation under variable agricultural irrigation systems, that the soil content of potassium decreased during the Zea maize male flowering phase compared to the early and late stages of its growth.

Table (4) Effect of Addition of Potassium Sulphate Fertilizer and Organic Fertilizer and their Interaction in the Amount of Soluble Potassium (Cmol. Kg soil^{-1}) inside and outside rhizosphere After 70 Days of planting.

Treatment		Sampling area	
Mineral fertilization	Organic fertilization	Inside root zone	Outside root zone
K_0	O_0	0.056	0.071
	O_1	0.064	0.081
	O_2	0.075	0.090
	O_3	0.089	0.104
	Average	0.071	0.087
K_1	O_0	0.073	0.092
	O_1	0.084	0.104
	O_2	0.099	0.124
	O_3	0.117	0.139
	Average	0.093	0.115
K_2	O_0	0.083	0.105
	O_1	0.101	0.127
	O_2	0.114	0.142
	O_3	0.129	0.153
	Average	0.107	0.132
K_3	O_0	0.090	0.115
	O_1	0.113	0.145
	O_2	0.122	0.158
	O_3	0.131	0.167
	Average	0.114	0.146
Factors		$LSD_{0.05}$	
K		0.0019*	0.002*
O		0.0019*	0.002*
K*O		0.0039*	0.004*

3. Soluble potassium after 100 days of planting:

Table (5) shows the effect of potassium and organic fertilization and their Interaction on the amount of soluble potassium inside and outside the root zone soil after 100 days of planting. The potassium and organic fertilization processes resulted in an increase in soluble potassium concentration in soil with the increase of the levels of fertilization, and the results of the statistical analysis at a significant level 0.05 showed that all the levels of potassium fertilization and organic fertilizer significantly exceeded the control treatment (K_0O_0). As in the root zone the (K_2O_3) treatment that includes the addition of 150 kg K. ha^{-1} with 30 tons. ha^{-1} organic fertilizer achieved the highest amount of soluble potassium 0.114 Cmol. Kg soil^{-1} with an increase rate of 128.00 % compared to the control treatment which achieved an amount of soluble potassium of 0.050 Cmol. Kg soil^{-1}, while outside the root zone the treatment (K_3O_3) that includes the addition of 225 kg K. ha^{-1} with 30 tons. ha^{-1} with an increase rate of 130.43% compared to the control treatment which achieved an amount of soluble potassium of 0.069 Cmol. Kg soil^{-1}.

Table (5) Effect of Addition of Potassium Sulphate Fertilizer and Organic Fertilizer and their Interaction in the Amount of Soluble Potassium (Cmol. Kg soil^{-1}) inside and outside rhizosphere After 100 Days of planting.

Treatment		Sampling area	
Mineral fertilization	Organic fertilization	Inside root zone	Outside root zone
K_0	O_0	0.050	0.069
	O_1	0.060	0.083
	O_2	0.071	0.094
	O_3	0.088	0.110
	Average	0.067	0.089
K_1	O_0	0.063	0.087
	O_1	0.074	0.100
	O_2	0.089	0.121
	O_3	0.108	0.138
	Average	0.084	0.112
K_2	O_0	0.072	0.098
	O_1	0.088	0.122
	O_2	0.100	0.137
	O_3	0.114	0.148
	Average	0.094	0.126
K_3	O_0	0.078	0.106
	O_1	0.096	0.138
	O_2	0.100	0.150
	O_3	0.108	0.159
	Average	0.096	0.138
Factors		$LSD_{0.05}$	
K		0.0022*	0.0021*
O		0.0020*	0.0021*
K*O		0.0043*	0.0042*

The results of tables (3,4,5) showed a continuous decrease in the amount of soluble potassium in all studied periods for soils of the root zone and outside it and the increase in potassium and organic fertilization levels and their interactions led to an increase in its amounts (Figure 1), soluble potassium decrease inside and outside the root zone indicates the rapid mobility of this element from outside the root zone to the biological activity zone (root zone) to substitute for the element's lack in it (Ali et.al, 2014) The results also showed that potassium fertilization without the interference with the organic fertilization (K_1O_0, K_2O_0, K_3O_0) tables (3,4,5) resulted in an increase in soluble potassium values with the increase in plant growth period and for both inside and outside the root zone. While the organic fertilization (K_0O_1, K_0O_2, K_0O_3) resulted in a decrease in soluble potassium values with the increase in plant growth period in the root zone, while there was a decrease up to 70 days and an increase after 100 days of planting outside the root zone and this indicates the gradual degradation of organic matter and thus it is unable to supply all the plant's needs.

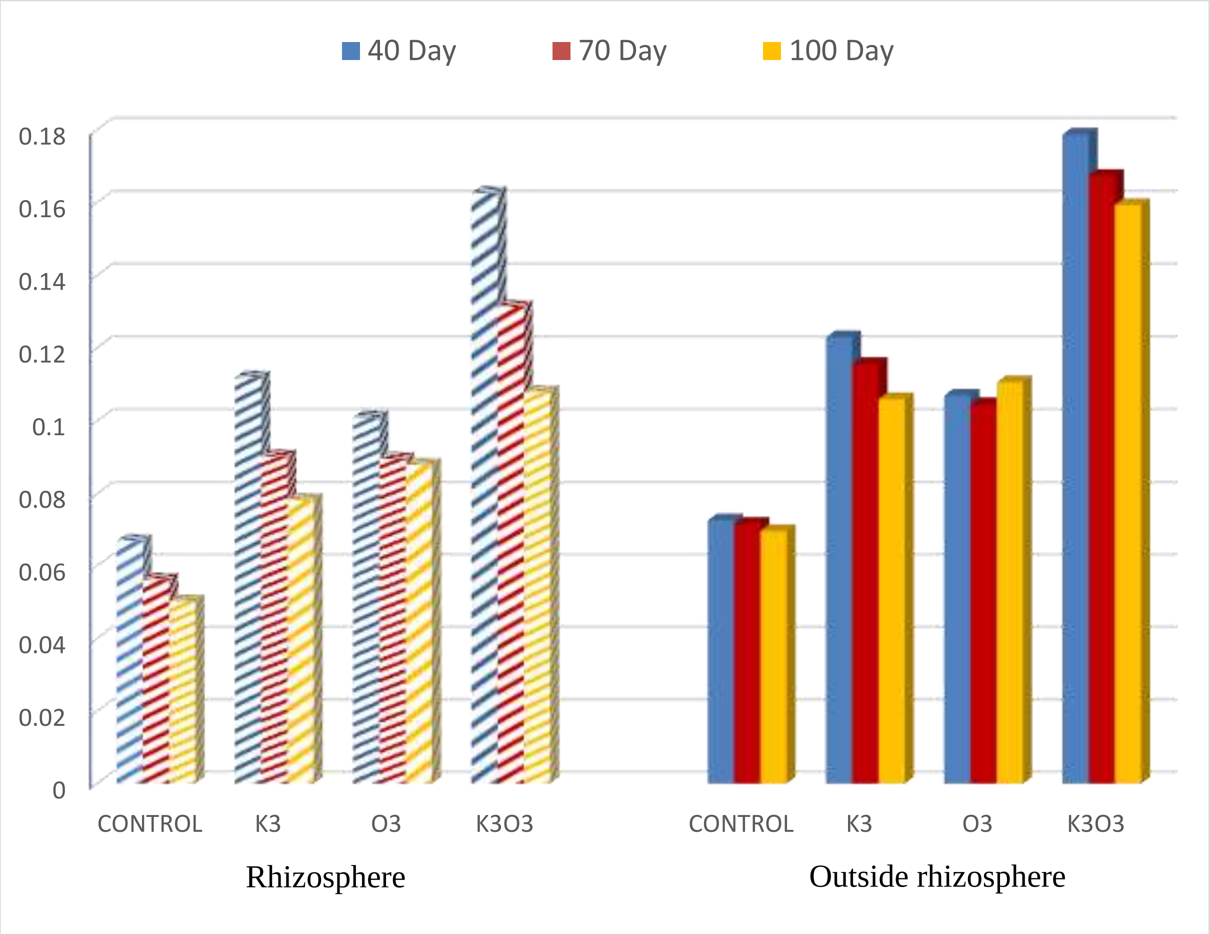

Figure (1) Effect of Addition of Potassium Sulphate Fertilizer and Organic Fertilizer and their Interaction in the Amount of Soluble Potassium inside and outside rhizosphere.

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تأثير التسميد العضوي والمعدني في قيم البوتاسيوم الذائب في رايزوسفير الذرة الصفراء وخارجهُ

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الخلاصة

نفذت تجربة حقلية في أحد مزارع الفلاحين الخاصة والواقعة في محافظة القادسية/ قضاء الديوانية/ ناحية الدغارة/ صدر الدغارة بهدف دراسة تأثير التسميد العضوي والبوتاسي في قيم البوتاسيوم الذائب في رايزوسفير الذرة الصفراء. وصممت التجربة وفق القطاعات العشوائية الكاملة (RCBD) بثلاثة مكررات وتضمنت التجربة عاملين الأول أربعة مستويات من البوتاسيوم (0،75،150،225) كغم K. هـ$^{-1}$ التي يرمز لها بالرموز (K_0، K_1، K_2، K_3) على التتابع، والثاني أربع مستويات من المادة العضوية (مخلفات الدواجن) وهي (0، 10، 20، 30) طن. هـ$^{-1}$ التي يرمز لها بالرموز (O_0، O_1، O_2، O_3) على التتابع، وتم زراعة بذور الذرة الصفراء (*Zea mays* L.) صنف بحوث (DKC 6120) أمريكية على شكل خطوط بتاريخ 2016/7/20.

بينت النتائج أن إضافة كل من سماد كبريتات البوتاسيوم بمستويات مختلفة قد حقق زيادة معنوية في كمية البوتاسيوم الذائب في تربة المنطقة الجذرية وخارجها وللمدد الزمنية جميعها (40، 70، 100) يوم من الزراعة وقد تفوق التسميد البوتاسي في زيادة كمية البوتاسيوم الذائب على السماد العضوي وأن التداخل بين أعلى مستوى من التسميد البوتاسي 225 كغم K. هـ$^{-1}$ وأعلى مستوى من التسميد العضوي 30 طن. هـ$^{-1}$ (K_3O_3) حقق أعلى كمية من البوتاسيوم الذائب في تربة المنطقة الجذرية بلغ قدرها (0.163، 0.131) سنتي مول. كغم$^{-1}$ و (0.167،0.179) سنتي مول. كغم$^{-1}$ خارج المنطقة الجذرية للمدد (40، 70) يوم من الزراعة على التتابع أما المدة 100 يوم من الزراعة فحقق التداخل (K_2O_3) أعلى كمية من البوتاسيوم الذائب بلغت 0.114 سنتي مول. كغم$^{-1}$ في تربة المنطقة الجذرية وحقق التداخل (K_3O_3) أعلى كمية من البوتاسيوم الذائب بلغت 0.159 سنتي مول. كغم$^{-1}$ في تربة المنطقة خارج الجذور، كما يلاحظ انخفاض كمية البوتاسيوم الذائب ولجميع المعاملات بزيادة مدة نمو النبات.

* جزء من رسالة الماجستير للباحث الثاني