ISSN NO: 2771-8840
Date of Publication: 11-02-2023

Effect of adding methods of potassium sulfate fertilizer to two cultivars of *Zea mays* on PH and some chemical elements in soil and plants

Kahraman H. Habeeb*
Department of Soil and Water Resources, College of Agriculture, Wasit University, Wasit, Al-Kut, Iraq.
*Corresponding author: kahraman@uawasit.edu.iq

Abstract: A field experiment was applied in the fall season in Wasit province/ Qalaat al-Suwaira District). The great soil aggregates (Typictorrifurert) according to the American classification (Soil Taxonomy) (1975). In order to improve the performance of growth and yield of *Zea mays* by the effect of fertilization with potassium sulfate on the availability of nutrients in the soil. The experiment was applied according to a randomized complete block design (RCBD) with a factorial experiment and with three replications. Ground fertilization, foliar fertilization, ground fertilization+ foliar fertilization, and control have been studied. The results have been showed that the fertilization treatment (ground + foliar fertilization treatment) was significantly superior in each of the pH in the period of 100 days, the available potassium concentration in the soil, the available sulfur concentration in the soil at 100 and 80 periods. The highest available nitrogen concentration in the soil in the 100 and 80 period, in fertilization Foliar, while the treatment (foliar fertilization) was significantly superior in the concentration of nitrogen in the plant, while the concentration of potassium in the plant, sulfur in the plant, was significantly superior in the period 100 in the fertilization of ground and foliar.

For the nitrogen in the plant and the potassium in the plant, it has been recorded the highest averages in the ground fertilization, as well as the superiority of both sulfur in the soil and sulfur in the plant. The American Gentex variety was significantly superior and gave the highest averages in the pH. Sulfur in the soil, nitrogen in the soil, potassium in the soil, nitrogen in the plant, sulfur in the plant, potassium in the plant were significantly superior to the interaction treatment (ground + foliar fertilization of American Gentex variety). It has been found the highest averages in each of potassium in the soil, nitrogen in the soil, phosphorus in the soil, potassium in the soil, while the combined treatment (ground fertilization + foliar and American Gentex) achieved the highest averages in each degree of soil interaction, magnesium in the soil, Magnesium in the plant, sulfur in the plant, nitrogen in the plant.

Key words: potassium sulfate, fertilizer, *Zea mays*, PH, magnesium.

Introduction

The *Zea mays* is one of the main and important crops worldwide because its nutritional value is used for different purposes, including food, industry. It is also of great economic importance, as the seeds contain carbohydrates, proteins and oils. The crop occupies the second place in the world, after the wheat crop, in a cultivated area of about 166 million ha, the first place in terms of production out of the total world production (Arab Organization for Agricultural Development, 2011).

Sulfur S constitutes about 0.1% of the earth's crust. It is found in the soil in many forms, including free or bound with the basic elements such as Ca, Mg, Na, K, near arid and semi-arid regions. The sources of sulfur in the soil are pure sulfur (S 100%), agricultural sulfur (S 90%) and foamy sulfur (S 100%). To manufacture sulfur in P, S and other nutrients from its compounds deposited in the soil by reducing the degree of soil interaction (PH) by forming H2SO4 acid, which leads to the liberation of nutrients and an increase in soil fertility.

The varieties are differing according to the genetic ratio of each variety. Each region has an environment suitable for it by means of cultivation, service operations, methods of adding fertilizer and types of good fertilizer. The aim of study was to estimate the effect of potassium sulfate on the release of nutrients. Also, to select the best period for adding fertilizer and the best treatment for adding fertilizer (ground fertilization, foliar fertilization, or the overlap between ground and foliar fertilization by improving soil properties. As well as, to determine the best variety in terms of response to fertilization and addition.

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

Materials and methods

The field experiment was applied in the fall season (4/8/2022) in Wasit province, Al-Suwaira district, among the great soil groups (Typictorrifurert) according to the American classification (Soil Taxonomy) (1975). The soil of the field was classified as having a clay loam texture. The soil of the field 2 was prepared after plowing, amending and leveling the soil. The field was divided into 36 experimental units with an area of (3×4 m^2).

The complete randomize block design (RCBD) has been used included each experimental unit (4 corridors with a length of 4 m and an area of 70 cm between the corridor and another. The distance of 20 cm (between one chamber and another), leaving a distance of 2 m^2 between one experimental unit and another, and between one variety and another was (1 m^2) and between one repeater and another was (2 m^2). Three seeds have been planted in each and then thinning operations after 3 weeks of sowing.

Phosphorus (P) was added at the level of 75 kg/ ha in the form of triphosphate 20% p when planting, while potassium (K) was added at the level of 160 kg/ha^{-1} in the form of K2SO4 (43% K) and in full quantity with the first batch with nitrogen. Nitrogen was added in the form of urea (N% 46) in an amount of 200 kg/ha^{-1}, half of the amount for the first batch a week after germination and the other half for the second batch 45 days from germination

The granulator was also used at a concentration of (10%) to control the corn borer (*Elasmopalpus lignosellus*) and in two batches. The first batch was added after 20 days of germination and the second after 15 days of the first batch, as well as the manual hanging process. The experimental plants were irrigated relatively under supervision with 50% of the prepared water. The delivery of moisture content limits the field capacity. The potassium sulfate fertilizer has been added at four levels, level of ground fertilizer and foliar fertilizer, and an overlap between ground and foliar fertilizer, and the control without adding the fertilizer (10 kg per hectare means (12 g per 1 quarter of the line) and (80 rounds) for each round of 0.15 g, and the fertilizer was added in the form of two batches after 35 days of cultivation and after 7 days of cultivation.

Seeds of corn cultivars belonging to the Poaceae family, American Gentex and Bahia, were planting. Soil samples were taken from several random sites before planting and conducting physical and chemical analyses the volume distribution was estimated by the hydrometer method according to the method of (Block, 1965). The field capacity was estimated at moisture tension 1/3 by means of (Pressure) the method presented (1965), and the degree of interaction of the soil PH in the soil extract was estimated 1:1 using the PH Meter according to the method (Jackson, 1958). The EC was measured with the Conductivity Bridge equipment according to the method given by Jackson (1958). The exchange capacity of positive ions (CEC) was estimated using ammonium acetate NH4OACL at pH = 70 and according to Black (1965).

The percentage of carbonate minerals was measured using acid (HCL) (1N) and pulverizing the remaining acid with (NaOH) (1N) according to Jackson (1958). The carbonate and bicarbonate ions were estimated by denaturing with sulfuric acid (H2SO4) (0.01) according to Jackson (1958). The sulphate was determined by the turbidity method. Magnesium was determined by fermentation with a ferric solution according Black (1965). The available nitrogen was estimated by extraction with a potassium solution ($N_2$2) and using (MgO) according to Black (1965), and the available phosphorus was estimated after extraction by sodium bicarbonate 0.5 M PH 8.5 (Wackily et al., 1982).

The potassium was determined by ammonium acetate solution (N1) and determined by a flame photo meter as reported by Black (1965). Chlorides were determined by denaturation with silver nitrate (AgNO3) (0.5) as reported by Jackson (1958). Finally, the organic matter was estimated by the method of wet digestion according to the method of Black, Wackily that reported by Jackson (1958). Determination of nitrogen in the digested plant extracts using the microcalcification device by the addition of (NaOH) (10) with the extract in the distillation cylinder and adding boric acid+ reagents mixture in the receiving flask, then flushing with sulfuric acid (0.005) (Bhargava and Raghupathi, 1993).

Potassium was estimated in the digested plant sample using a flame photometer, according to Page et al. (1982). The sulfur in the plant was determined by adding Gum acacia 0.5% and glacial acetic acid to distilled water at a ratio of 1:1 and adding barium chloride ($BaC_{l2}.2H_2O$) and then assessing it using a spectrophotometer at a wavelength of 420 nm according to (Bhargava and Raghupathi, 1993). The nitrogen was estimated by extraction with a solution of potassium chloride (2_2N) and used (MgO) and measurement

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

through a microcalculator according to Black (1965). The potassium ion was determined by extracting it with a solution of ammonium acetate (N1) and then estimated by a flame-photometer (Black, 1965). Extract the sulfate ion using calcium phosphate (CaH2PO4) and estimate the turbidity method using barium chloride (BaCL2.2H2O) that measuring with a spectrophotometer at (420) wavelength.

The data of the experiment have been analyzed according to the analysis of variance (ANOVA) table. The factorial experiment was used according to the randomized complete block design (RCBD) to study the effect of the interaction between fertilization and cultivars. The averages were compared according to the Least Significant Difference (LSD) test at the level of probability 0.05 for the purpose of determining the effect of the treatment on the studied traits. Genestat program (2008) was used the analysis the data.

Table (1) some of the chemical and physical characteristics of the soil before planting

Characteristics	Value	Unit
pH	7.6	-----
ECe	2.1	dSm^{-1}
CEC	21.5	$Cmol(+)\ kg^{-1}$
CaCo3	152.03	$gm\ kg^{-1}$
Organic	1.28	$g\ k^{-1}$
Calcium	11.37	$mmole\ L^{-1}$
Magnesium	7.2	$mmole\ L^{-1}$
Sodium	2.3	$mmole\ L^{-1}$
Potassium	0.7	$mmole\ L^{-1}$
Chloride	24.01	$mmole\ L^{-1}$
Carbonate	0.0	Nill
Bicarbonate	18.3	$mmole\ L^{-1}$
Sulfites	13.89	$mmole\ L^{-1}$
Nitrogen	12.9	$mg\ kg^{-1}$
Phosphorous	0.38	$mmole\ L^{-1}$
Potassium	1.21	$mmole\ L^{-1}$
Sand	209	$gm.\ Kg^{-1}$ Soil
Clay	344	$gm.\ Kg^{-1}$ Soil
Silt	447	$gm.\ Kg^{-1}$ Soil
Soil	Clay loam	

Results and Discussion

Soil PH

Table (2) has been indicated that the addition of potassium sulfate fertilizer (ground, ground and foliar) had a significant effect on reducing the values of the degree of soil reaction (pH), as it reached the highest decrease for the values (7.34 and 7.33), respectively, at 100 days after planting and 7.31 and 7.31. 7.26 at the time 80 days after planting and 7.30 at the time 40 days after planting for ground fertilization with the control treatment at which the highest values for the soil pH has reached 6.91, 7.31 and 7.43, respectively. However, it did not differ significantly with the treatment of foliar fertilization. The reason is due to the sulfur content of the fertilizer, which can reduce the pH as a result of its oxidation and the formation of sulfuric acid, which ionizes into H + and SO4-2 ions, causing a decrease in pH. The results agree with Ali (2012) who found a significant decrease in the (pH) from the addition of sulfur from its different sources in some Iraqi soils.

The results of the statistical analysis has been showed that the cultivars had a significant effect in the time period 80 days after planting in reducing the pH, which amounted 7.19 and 7.30 for the two cultivars (Bahia), respectively, while the cultivars did not differ significantly between them for the time periods 40 and 100 days of cultivation (Table 2). The interactions between fertilization with potassium sulfate and the cultivars have been achieved a significant decrease in the values of (pH) and for all time periods 40 - 80 - 100 days after planting. The highest decrease in (pH) was reached at the time period of 100 days. From planting to the treatment of ground + foliar fertilization, American Gentex, and the treatment of ground +

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

foliar fertilization, and Bahia cultivar, the treatment was fertilization of the ground and the American Gentex variety. It has been recorded 6.63, which did not differ significantly with many treatments for the same period of time (Table 2).

The highest value of (pH) was for the treatment of foliar fertilization and the American Gentex variety in the period of 100 days. It was 7.56, while the lowest rate of decrease in the time period 80 days after planting was for the treatment of ground + foliar fertilization and for the American Gentex variety, which has been 7.06. The highest degree of reaction occurred at the Bahia cultivar. The treatment of foliar fertilization, which was 7.46, and in the time period of 40 days from cultivation, the treatment of ground fertilization and Bahia cultivar had the least decrease value, as it amounted 7.30. The highest increase in the degree of interaction for this period of time, it was found in the control treatment and for Bahia cultivar, which reached 7.43. The reason may be due to the positive effect of fertilizer in increasing the vegetative system, which is reflected in the growth of the root system of some varieties, which increases the roots' secretions of organic acids. As well as, the reason is due to the reduction in the degree of interaction as a result of the availability of an amount of hydrogen ions as a result of the oxidation of sulfur available in the fertilizer, which is reflected in the decrease in the value of the degree of soil interaction due to a decrease in the degree of soil interaction in different periods of growth. Also, the reason is attributed to the fact that this significant decrease in the values of the degree of soil reaction may be due to the role of potassium sulfate, which affects the reduction of (pH).

Table (2) the effect of adding potassium sulfate fertilizer to two cultivars of *Zea mays* on the (pH)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	7.30	7.30	7.30
Foliar fertilization	7.43	7.43	7.40
Ground + foliar fertilization	7.33	7.50	7.41
Control	7.43	7.43	7.43
Average	7.37	7.40	
LSD 0.05	combined	treatment	cultivars
	0.326	0.230	0.163
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	7.53	7.10	7.31
Foliar fertilization	7.06	7.46	7.26
Ground + foliar fertilization	7.06	7.46	7.26
Control	7.10	7.16	7.13
Average	7.19	7.30	
LSD 0.05	combined	treatment	cultivars
	0.433	0.306	0.216
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	7.43	7.43	7.43
Foliar fertilization	7.56	7.46	7.51
Ground + foliar	7.56	7.10	7.33

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

fertilization			
Control	7.20	6.63	6.91
Average	7.44	7.15	
LSD 0.05	combined	treatment	cultivars
	0.542	0.383	0.271

The results have been showed that there were significant differences for the fertilization treatments for the periods 40, 80 and 100 of cultivation in the amount of potassium. The treatment of adding soil fertilization has been achieved the highest values of 186.0 and 155.6 mg Kg^{-1} soil, respectively (Table 3). For the periods of 40 and 80 days of cultivation, the treatment of adding foliar fertilization achieved the highest values for the period of 100 days of cultivation, reaching 193.5 mg kg^{-1} soil, compared to the lowest amount of potassium in the soil for the non-fertilization treatment, which amounted to 154, 158.8, and 165.4 mg Kg^{-1} soil respectively. The varieties recorded significant differences between them in the soil content of potassium, as the superiority was for the American Gentex variety in the 40 day period of cultivation, achieving the highest values, which amounted 304 mg kg^{-1} soil and in the periods 80 and 100 days. From cultivation, the American Gentex variety excelled, achieving the highest values, which amounted to 165.8 and 189.5 mg kg^{-1} soil.

The lowest averages were for the Bahia cultivar for the period of 40 days of cultivation, which amounted 166 mg kg^{-1} soil, and in the periods of 80 and 100 days of cultivation, it was for the Bahia cultivar, which amounted to 163.3 and 171.5 mg kg^{-1} soil, respectively (Table 3).

Table (3) the effect of adding potassium sulfate fertilizer for two cultivars of *Zea mays* on the soil concentration of potassium (mg K soil)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	185.8	155.0	170.4
Foliar fertilization	168.1	149.0	158.5
Ground + foliar fertilization	163.5	176.1	169.8
Control	140.2	147.7	144.0
Average	164.4	157.0	
LSD 0.05	combined	treatment	cultivars
	30.20	21.35	15.10
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	164.0	185.6	174.8
Foliar fertilization	174.1	163.8	168.9
Ground + foliar fertilization	155.5	155.7	155.6
Control	169.4	148.1	158.8
Average	165.8	163.3	
LSD 0.05	combined	treatment	cultivars
	26.70	18.88	13.35
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	195.4	180.9	188.2

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

Foliar fertilization	204.5	182.5	193.5
Ground + foliar fertilization	182.7	166.9	174.8
Control	175.4	155.5	165.4
Average	189.5	171.5	
LSD 0.05	combined	treatment	cultivars
	21.60	15.27	10.80

The interactions between fertilization and cultivars showed significant results for all periods, as the interaction treatment between ground and foliar fertilization and Bahia cultivar achieved the highest amount of potassium in the soil and plants for the period of 40 days of cultivation, which amounted 185.6 mg K kg -1 soil.

In the period of 80 days of cultivation, the treatment of ground and foliar fertilization and the cultivar Bahia achieved the highest amount of potassium, which amounted to 155.6 mg Kg-1 soil. In the period of 100 days of cultivation, the treatment of foliar fertilization and the American Gentex cultivar achieved the highest amount of potassium amounted to 182.7 mg Kg-1 soil (Table 3). For the lowest available potassium in the soil, it was obtained when the interactions of non-fertilization treatment, Bahia cultivar, non-fertilization treatment, American Gents, non-fertilization treatment, and Bahia cultivar for periods 40, 80, and 100 of sowing, which reached 148, 148.1, and 155.5 mg K kg-1 soil, respectively. The reason is attributed to the fact that the increase in the available potassium in the soil is due to the effect of an addition that have been agreed with Al-Jubouri (1982), Al-Lami (1999), Ahmed (2006) and Al-Khuzai (2006).

The results have been showed that there were significant differences for the fertilization treatments for the period of 40 days of cultivation in the amount of sulfur, as the ground fertilization treatment achieved the highest values, reaching 12.8 mg S kg^{-1} soil, and the periods 80 and 100 of cultivation, as the ground and foliar fertilization treatment together achieved the highest values It reached 12.69 and 16.53 mg S of kg^{-1} soil, respectively, compared to the lowest amount of sulfur in the soil for the non-fertilization treatment, which amounted to 10.4, 8.90 and 16.66 mg S of kg^{-1} soil, respectively (Table 4). The reason for the increase in the amount of available sulfur in the soil may be attributed to the role of potassium sulfate fertilizer, which works to dissolve the precipitated quantities of sulfur and liberate it to the form ready for absorption by plants (Al-Adhami 1990).

There was a difference between the plant varieties and the presence of significant differences between the soil content of ready sulfur, as the superiority was for the Bahia variety in the period 80, as it reached 11.82 and 100 days of cultivation, achieving the highest values, which amounted 16.06 mg S kg-1 soil. It did not differ significantly with the Bahia cultivar, which achieved the highest sulfur in the 40 day period of cultivation, amounting 19.1 mg S kg-1 soil, while the lowest averages were at Bahia for the period 40 days of cultivation, as it amounted to 13.5 mg S kg-1 soil. The American Gentex cultivar for the period of 80 and 100 days of cultivation, 9.14 and 15.57 mg S kg-1 soil, respectively.

Table (4) the effect of adding potassium sulfate fertilizer for two cultivars of *Zea mays* on the soil concentration of sulfur (mg S kg^{-1} soil)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	14.9	10.8	12.8
Foliar fertilization	14.0	16.3	15.2
Ground + foliar fertilization	13.2	40.4	26.8
Control	11.8	8.9	10.4
Average	13.5	19.1	
LSD 0.05	combined	treatment	cultivars

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

	32.96	23.30	16.48
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	10.62	12.34	11.48
Foliar fertilization	7.93	9.77	8.85
Ground + foliar fertilization	10.00	15.39	12.69
Control	8.01	9.78	8.90
Average	9.14	11.82	
LSD 0.05	combined	treatment	cultivars
	1.769	1.251	0.884
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	20.72	14.77	17.74
Foliar fertilization	16.92	13.77	12.34
Ground + foliar fertilization	15.23	17.83	16.53
Control	17.42	15.90	16.66
Average	16.07	15.57	
LSD 0.05	combined	treatment	cultivars
	3.203	2.265	1.602

The interactions between fertilization and cultivars showed significant results for the two periods 40 and 100 days of cultivation. The treatment of interactions between the soil fertilization and the cultivar Bahia has been achieved a significant amount of sulfur in the soil, which recorded 10.8 mg kg^{-1}. The soil of the 70 day period of cultivation did not achieve significant superiority (Table 4). For the lowest available sulfur in the soil, it was obtained when the interactions of the non-fertilization treatment and the Bahia variety for the period of 40 days of cultivation, which reached 8.4 mg S kg^{-1} soil. The non-fertilization treatment and the American Gentex variety have been recorded 15.57 mg S kg^{-1} soil for the period 100 days of cultivation (Table 4). The reason for the increase in the amount of sulfate in the soil solution is due to the addition of potassium fertilizer, whose source is potassium sulfate, and the latter contains a percentage of sulfur in addition to the potassium in the soil. The increase in the amount of sulfur in the soil to the role of potassium sulfate fertilizer, which plays to dissolve the precipitated quantities of sulfur and free it to the form ready for absorption by the plant (Al-Qaisi and Salim 1990).

Table (5) has been showed that there were significant differences for the fertilization treatments for the periods 40, 80 and 100 days after planting, where the highest amount of nitrogen was recorded. The treatment of adding ground and foliar fertilization together for soil and plants for the period of 40 days of cultivation achieved the highest values of 11.83 mg N kg $^{-1}$ soil. For the period of 80 and 100 days of cultivation, the foliar fertilization treatment achieved the highest values of 17.04 and 17.46 mg N kg^{-1} soil, respectively, compared to the lowest amount of nitrogen in the soil for the non-fertilization treatment, which amounted 10.63, 15.31 and 11.03 mg N Kg^{-1} soil respectively. The varieties recorded significant differences between them in soil nitrogen content during the 100 day period of cultivation. The superiority was for the American Gentex variety, achieving the highest values, which amounted 13.54 mg Kg^{-1} soil, while in the periods 40 and 80 days from planting. The cultivars did not record significant differences between them.

The interactions between fertilization and cultivars showed significant results for all periods, as the interaction treatment between ground and foliar fertilization and the ZP variety achieved the highest amount of nitrogen in the soil for the periods 40 and 80 days of cultivation, which amounted to 18.32 and 19.90 mg

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

N Kg $^{-1}$ soil respectively (Table 5). For the period of 100 days of cultivation, the treatment of foliar fertilization and the variety Furat had the highest nitrogen and amounted 15.05 mg N Kg^{-1} soil, while the lowest nitrogen in the soil was obtained when the interactions of the non-fertilization treatment ground and foliar fertilization, the cultivar Bahia, the non-fertilization treatment and the ZP variety for periods 40 and 80 and 100 days of cultivation have been recorded 9.29, 13.72 and 9.42 mg Kg^{-1} soil, respectively (Table 5).
The increase in the available nitrogen in the soil is due to the addition of potassium sulfate fertilizer in the soil through an increase in the concentration of potassium in the soil. The reason for this is due to the faster solubility of the fertilizer. This is reflected of the plant in the formation of the root system, which leads to an increase in potassium, and this is found by Merhaut (2007). The increase in potassium fertilizer that is added to the soil leads to a significant increase in the availability of nitrogen in the soil, and this is found by (Al-Lami, 1999).

Table (5) the effect of adding potassium sulfate fertilizer for two cultivars of *Zea mays* on the soil concentration of nitrogen (mg N kg $^{-1}$ soil)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	13.26	11.93	12.59
Foliar fertilization	15.06	14.93	15.00
Ground + foliar fertilization	14.23	9.43	11.83
Control	11.65	8.84	10.24
Average	13.55	11.28	
LSD 0.05	combined	treatment	cultivars
	4.176	2.953	2.088
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	9.30	11.93	16.61
Foliar fertilization	14.70	11.87	13.29
Ground + foliar fertilization	15.75	18.33	17.04
Control	12.55	14.43	13.49
Average	13.07	14.14	
LSD 0.05	combined	treatment	cultivars
	5.677	4.014	2.838
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	17.68	13.98	15.83
Foliar fertilization	18.35	16.57	17.46
Ground + foliar fertilization	18.67	19.90	19.28
Control	14.39	15.64	15.01
Average	17.27	16.52	
LSD 0.05	combined	treatment	cultivars
	5.677	4.014	2.838

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

The results have been showed that there were significant differences for the fertilization treatments for the periods 40 and 80 days of cultivation in potassium in the plant, as the addition of ground and foliar fertilization together to the soil and the plant achieved the highest values of 1.67 and 2.68%, respectively, for the two periods above, compared to the lowest amount of potassium in the plant. For the non-fertilization treatment, this amounted 1.24 and 2.23%, respectively, for the two periods. For the last period of 105 days of cultivation, the fertilization treatments did not differ significantly in potassium in the plant (Table 6). The varieties recorded significant differences for all periods in the plant concentration of potassium, as the superiority of Bahia cultivar was in the periods of 40 and 80 days of cultivation has achieving the highest values, which amounted 1.71 and 2.47%, while in the period of 100 days of cultivation it was for the American Gentex variety that achieved the highest values of 2.65%, while the lowest averages were for the Furat cultivar, which amounted 1.71 and 2.43% for the periods of 40 and 80 days of cultivation, as well as in the period of 100 days of cultivation.

Table (6) Effect of methods of adding potassium sulfate fertilizer for two cultivars of *Zea mays* on plant concentration of potassium (%)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	1.66	1.87	1.76
Foliar fertilization	1.71	1.67	1.69
Ground + foliar fertilization	1.73	1.78	1.76
Control	1.28	1.19	1.24
Average	1.71	1.71	
LSD 0.05	combined	treatment	cultivars
	0.199	0.141	0.999
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	2.26	2.34	2.30
Foliar fertilization	2.54	2.64	2.59
Ground + foliar fertilization	2.60	2.77	2.68
Control	2.35	2.12	2.23
Average	2.43	2.47	
LSD 0.05	combined	treatment	cultivars
	0.365	0.258	0.182
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	2.39	2.52	2.45
Foliar fertilization	2.59	2.68	2.63
Ground + foliar fertilization	2.65	2.84	2.74
Control	2.26	2.56	2.41
Average	2.47	2.65	
LSD 0.05	combined	treatment	cultivars
	0.113	0.080	0.056

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

The combined between fertilization and cultivars showed significant results for all periods, as the combined treatment between foliar fertilization and the American Gentex cultivar has been achieved the highest amount of potassium in the plant, which amounting 1.71% for the period of 40 days of cultivation. The combined between the ground and foliar fertilization together and the Bahia cultivar reached 2.77% in the period 70 days of cultivation. However, in the period of 100 days of cultivation, the combined between the ground fertilization and the Bahia cultivar has been achieved the highest values 2.52%, while the lowest potassium in the plant was obtained when the combined of the non-fertilization treatment and the Bahia cultivar amounted 1.198 and 2.12%, respectively. For the two periods of 40 and 80 days of cultivation, the non-fertilization treatment and the American Gentex cultivar has been reached 26.2% at the period of 100 days of cultivation (Table 6). The reason for the increase in potassium concentration by the plant is due to the addition of magnesium sulfate fertilizer (Abu Dahi and El-Younes, 1988).

There were significant differences for the fertilization treatments for the periods 40, 80 and 100 days of cultivation in sulfur in the plant. The treatment of adding ground and foliar fertilization achieved the highest values of 0.30 for the periods 40 and 100 days of cultivation and for the same value and at the period of 80 days of cultivation The two treatments of adding ground fertilization as well as foliar fertilization achieved the highest values of 0.30, compared to the lowest sulfur in the plant for the non-fertilization treatment, which amounted 0.30, 0.26, and 0.22, respectively (Table 7).

Table (7) has been recorded significant differences between the concentration of sulfur in the plant, as the superiority of the American Gentex variety was in the periods of 80 and 100 days of cultivation, achieving the highest values, which amounted 0.27 and 0.25, respectively. The cultivars did not record significant differences between them, while the least averages were for the American Gentex cultivar during the 80 day period of cultivation, which amounted 0.24, and for the Bahia cultivar, which reached 0.24 at 100 days of cultivation. The combined between fertilization and cultivars showed significant results for all periods. The combined treatment between ground fertilization and the variety has been achieved the highest sulfur in the plant, that reaching 0.31 for the period of 40 days of cultivation, while the period of 80 days of cultivation achieved the combined treatment between foliar fertilization and the American Gentex variety the highest amount of sulfur in the plant, which reached 0.33, and in the period of 100 days of cultivation. The treatment of foliar and foliar fertilization and the American Gentex Bahia cultivar has been achieved the highest amount of sulfur in the plant, which recorded 0.27. The lowest concentration of sulfur in the plant, it was obtained when the interactions of the control treatment and the Bahia cultivar amounted to 0.27 and 0.25 for the periods of 35 and 70 days of cultivation. The treatment of non-fertilization and the cultivar Bahia 0.24 each for the period of 100 days of cultivation, and the increase is due to the concentration of sulfur from the potassium sulfate fertilizer in the soil. This leads to an increase in the readiness of sulfur by the plant and then the uptake of sulfate, which represents the ready form of sulfur. Increasing potassium added to the soil increases the concentration of sulfur in the plant. These results are agreed with Al-Lami (1999), Jabr (2001), and Al-Hassoun (2010).

Table (7) effect of methods of adding potassium sulfate fertilizer for two cultivars of Zea mays on plant concentration of sulfur (%)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	0.30	0.29	0.30
Foliar fertilization	0.29	0.31	0.30
Ground + foliar fertilization	0.28	0.27	0.28
Control	0.29	0.23	0.26
Average	0.29	0.27	
LSD 0.05	combined	treatment	cultivars
	0.061	0.045	0.031
Second stage (80 days)			

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	0.24	0.22	0.33
Foliar fertilization	0.33	0.26	0.30
Ground + foliar fertilization	0.27	0.27	0.27
Control	0.23	0.27	0.24
Average	0.27	0.25	
LSD 0.05	combined	treatment	cultivars
	0.095	0.067	0.047
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	0.24	0.22	0.23
Foliar fertilization	0.27	0.27	0.27
Ground + foliar fertilization	0.27	0.27	0.27
Control	0.23	0.21	0.22
Average	0.25	0.24	
LSD 0.05	combined	treatment	cultivars
	0.018	0.012	0.009

The results showed that there were significant differences for the fertilization treatments for the periods 40 and 100 days of cultivation in the amount of nitrogen in the plant, as the treatment of adding foliar fertilization achieved the highest values of the averages in a period of 40 days amounted to 1.38% and in the period of 100 days of cultivation (Table 8). The treatment of adding ground and foliar fertilization together achieved the highest values of 2.16%, while in the period of 80 days of planting, no significant differences were recorded with regard to the fertilization treatments compared to the lowest nitrogen in the plant was for the non-fertilization treatment, which amounted 1.24 and 2.09% for the two periods, respectively.

Table (8) Effect of methods of adding potassium sulfate fertilizer for two cultivars of *Zea mays* on plant nitrogen concentration (%)

First stage (40 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	1.28	1.23	1.26
Foliar fertilization	1.43	1.33	1.38
Ground + foliar fertilization	1.33	1.42	1.37
Control	1.29	1.19	1.24
Average	1.33	1.29	
LSD 0.05	combined	treatment	cultivars
	0.136	0.069	0.068
Second stage (80 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	2.23	2.23	2.23
Foliar fertilization	2.24	2.28	2.26

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

Ground + foliar fertilization	1.94	2.29	2.11
Control	2.14	2.18	2.16
Average	2.14	2.24	
LSD 0.05	combined	treatment	cultivars
	0.348	0.246	0.174
Third stage (100 days)			
Treatments	Cultivars		
	American Gentex	Bahia	average
Ground fertilization	2.11	2.14	2.13
Foliar fertilization	2.12	2.15	2.14
Ground + foliar fertilization	2.14	2.17	2.16
Control	2.05	2.12	2.09
Average	2.11	2.15	
LSD 0.05	combined	treatment	cultivars
	0.071	0.050	0.035

The varieties recorded significant differences among them in the concentration of nitrogen in the plant, as the American Gentex variety excelled in the periods of 80 and 100 days of planting, achieving the highest values, which amounted 2.24 and 2.15%, respectively, while in the period 40, there is no significant differences were recorded between days of cultivation, while the lowest averages were for Furat cultivar for the two periods, which amounted 2.14% and 2.11%, respectively. The combined between fertilization and cultivars showed significant results for all periods. The combined treatment between ground and foliar fertilization together and the cultivar Bahia has been achieved the highest amount of nitrogen in the plant for the periods of 40, 80 and 100 days of cultivation, which were 1.42, 2.29 and 2.17%, respectively (Table 8).
For the lowest nitrogen in the plant, it was obtained when the combined of the non-fertilization treatment and the Bahia variety amounted to 1.17% for the 40 day period of cultivation, the ground and foliar fertilization treatment, and the Furat variety, which amounted 1.93% for the 80 day period of cultivation, and the non-fertilization treatment and the Furat variety amounted 2.05% for the 100 day. The increase in the nitrogen absorbed by the plant is due to the effect of adding potassium sulfate fertilizer, which is highly soluble, which leads to an increase in the potassium, and then an increase in its absorption by the plant. This is agreed with Al-Lami (1999) and Merhaut (2007). The nitrogen absorbed by the crop increases from the addition of a source of potassium sulfate fertilizer in the soil, which is reflected in the increase in the concentration of nitrogen in the soil solution, which is important in plant nutrition. Thus, the importance of nitrogen increases with the increase in the fertilizer addition of magnesium sulfate, and thus is reflected in an increase in the concentration of nitrogen by the plant. In addition, to the important role of potassium in the process of reducing (NO3) inside the plant cells, which leads to an increase in the plant's efficiency in obtaining benefit from the nitrogen concentration inside the plant.

Conclusion

The study conclude that the highest averages in potassium, nitrogen, phosphorus, potassium, while the combined treatment (ground fertilization + foliar and American Gentex) achieved the highest averages in each degree of soil interaction, magnesium in the soil, Magnesium in the plant, sulfur in the plant, nitrogen in the plant. For the nitrogen in the plant and the potassium in the plant, it has been recorded the highest averages in the ground fertilization, as well as the superiority of both sulfur in the soil and sulfur in the plant. The American Gentex variety was significantly superior and gave the highest averages in the pH. Sulfur in the soil, nitrogen in the soil, potassium in the soil, nitrogen in the plant, sulfur in the plant, potassium in the plant were significantly superior to the interaction treatment (ground + foliar fertilization of American Gentex variety).

ISSN NO: 2771-8840
Date of Publication: 11-02-2023

References

1- Abu Dahi, Youssef M. and Moayad A. El-Younes. 1988. Handbook of Plant Nutrition. Ministry of Higher Education and Scientific Research. Baghdad University.
2- Jabr, A. Salman. 2001. The state and release of potassium in some greenhouse soils. Iraqi Agricultural Sciences Journal. 32 (6): 31-38.
3- Al-Jubouri, A. Khalaf. 1982. A Study of Magnesium and Potassium in Hatra and Dohuk Regions and Their Relationship with Grass-Tetany Disease. Master Thesis. College of Agriculture and Forestry. University of Al Mosul.
4- Al-Hassoun, Samira N. Hassoun. 2010. The effect of levels of sulfur, magnesium and phosphate rock on the release of phosphorus and the growth of wheat crop *Triticum aestivum* L.. Master thesis. College of Agriculture, University of Baghdad
5- Al-Khuzaie, Alaa M. Issa. 2006. The effect of adding potassium and magnesium to the soil and spraying and their interaction on the growth and yield of cucumber (*Cucumis sativus* L.) in greenhouses. Master Thesis, College of Agriculture, University of Baghdad.
6- Al-Lami, Abdul S. Jabr. 1999. Evaluation of magnesium readiness in some greenhouse soils. PhD thesis. Soil department. Faculty of Agriculture. Baghdad University.
7- Bhargava, B.S. and H.B Raghupathi.1993. Analysis of plant Materials for Macro and Micronutrients . In : HLS Tandon (Ed) Methods of Analysis of Soils, Plants, Waters and Fertilisers . fertiliser development and Consultation Organisation 204204A Bhanot Corner,12 Pamposh Enclave , New Delhi110048(India).Pp.49 - 82.
8- Black, C.A. 1965. Methods of soil analysis. Part2. Agronomy 9.Madison, Wisconsin, USA.
9- Havlin, J. L.; J. D. Beaton, S. L. Tisdal and W. L. Nelson. 2005. Soil fertility and fertilizers. 7th Ed. An introduction to nutrient management .Upper Saddle River, New Jersey.
10- Jackson, M.L. 1958. Soil chemical analysis. Prentiss-Hall Inc. Englewood, Cliffs,N 11: 188- 196.
11- Merhaut, D.J. 2007. Magnesium In: Barker, A. V. and D. J. Pilbeam. (Ed) Handbook of plant nutrition. Taylor and Frances group CRS. New York.
12- Page, A.L.; R.H. Miller, and D.R. Kenney. 1982. Methods of Soil Analysis Part (2). 2nd ed. Agronomy 9 Am. Soc. Agron. Madison, Wisconsin.