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ORIGINAL ARTICLE

INFLUENCE OF AGRICULTURAL SULPHUR AND ORGANIC MATTER ON THE GROWTH OF CORN (*ZEA MAYS* L.) AND LEAVES CONTENT OF SOME NUTRITIOUS ELEMENTS

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Abstract: A research teamwork conducted this field experiment in silty loam soil at spring of 2018 in the College of Agriculture's Research Station, University of Anbar. The treatments consisted of two agri-sulphur (AS) levels (0, and 2 Mg. ha^{-1}), three organic matter (OM) sources of sheep manure (SM), cattle refuse (CR), and wheat straw (WS), as well as control treatment (CT) (zero addition). They added as mixture with soil (5%). The objective is to investigate effects of those treatments and their interactions on the growth indicators of corn, NPK (nitrogen, potassium, and phosphorus) content of leaves, and some chemical properties of soil after the end of experimental work. The factorial experiment contained three replications distributed according to Randomized Complete Block Design (RCBD). The results indicted significant superiority of AS on the mean of plant height (PLH) and green dry weight (GDW) with values of (122.8 cm and 432 g.$plant^{-1}$) respectively, whereas there were a significant decrease in soil electrical conductivity (EC) of 6.8 dS.m^{-1} and potential of hydrogen (pH) of (7.3). On the other hand SM highly affected PLH, LA (leaf area), and K content significantly to reach (126.9 cm, 490 g, and 1.240%) respectively. The CR significantly affected on N, P concentrations of (0.590 and o.110%) successively. Meanwhile WS affected on LA to reach its maximum value of 517.2 dcm^2, whereas there was a significant decrease in EC at CR treatment only to reach 6.4dS.m^{-1} with decline ratio of 16.88% compared with CT.

Key words: Maize, Organic matter, Cattle refuse, Wastes, Randomized complete block design (RCBD).

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1. Introduction

Generally speaking, one of the most important problems of calcareous soils is the high values of their soil reaction, which negatively affects the availability of most of the nutrients needed for the plant, so researchers have resorted to find means to reduce the values of pH, especially in the root environment (rhizosphere), the most important of which is the addition of agricultural sulphur, which is available in large quantities in Iraq, as well as being one of the necessary nutrients for plant growth. Therefore, the pre-addition of AS before cultivation will generate more hydrogen ions as sulphur oxidation by *Thiobacillus* spp. Bacteria and thus removing exchangeable cations to soil solution and lime soluble with the effect of sulfuric acid that leads to the release of associated ions, sulphur has also positive role in plant growth as it composes amino acids like Methionine, Cysteine, and Cytosine that contribute in protein and lipoic acid molecules and it has important role in anabolism operations in plants. The total green dry weight of corn was significantly increased due to addition of (0, 1, and 2) Mg. ha^{-1} of sulphur [Bressem *et al*. (2009)]. Jabir and Habeeb (2017) found a significant increase in plant height, leaf area, and green matter yield for maize crop as a result of three levels of sulphur (0, 2.5 and 5 Mg.ha^{-1}), respectively.

On the other hand, organic matter is a basic component of soil plays role in its chemical physical, and biologic traits like pH buffering, rise of nutrients

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availability and bulk density etc. The joint addition of organic matter and chemical fertilizers to poor nutritious. Iraqi soils may assist in supporting mineral nutrients to plants especially at slow dissolution of OM, which relays release of important nutrients. The organic materials like animal wastes and plant residues *e.g.* cattle refuse, sheep manure and wheat straw differ in their content of N, P and K, which are used widely for their obtainability and readiness [Ayed *et al*. (2010)].

The corn crop (*Zea mays* L.) is one of most important food and industrial crops in many regions of the globe, furthermore, it comes in the third order after wheat and rice for its high productivity and adaptability with variated environment conditions compared to other gramineae members. The main goal of this study is to investigate influence of chemical, Sulphur, organic fertilizers and their interactions on maize crop to reach the best productivity.

2. Materials and Methods

The team in the Research Station in College of Agriculture, University of Anbar had conducted this experiment in spring season of 2018 at a silty loam soil has a (Typic Torrifluvent) great group class according to USDA (2010). Table 1 shows the chemo-physical properties of soil.

Table 1: Some physical and chemical properties of field soil pre cultivation.

Physical properties			Chemical properties		
Trait		**Value**	**Trait**	**Unit**	**Value**
Soil separates $gm.kg^{-1}$	Sand	392	pH	-	7.24
	Silt	500	Ec	$ds\ m^{-1}$	3.25
	Clay	108	Ca^{+2}	**$mmol\ L^{-1}$**	59.25
Texture	Silty Loam		Mg^{+2}		82.33
Moisture tension (kps)	0	48.5	Na^{+}		230.18
	33	32.8	K^{+}		5.73
	1500	12.6	Cl^{-}		208.52
Available water %		20.2	HCO_3^{-}		19.01
Bulk density $Mg\ m^{-3}$		1.36	CO_3^{-2}		1.81
Particle density $Mg\ m^{-3}$		2.53	SO_4^{-2}		8.64
Porosity %		47.90	OM	$g\ kg^{-1}$	0.38

The experiment soil plowed with two perpendicular plows to 20-30 cm depth, then was crushed by disc combs and divided into experimental units according to the design of the Randomized complete block design of three repeats each contained 8 experimental units area Each of them 2 m^2 in replications (2 × 1 m) comprised of five lines of 50 cm distance among lines and the distance between pits were 20 cm. The blocks and replicates were separated with ridges of 50 cm wide to avoid overlapping between blocks and replicates. The phosphorus additions were at a rate of 80 kg P. ha^{-1} in the form of triple superphosphate (TSP) fertilizer (20%) during the preparation of the land for cultivation, while nitrogen fertilizer was added at a rate of 240 kg N.ha^{-1} using urea fertilizer (46%N) in two batches, the first after germination and the second at the beginning of flower buds formation at flowering phase.

The experiment consisted of two factors: the first is agricultural sulphuric fertilizer (95% S) of (0 and 2 Mg.ha^{-1}) levels which are (AS_0 and AS_1) respectively, the second factor contained three types of decomposed organic matter sources (OMS) which were: control (zero addition) CT, sheep manure (SM), cattle refuse (CR), and wheat straw (WS) successively. They added as mixture with soil (5% level) at 0-30 cm depth with considering moisture of each organic source. Table 2 shows some of OMS properties. Seed drilling of corn were done on 15 March 2018 at a depth of 4-5 cm and at rate of three seeds. pit^{-1} were reduced to one plant after full germination.

Irrigation was performed when 50% of the available water was drained using the weighted method. Then, the service operations and weeding were manually done when needed. At the end of experiment on July 1, 2018,

Table 2: Some of used OMS properties in experiment.

Studied properties	Unit	Value		
		SM	CR	WS
EC (1:5) extract	$dS.m^{-1}$	2.72	2.55	2.12
pH (1:5) extract	—	6.92	6.96	6.88
Nitrogen	$mg.kg^{-1}$	22.43	20.64	14.26
Phosphorus		11.20	10.82	8.80
Potassium		23.80	9.44	14.87

five plants were previously selected from every unit in experiment to calculate the following traits; plant height (PLH) cm, leaf area (LA) dcm^2, green dry weight (GDW) gm, nitrogen concentration in leaves (N) %, phosphorus concentration in leaves (P) %, potassium concentration in leaves (K) %, soil reaction (pH), and electrical conductivity (EC) $dS.m^{-1}$. Soil sampling from mildness among experimental unites were executed to measure soil properties.

GenStat statistical program was used to apply analysis of variance (ANOVA) and to perform data analysis of RCB design using least significant difference (LSD) test.

3. Results and Discussion

3.1 Plant height (PLH) (cm)

Table 3 shows the effects of AS, OM and their interactions on PLH. The AS_2 led to significant increase in PLH to reach 122.8 cm compared to CT treatment which recorded the least PLH value of 106.7 cm *i.e.* increased ratio was 15.08%.

Table 3: Effect of AS and OM on PLH (cm).

AS levels $Mg.ha^{-1}$	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	80.3	125.2	130.3	90.8	106.7
AS_1	108.8	128.6	118.5	135.2	122.8
Mean	94.6	126.9	124.4	113.0	
$L.S.D_{0.05}$	OS = 15.70		O=11.10		S = 7.85

In the same time, statistical analysis shows a significant influences of OM on the same trait, where SM_1 treatment had significant superiority in PLH reached 126.9 cm, which significantly exceeded WS_3 and CT treatments to reach 113.0 and 94.6 cm *i.e.* increased ratios were 34.14 and 19.45% successively in comparison with CT treatment. The interaction between AS and OM had a significant effect on PLH whereas the maximum height was 135.2 cm at AS_2 + WS_1 compared to 10.90% in CT_0 with increased ratio of 68.36%.

3.2 Leaf area (LA) (dcm^2)

Table 4 states the effects of AS and OM on LA mean values. All the OM types significantly outperformed than CT treatment where WS recorded the highest LA mean value reached (5.17.2 dcm^2) in comparison with CT that recorded minimum value of (4.17.1 dcm^2) with excess rate of 23.99%. The interaction between the addition of AS and OM was also significant. The least rate of LA was (417.1 dcm^2) at CT treatment (zero addition of SA and OM), whereas the highest rate (540.7 dcm^2) at the AS_0SR_2 treatment with an increase of 29.63%.

Table 4: Effect of AS and OM on the LA mean values (dcm^2).

AS levels $Mg.ha^{-1}$	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	417.1	478.6	540.7	531.7	492.0
AS_1	430.0	464.5	448.0	502.8	461.3
Mean	423.5	471.6	494.4	517.2	
$L.S.D_{0.05}$	OS = 65.34		O=46.21		S = 32.67

3.3 Green dry weight (GDW)

Table 5 shows the effects of AS, OM type and their interactions on the values of green dry weight compared with CT. The AS_1 treatment led to an insignificant increase in GDW mean values, whereas, OM increased GWE significantly, where the treatments mean values recorded (490, 471, and 372 g. $plant^{-1}$) for SM_1, CR_2, and WS_3 respectively with increasing ratios of 57.55, 51.44 and 19.61% successively compared to CT_0, which recorded the least mean GDW value of (311 $g.plant^{-1}$).

Table 5: Effects of OM and AS on the GDW mean values (g. $plant^{-1}$).

AS levels $Mg.ha^{-1}$	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	294	429	457	382	391
AS_1	328	552	484	363	432
Mean	311	490	471	372	
$L.S.D_{0.05}$	OS = 108.6		O=76.8		S = 54.3

There was also a significant interaction between the addition of AS and the addition of OM in the GWD, as the treatment of AS_1SM_1 stated the highest mean of (552 g.plant^{-1}), whereas the least mean value of (294 g.plant^{-1}) with an increase of 87.75%. The increase in PLH and LA due to the addition of AS is attributed to the role of added AS in increasing the availability of sulfates (SO_4^{-2}) and other nutrients in the soil as a result of its oxidation by specialized microbiology and its absorption and metabolism in the plant in the form of amino acids, as well as the effect on the efficiency of the metabolism of nitrogen in the plant by contributing to nitrate reduction [Havlin *et al*. (2005)] and thus increasing the height of the plant and LA. These results are consistent with Bressem *et al*. (2009) and Jabir and Habeeb (2017).

The reason may be due to the quantity and speed of released substances from OM, which are polysaccharides, humic acid, fulvic acid and amino acids directly or indirectly in plant growth, either to promote growth by enzyme or hormonal, or to contain nutrients needed by the plant or to affect the availability of the elements originally existed in the soil [Rauthan and Schnitzer (1981)]. Also, because of the role of these residues in improving the physical properties of soils such as the apparent density of soil and porousness, this is reflected in increased plant growth. The results are consistent with Abboud and Karim (2014), Abbood and Abed (2017).

3.4 Nitrogen concentration in leaves (N%)

Table 6 shows the effects of AS and OM addition and their interactions on nitrogen concentrations in the leaves of corn (N%). The results showed an insignificant effect of AS_1 of this trait compered to AS_0. The statistical analysis results revealed a significant differences among OM treatments on leaves content of nitrogen, where the highest mean value of 0.590% recorded in CR_2 treatment, which was significantly greater than WS_3 treatment (0.543%) with increase ratio of 8.65%. CR_2 was significantly greater than CT_0 which recorded the least N% mean value of 0.548% with an increased ratio of 7.66%. It is noticed that AS versus OM interaction had a significant influence on leaves N% content where the highest mean value was 0.616% in AS_1CR_2 treatment compared to AS_1WS_3 treatment which was 0.520% with increased ratio of 18.46%.

Table 6: Effects of AS and OM on N concentration in leaves (%).

AS levels Mg.ha^{-1}	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	0.540	0.583	0.563	0.566	0.563
AS_1	0.556	0.570	0.616	0.520	0.566
Mean	0.548	0.576	0.590	0.543	
$L.S.D_{0.05}$	OS = 0.0475		O = 0.0336		S = 0.0237

3.5 Phosphorus concentration in leaves (P%)

Table 7 depict the influence of AS, OM and their interactions on P concentration in leaves of corn. The results indicated existence of an insignificant effect for AS on P content in leaves compared with zero addition.

Statistical analysis revealed a significant difference among OM additions in the trait of P concentration in leaves. The highest mean value was in CR_3 treatment of 0.110%, which did not differ significantly from other OM types but CT_0 that differed significantly that recorded the least mean value of P content in leaves mounted 0.096% with increasing ratio of 14.58%.

Table 7: Effect of AS and OM on P concentration in leaves (%).

AS levels Mg.ha^{-1}	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	0.093	0.106	0.106	0.103	0.102
AS_1	0.100	0.103	0.113	0.103	0.105
Mean	0.096	0.105	0.110	0.103	
$L.S.D_{0.05}$	OS = 0.0132		O = 0.0093		S = 0.0066

The interactions among AS and OM levels had a significant effect on P concentration in leaves. The highest mean value was 0.113% at AS_1CR_3 compared to CT_0AS_0, which was 0.093% with increasing ratio of 21.50%.

3.6 Potassium concentration in leaves (P%)

Table 8 shows the effect of adding AS and OM and their interactions in potassium concentration in yellow corn leaves. The results showed no significant effect to add AS in the concentration of potassium in the leaves compared to not adding it. The results of the statistical analysis also showed a significant difference between the addition of organic residues (OM) in the potassium concentration in the leaves. SM_1 gave the highest rate of 1.240%, which did not significantly outperform the rest of the other organic residues, which

Table 8: Effect of AS and OM on K concentration in leaves.

AS levels Mg.ha^{-1}	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	1.213	1.240	1.240	1.243	1.234
AS_1	1.223	1.240	1.230	1.226	1.230
Mean	1.218	1.240	1.235	1.235	
$L.S.D_{0.05}$	OS = 0.0232	O = 0.0164	S = 0.0116		

amounted to 1.235% for each of the CR_2 and WS_3, which increased significantly by 1.80 and 1.39% in succession to SM_1, CR_2 and WS_3 together, compared to the CT_0 treatment that gave the least concentration of potassium in the leaves of 1.218%.

The increase in K content may contributed to decrease of soil pH (Table 8) that enhance chemical and biological oxidization of mineral Sulphur (MS) to formulate Sulphuric acid and thus increase solubility of phosphoric compounds to release available P for plants and thus increasing its uptake [Omran *et al*. (2016), Al-Hamandi (2018)].

The increased concentration of nitrogen, phosphorus and potassium may be caused by the effect of the addition of organic residues, which contributed to the amount of elements released from their decomposition [Adekiya and Agbede (2009)], as well as the fact that the humic acids produced by organic residues during their decomposition have a similar effect to the effect of the hormone that helps to form complexes with metal ions and increases the availability of plant nutrients [Plaster (1997)].

3.7 Electrical conductivity (EC) (dS. m^{-1})

Table 9: Effect of AS and OM on EC (dS.m^{-1}).

AS levels Mg.ha^{-1}	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	8.4	6.7	6.2	8.2	7.4
AS_1	7.0	7.3	6.5	6.5	6.8
Mean	7.7	7.0	6.4	7.3	
$L.S.D_{0.05}$	OS =1.752	O = 1.239	S = 0.876		

Table 9 indicated the effects of AS, OM , and their interactions on the decrease of EC values of studying soil in comparison with CT. The AS_1 application led to an insignificant decrease of EC, where the CR_2 only treatment reduced EC value significantly to 6.4 dS.m^{-1} with decline ratio of 16.88% compared to CT_0 which mounted 7.7 dS.m^{-1}.

There was also a significant interaction between AS and OM, where the treatment of AS_0CR_3 had the least EC mean value of 6.2 dS.m^{-1} compared to control treatment (AS_0CT_0), which had the maximum mean value of 8.4 dS. m^{-1}.

3.8 Soil reaction degree (pH)

Table 10 shows the effects of AS, OM and their interactions on the decrease of pH values. The AS_1 treatment decreased pH mean value to 7.3 compared to 7.4 in AS_0CT_0 with decline ratio of 8.82%. This result attributed to enhance chemical and biological oxidization of mineral Sulphur (MS) to formulate Sulphuric acid which simultaneously released H^+ to decrease soil pH. Meanwhile there were no significant differences among OM treatments and CT in decreasing pH values, whereas the interaction between AS and OM was significant. The AS_1SM_1 had least significant mean value of 7.2 and the highest mean value was 7.4 at AS_0 with or without WS_3.

Table 10: Effect of AS and OM on Soil pH.

AS levels Mg.ha^{-1}	OM types				Mean
	(CT_0)	(SM_1)	(CR_2)	(WS_3)	
AS_0	7.4	7.3	7.3	7.4	7.4
AS_1	7.3	7.2	7.3	7.3	7.3
Mean	7.4	7.3	7.3	7.3	
$L.S.D_{0.05}$	OS = 0.1868	O = 0.1321	S = 0.0934		

4. Conclusion

The Iraqi soils is distinguished by the fact that its pH is almost acidic and appears to be alkaline in certain areas, which affects the availability of nutrients in the soil, so it is important to apply agricultural sulphur mixing with the soil, which has directly affected the pH reduction and the soil solution's electrical conductivity, which has resulted in increased growth indicators of corn. The results of this study also indicated that organic residues from different sources (sheep wastes, cattle refuse and wheat straw) have encouraged better plant growth as a result of its role in increasing the availability of N P K elements and their absorption by the plant and improving the chemical properties of the soil.

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