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EFFECT OF AGRICULTURE SULFUR FERTILIZER LEVELS ON GROWTH, AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

A field experiment was conduct in Basrah provinace – Qurna district – Al-Gomage (70 km north of Basrah city center) during winter season 2019-2020 to estimate the effect of apply different levels of sulfur agricultural fertilizer on some growth properties of wheat plant (*Triticum aestivum* L.) . Four levels of agricultural sulfur fertilizer at: 0, 1, 2, 4 Ton S. ha^{-1} and four wheat varieties: IPA-99, IPA-95, Rasheed and Baraka were used. The experiment were design with randomized complete block design with three replicates, varieties in main block while levels of sulfur fertilizer in secondary block. Results showed significant effect of 4 Ton S.ha^{-1} sulfur fertilizer on all study characteristics, it has given highest plant height with 104.88 cm, highest leaf area with 43.96 cm^2, numbers of tillers with 639.8 $tiller.m^{-2}$, total chlorophyll 45.52 SPAD, grain yield with 6.231 $ton.ha^{-1}$. Rasheed variety was significant effect compared with other varieties with highest leaf area 45.70 cm^2, Number of tillers 646.0 $tiller.m^{-2}$, total chlorophyll 45.68 SPAD, grain yield 5.793 $ton.ha^{-1}$. Interaction between level 4 Ton S. ha^{-1} and Rasheed variety get highest number of tillers, highest total chlorophyll and highest leaf area with 804.7 $tiller.m^{-2}$, 56.86 SPAD and 51.09 cm^2 respectively.

***Keyword*:** wheat, agriculture sulfur, varieties, growth properties.

Introduction

At the present time, human demand of grain crops about 75% from his nutrition, wheat (*Triticum aestivum* L.) is the primary strategical important crop in the world, that the largest grown area and yield. Wheat crop have a huge nutrition value represented in appropriate balance in grains between proteins and carbohydrates and including fat and proteins such as: B1, B2 and some mineral salts (Al-Mohammedy, 2010). The world population depend on this crop in agricultural activists, as more than 2.35 Million hectare were grown in Iraq with average yield about 1.80 Ton. ha^{-1} (Directorate of Agriculture statistics, 2019). In spite of Iraq was one of many countries have appropriate conditions to grown wheat crop (Al-Asafi, 2015), but still suffer from reduced yield and bad quality due to incorrect techniques management used to grown this crop such as used traditional variety and hard weathering conditions, although Iraq consider the first global country to grow wheat (Jadoaa and Baker, 2012). Wheat varieties can play a good role to determination the total yield and quality, many studies showed a clear comparison between different varieties and find many differences between varieties on growth properties, yield, weight of 1000 grain and grain yield (Al-Rafaai *et al.*, 2013), beside of the important role of variety on determination protein percentage in grain (Al-Aani , 2017). Al-Abodi (2019) showed during study on different varieties of wheat, that varieties differences between others in many growth properties, yield, plant height, leaf area numbers of tillers, number of spikes, number of grain, weight of 1000 grain and grain yield.

In view of produced a huge amounts of agriculture sulfur in Iraq and available in local market with cheap prices, as well as important role in plant growth by improved metabolic processes in plant cell and formation proteins and increased enzymes and vitamins activity, so can it be useful from this element to improvement growth of crops and increased yield (Al- Saady, 2006). Sulfur is one of 17^{th} essential nutrition elements for plant growth after Nitrogen, phosphorus and potassium, demined of Sulfur by plant such it demined to phosphorus (Havlin *et al.*, 2005). Farmers classified Sulfur as a fourth important nutrition element for plants. Kadhem (2016) find significantly effect of apply different levels of agriculture Sulfur on growth properties of wheat plant, level of 2000 kg S ha^{-1} get highest rang of plant height, leaf area, number of tillers and leaf chlorophyll content .

To study the importance of wheat varieties, levels of agriculture Sulfur and its interactions on growth characteristics, yield and yield components of wheat crops, conduct this study, and the aims to:

1- Select the appropriate agriculture Sulfur levels to varieties.

2- Exam the best varieties given high yield and resistance to prevailing conditions.

Materials and Methods

A field experiment was conduct in Basrah Province – Qurna district – Al-Gomage (70 km north of Basrah city center) during winter season 2019-2020 in clay soil (characteristics in table 1). The experiment including four agricultural sulfur levels : 0, 1, 2, 4 Ton S ha^{-1} apply to the study soil in one dose before one month from planting seeds, and including four varieties of fine wheat : IPA-99, IPA-95,

Al-Rasheed and Al-Baraka depend by agriculture ministry in Iraq, obtained from general state of agricultural researches (Abo Greeb – Baghdad). Laboratory seeds percentage before planting was: 99, 100, 99 and 99% respectively. Field area for conduct this study were preparing by plowing, settlement and divided to experiment units (2×3 m) =6m^2. Each experiment unit including 10 lines for grown grain with 3 m length and 20 cm between replicates. Factorial experiment was design using randomized complete block design with three replicats, varieties in main plots while S-fertilizer levels in secondary plots. Varity grain planting at 15 Nov. 2019 at rang 120 kg.ha^{-1} and irrigated, Urea fertilizer (46% N) was added at rang 120 kg N ha^{-1} by two doses: First does after seedling emerge, second at elongation stage. 100 kg.ha^{-1} P was added as triple super phosphate (20% P_2O_5) in one does at plowing. All field service was complete during grown season; harvest was conduct at 7 April 2020 and record below data for study properties:

1- S-concentration in leaves at branches stage (%)

Plant samples were digestion according to Karla (1998) and determined Sulphur element in solution by turbid metric method using spectrophotometer as described in Pag *et al.* (1982).

2- Plant height (cm)

A mean of ten random plant from each experiment unit was collected at following stage. Measured was conduct from plant base with soil to the top of spike using graduate matter.

3- Leaf area (cm^2)

A mean of ten random plant from each experiment unit was collected at following stage according to Thomas (1975) equation:

Leaf area = leaf length (cm) × maximum width (cm) × 0.95

4- Tillers number (tiller m^{-2}) :

Collected by harvest one square meter area from middle lines from each experiment unit.

5- Chlorophyll content of flag leaf (SPAD) :

A mean from different record of ten leaves from each experiment unit was collected when complete following stage using chlorophyll meter CCM-200 plus.

6- Grain yield (Ton ha^{-1}) :

After harvesting sample (one square meter), straw was divided and weight grain for each experiment unit and collected to Ton ha^{-1}.

The statistical analysis for characteristic data were used depend on variation analysis according to Gen-stat statically program, use least significant difference test at level (0.05) to compared treatments mean.

Table 1 : Some Chemical and Physical Properties of Soil

Properties	Unit	Value	Properties	Unit	Value
pH	----	7.22	Dissolved Ions	Ca^{+2}	12.01
E.C.	ds m^{-1}	6.95			
Organic matter	g kg^{-1}	3.98		Mg^{+2}	18.35
$CaCO_3$	g kg^{-1}	252			
Sand	g kg^{-1}	239.90		Na^{+}	13.28
Silt		330.15		K^{+}	0.14
Clay		309.95		$SO_4^{=}$	9.77
Soil texture	----	Silty clay soil			
Available elements (mg kg^{-1})	N	56		HCO^{-3}	1.75
	P	13.65			
	K	165		Cl^{-}	24.00

Results and Discussions

1. Sulfur concentration in leaves at branching stage (%):

Table (2) shows that 4 ton. ha^{-1} was superiority, gave the highest average of 0.232% compared to the control treatment, which gave the lowest averages 0.092% , the increase in the sulfur concentration in the leaves with the levels of additive increase, it is attributed to the fact that its addition reduced the degree of soil pH through oxidation and conversion to sulfuric acid, by increased the number of sulfur-oxidizing microorganisms (*Thiobacillus*), which decomposes into sulfur ions SO_4^{-2} and increases readiness in the soil, as well as the sulfuric acid role in dissolving some compounds and minerals carrying the sulfur ion in the soil, increasing plant absorption, which increases concentration in leaves, the result agreed with Al-Zubaidi (2015) .

The results at the same table show that the effect of the cultivated cultivars on the sulfur content of leaves, Al-Baraka cultivar was outperformed, gave the highest average 0.182% , with an increase of 29.01%, compared to IPA-99 cultivar, which gave the lowest mean 0.141%, which did not significantly differ from the Al-Rasheed and IPA-95 cultivars. The reason was due to the different response of the cultivars to the absorption of sulfur in their leaves, this result is in agreed with Kadhum (2016).

No significant effects were shown for the interaction between fertilizer levels and cultivars for this character (Table 2).

2. Plant height (cm):

Table (3) shows that sulfur fertilizer level had a significant effect on increasing plant height, the height increased as the fertilizer level increased, 4 ton. ha^{-1} level gave the highest plant height 104.88 cm , with an increase of 13.36%, compared with the control treatment, which gave the minimum plant height of 92.52 cm, the increase in plant height was attributed to the role of sulfur in reducing the degree of soil pH, then increase the readiness of the

nutrients, reflected on the growth character, including plant height, as well as its important in the biological processes in plants, as the sulfur present in the SH group increases cell division and elongation (Stangeev *et al.*, 1990), also agreement with Jawahar and Vaiyapuri (2010).

Table (3) indicates cultivar IPA-99 was significantly superior, recording the highest average plant height 105.85 cm, with an increase of 13.66%, compared to the Al-Rasheed cultivar, gave the lowest height 93.13 cm, the reason for this variation was due to their genetic variation in the number and length of phalanges, especially the supreme phalanx, which was one of the important character that distinguish the varieties (Muhammad, 2000), this result was in agreement with Al-Aboudi (2019).

The interaction between the level of sulfur fertilizer 4 ton. ha^{-1} with the IPA-99 cultivar was significantly superior to the rest of the interactions, giving the highest height 116.95 cm, while the treatment control with the Al-Rasheed cultivar, record the lowest average 90.36 cm .

3. Leaf area (cm^2)

Table (4**)** indicates that fertilizer levels had a positive role in increasing the leaf area, level 4 ton. ha^{-1} gave the highest leaf area 43.96 cm^2, with an increase of 26.72%, compared to the control treatment, it gave the lowest mean 34.69 cm^2, the reason for that the sulfur plays an important role in reducing the degree of soil reaction, and increase the readiness of nutrients in the soil, reflected positively on plant growth (Havlin *et al*., 2005), as well as its direct role in the leaf area increased, through its entry into the Ferredoxin composition, which important to nitrates and sulfates reduced .The transfer of electrons in the process of photosynthesis, the materials produced in plant growth, including increasing the leaf area, agreed with Kadhum (2016).

Al-Rasheed cultivar was significant superior in the leaf area by giving the highest average 45.70 cm^2 with a significant difference from the other cultivars, with an increase of 44.07%, compared to the IPA-99 cultivar, which had the lowest mean 31.72 cm^2, the reason was due to the superiority of the Al-Rasheed cultivar, exploited the genetic and physiological capabilities with high efficiency, for better growing requirements than other cultivars, reflected in increasing the leaf area, as well as the difference in genotypes, which leads to the difference in the growth, photosynthesize ability and prepare the nutrients necessary for growth, leaf area was varies, agreed with AL- Abdullah (2015)

The effect of the interaction between the levels of sulfur fertilizer and the cultivars was not significant in this character

4. Number of tillers (tiller. m^{-2}):

Table (5) showed that increasing the apply amount of sulfur levels to the soil, was a significant increase in the number of tillers for the wheat crop, the fertilizer treatment exceeded 4 ton. ha^{-1}, as it gave the highest average 639.8 tiller. m^{-2} , with an increase of 64.30% , as compared control treatment, which gave 389.4 tiller. m^{-2}. The increase in the number of tillers may be attributed to high levels of compost, the response of wheat cultivars to sulfur, led to an increase in the readiness of some elements, such as nitrogen and phosphorous, which have a role in increasing root branching, and increase the tillers, in addition to increasing the plant's content of trace elements such as iron and zinc, which have a role in increasing chlorophyll, then the increase in vegetative growth and cell division due to the increase in their readiness in the soil due to the decrease in the degree of soil interaction, its role as a nutrient that the plant needs during its growth, agreed with Ali *et al*. (2012) and Kadhum (2016), indicated that sulfur had a significant effect on increasing the number of tillers.

The same table indicates the superiority of the Al-Rasheed cultivar by giving the highest average 646.0 tiller. m^{-2}, with an increase of 48.40%, compared to the cultivar IPA-95, which gave the lowest number of tillers 435.3 tiller. m^{-2}, the reason may be attributed to the different cultivars in the number of tillers, to the genotype, which was the main factor in the ability of plants to be tiller, leads to its variation in the number of tillers, agreed with Al-Aboudi (2019), indicated that there was a significant difference between the cultivars of wheat in the number of tillers.

The interaction between the sulfur fertilizer and the cultivars have a significant effect on the number of tillers, the highest average number of tillers was 804.7 tiller. m^{-2} at the fertilizer level 4 ton. ha^{-1} with the Al-Rasheed cultivar, compare with with0ut add treatment with the IPA-95 cultivar, which amounted to 324.3 tiller. m^{-2}.

5. Chlorophyll content of flag leaf (SPAD):

Table (6) show that the 4 ton. ha^{-1} level was outperform by giving the highest average 45.52 SPAD , with an increase of 36.15% , compared to the lowest average 33.43 SPAD in without add treatment. The reason was that apply sulfur to the soil, reduced the degree of soil pH , and increase the readiness of nutrients in the soil, increasing its content in the plant, which has a role in the chlorophyll formation, as well as the sulfur increasing the chlorophyll content in the leaves, due to the positive relationship between the sulfur protein present in the green plastid and the optical density of the chlorophyll extract (Al-Sahaf, 1989), agreed with Kadhum (2016) .

The same table show that the results of the wheat cultivars differed significantly in the chlorophyll content of the flag leaf, as Al-Rasheed cultivar gave the highest content 45.68 SPAD, an increase of 33.49%, compared with the IPA-95 cultivar, which gave the lowest average 34.22 SPAD, the reason for this difference between the cultivars was due to the different nature of their growth and the extent of their response to the environmental conditions prevailing in the region, agreed with Al-Fahdawi (2019).

The interaction between agricultural sulfur fertilizer levels and cultivars showed a significant differences in the chlorophyll content of the flag leaf, fertilizer treatment of 4 ton. ha^{-1} with Al-Rasheed cultivar was significantly exceeded, with an average of 56.86 SPAD, whereas, the without add treatment with IPA-95 cultivar were recorded the lowest mean 30.18 SPAD .

6. Grain yield (ton ha^{-1}):

Table (7) show that the level of 4 ton. ha^{-1} was exceeded by giving the highest average 6,231 ton. ha^{-1}, with an increase of 55.79%, compared to the lowest average 3.997 ton. ha^{-1} of control treatment, the increase in grain

yield is attributed to the role of sulfur in the readiness of some nutrients in the soil, by reducing the degree of soil pH and increasing its uptake by the plant, reflected positively on the increase in growth character, includes the plant height (Table 3), the leaf area (Table 4) and the tiller number (Table 5), which increased with increasing levels of sulfur at the same levels of the additive, increasing the source efficiency in processing the represented materials, and increase the capacity of the sink to receive these materials and increase the grain yield, agreed with Jawahar and Vaiyapuri (2010).

The same table shows that the Al-Rasheed cultivar gave the highest average grain yield (5.793 ton. ha^{-1}), whereas, the IPA-99 cultivar gave the lowest average (4.573 ton. ha^{-1}), the reason of the Al-Rasheed cultivar in this trait may be due to the genetic difference, Hamam and Khaled (2009) stated that the reason for the superiority of a particular cultivar was that it has preferred genes not present in other cultivars, reflects positively on its performance, agreed with Al-Aboudi (2019) .

The interaction between levels of agricultural sulfur fertilizer and cultivars had no significant effect on this character.

Table 2 : The effect of cultivars, sulfur levels and the interaction on the sulfur concentration in wheat crop leaves at the branching stage (%).

Cultivars	sulfur levels (ton. ha^{-1})				Cultivar Means
	0	1	2	4	
IPA-99	0.067	0.132	0.153	0.212	0.141
IPA-95	0.079	0.168	0.163	0.230	0.160
Al-Rasheed	0.115	0.145	0.196	0.256	0.178
Al-Baraka	0.108	0.180	0.209	0.231	0.182
Sulfur Means	0.092	0.156	0.180	0.232	
$L.S.D_{0.05}$	Cultivars	Sulfur levels		Interaction	
	0.029	0.037		N.S	

Table 3 : The effect of cultivars, sulfur levels and the interaction on Plant height (cm) of wheat crop.

Cultivars	Sulfur levels (ton. ha^{-1})				Cultivar means
	0	1	2	4	
IPA-99	96.08	98.83	111.52	116.95	105.85
IPA-95	92.62	95.87	101.67	105.20	98.84
Al-Rasheed	90.36	92.23	93.65	96.28	93.13
Al-Baraka	91.03	94.67	97.22	101.08	96.00
Sulfur Means	92.52	95.40	101.01	104.88	
$L.S.D_{0.05}$	Cultivars	sulfur levels		Interaction	
	1.42	1.40		2.68	

Table 4 : The effect of cultivars, sulfur levels and the interaction on leaf area (cm^2) of wheat.

Cultivars	Sulfur levels (ton. ha^{-1})				Cultivar means
	0	1	2	4	
IPA-99	26.53	31.44	32.89	36.03	31.72
IPA-95	32.39	35.70	37.09	40.92	36.52
Al-Rasheed	40.98	44.10	46.65	51.09	45.70
Al-Baraka	38.86	40.44	42.96	47.82	42.52
Sulfur Means	34.69	37.92	39.90	43.96	
$L.S.D_{0.05}$	Cultivars	sulfur levels		Interaction	
	1.21	0.90		N.S	

Table 5 : The effect of cultivars, sulfur levels and the interaction on tillers (tiller. m^{-2}) of wheat.

Cultivars	sulfur levels (ton. ha^{-1})				Cultivar Means
	0	1	2	4	
IPA-99	356.0	440.0	473.3	590.0	464.8
IPA-95	324.3	434.3	465.7	516.7	435.3
Al-Rasheed	484.3	600.3	694.7	804.7	646.0
Al-Baraka	393.0	479.7	591.7	647.7	528.0
Sulfur Means	389.4	488.6	556.3	639.8	
$L.S.D_{0.05}$	Cultivars	sulfur levels		Interaction	
	9.99	11.77		21.85	

Table 6 : The effect of cultivars, sulfur levels and the interaction on chlorophyll content of flag leaf (SPAD) of wheat.

Cultivars	sulfur levels (ton. ha^{-1})				Cultivar means
	0	1	2	4	
IPA-99	30.77	32.13	35.88	40.56	34.84
IPA-95	30.18	32.99	33.69	40.04	34.22
Al-Rasheed	38.67	41.53	45.66	56.86	45.68
Al-Baraka	34.10	37.75	40.12	44.63	39.15
Sulfur Means	33.43	36.10	38.84	45.52	
L.S.D$_{0.05}$	**Cultivars**	**sulfur levels**		**Interaction**	
	2.52	0.95		2.79	

Table 7 : The effect of cultivars, sulfur levels and the interaction on grain yield (ton ha^{-1}) of wheat.

Cultivars	sulfur levels (ton. ha^{-1})				Cultivar Means
	0	1	2	4	
IPA-99	3.65	4.10	4.89	5.64	4.57
IPA-95	3.66	4.16	5.03	5.82	4.67
Al-Rasheed	4.52	5.22	6.19	7.22	5.79
Al-Baraka	4.14	4.77	5.64	6.22	5.19
Sulfur Means	3.99	4.56	5.43	6.23	
L.S.D$_{0.05}$	**Cultivars**	**sulfur levels**		**Interaction**	
	0.45	0.30		N.S	

The following concludes that Al-Rasheed cultivar excelled and gave the highest growth and yield compare with other cultivars of wheat, and the best fertilizer level for agricultural sulfur was 4 ton. ha^{-1} , which gave the highest grain yield .

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