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EFFECT OF SOIL SULFUR FERTILIZER AND SOME FOLIAR FERTILIZERS ON GROWTH AND YIELD OF BROCCOLI IN SALINE SOIL

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ABSTRACT
Factorial experiment was conducted in the open fields of Agricultural College, Al-Qasim Green University during the agricultural seasons of 2013/2014 and 2014/2015 to study the effect of adding two levels of agricultural sulfur (control and add 100 kg.ha^{-1}) and four levels of nutrient spray (without spray, high-potash fertilizer, high-phosphorus fertilizer and humic acid) on growth and yield of broccoli under drip irrigation and polyethylene soil mulching in saline soil (9.6 dS.m^{-1}). Randomized complete block design with three replicates was used. The results showed that agricultural sulfur led to increase number of leaves, leaf area, leaves chlorophyll content, diameter and weight of flower head compared to control. Spraying foliar fertilizer and its interaction with sulfur fertilizer also led to increase all of parameters above (except leaves chlorophyll content) significantly compared to control treatment.
KEY WORDS: *broccoli, foliar fertilizer, sulfur*

INTRODUCTION

Brassica oleracea L. *var italica* Plenk (broccoli) is a unique nutritious vegetables (El-Helaly, 2012). The green inflorescence is a commercial product of the broccoli plant. It is rich in chlorophyll, ascorbic acid and good source of vitamins and minerals (Fabek *et al.,* 2012) and some bioactive compounds such as phenolics, flavonoids and gluconsinolates that possess antioxidant and anticancer effects (Beecher, 1994).

Salt stress is one of the major abiotic stress factors that affect almost every aspect of physiology and biochemistry of a plant, resulting in a reduction in its yield (Faur, 1999; Munns, 2002; Foolad, 2004; Ianovici, 2011; Agarwal *et al,* 2013; Kahrizi *et al,* 2013; Gupta & Huang, 2014). It is a serious threat to agricultural productivity especially in arid and semi-arid regions (Parvaiz & Satyawati, 2008). When environmental conditions become stressful, plants cope with this pressure by adapting a strategy of reducing leaf expansion and closing their stomata to limit water loss.

Fertilizers is the main factor that affects vegetables yield. Mineral uptakes by plants are decline at salt stress, which can inhibit plant growth and yield. High soil pH affects soil elements availability and agriculture sulfur is used to decrease it. Besides, salinity is the major factor to inhibit K^+, and $NO3^-$ uptake (Shao *et al.,* 2013), and inhibit the activity of the key enzymes and photosynthesis (Karlberg *et al.,* 2006; He

et al., 2014). Various technical was used to control salinity including drip irrigation (Hanson & May, 2004), mulching (Pang e*t al.,* 2010; Jasim *et al.,* 2014), foliar nutrition application (Asghari *et al.,* 2011; Jasim & Abu-Altimman, 2014). Therefore, this study was conducted to assess the effect of agricultural sulfur as soil treatment and its interaction with foliar application of high potash fertilizer, high phosphorous fertilizer, humic acid as well as control on broccoli plants under salt stress condition.

MATERIALS AND METHODS

Factorial field experiment was conducted in the field of Agriculture college, Al-Qasim Green University, during the growing season 2014–2015, to study the interaction between two levels of agricultural sulfur as soil addition (control and adding 100 $kg.ha^{-1}$) and foliar application of high potash fertilizer, high phosphorous fertilizer, humic acid as well as control on broccoli plants under salt stress condition. The farm soil was sandy loam with pH 7.6 and salinity 9.6 $dS.m^{-1}$. Broccoli seeds were seeded in nursery at 3/10/2014, after 32 days, seedlings were planted on ridges 75 cm apart and 30 cm between plants with black polyethylene mulch and drip irrigation. Factorial experiment within Randomized complete Block Design (R.C.B.D.) with three replicates was used. The plants were treated with foliar fertilizers at 4, 6 and 10 leaf stage ($5gm.l^{-1}$with tween 20, spraying up to full wet). The experimental unit included 2 ridges (3 meters long) planting in both side. The data were recorded during the flowering stage, which included leaf number, leaf area (cm^2), chlorophyll content (SPAD), flower head diameter and weight. The data were analyzed and the means were compared according to Least Significant Difference ($LSD_{0.05}$) (Steel & Torrie, 1981).

RESULTS AND DISCUSSIONS

Table 1 and 2 show that adding agricultural sulfur caused a significant effect in increasing plant leaf number with an increasing percentage of 12.5 and 7.8% in 1st and 2nd season respectively compared to control. Foliar fertilizers achieved significant increases in leaves number compared to control, without significant differences between fertilizer kinds and spraying high phosphorus fertilizer gave the highest value with an increasing percentage of 22.0 and 21.3% in 1st and 2nd season respectively compared to control. The interaction had a significant effect, and highest leaves number obtained from sulfur fertilizer * spraying with high phosphorus fertilizer with an increasing percentage of 34.5 and 30.5% in 1st and 2nd season respectively compared to control.

Table 3 and 4 show that adding of agricultural sulfur caused a significant increase in broccoli leaf area with an increasing percentage of 7.6 and 8.6% in 1st and 2nd seasons respectively compared to control treatment. On the other hand, spraying foliar fertilizers caused a significant increase in leaf area compared to control (without

spraying), without differences between fertilizers kinds. Spraying humic acid gave the highest leaf area with increasing percentage of 17.2 and 18.3% in 1st and 2nd seasons respectively compared to control (without spraying). The interaction between soil and foliar fertilizer had a significant effect in increasing leaf area in which sulfur fertilizer spraying humic acid gave the highest leaf area with a percentage increase of 29.1 and 30.2% in 1st and 2nd seasons respectively compared to control.

TABLE 1. Effect of sulfur and foliar fertilizers on broccoli leaves number in 1st season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**17.1**	**19.3**	**18.2**
HIGH POTASH	**21.5**	**22.5**	**22.0**
HIGH PHOSPHORUS	**21.4**	**23.0**	**22.2**
ORGANIC	**19.9**	**22.2**	**21.1**
MEAN OF SOIL FERTILIZERS	**20.0**	**22.5**	
$LSD_{0.05}$	INTERACTION= 2.46SPRAYING=1.74 SULFUR = 1.23		

TABLE 2. Effect of sulfur and foliar fertilizers on broccoli leaves number in 2nd season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**16.7**	**18.1**	**17.4**
HIGH POTASH	**20.0**	**21.3**	**20.7**
HIGH PHOSPHORUS	**20.4**	**21.8**	**21.1**
ORGANIC	**19.8**	**21.6**	**20.7**
MEAN OF SOIL SULFUR	**19.2**	**20.7**	
$LSD_{0.05}$	INTERACTION= 2.29SPRAYING=1.62 SULFUR = 1.15		

TABLE 3. Effect of sulfur and some foliar fertilizers on broccoli leaf area in 1st season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**196**	**224**	**209**
HIGH POTASH	**237**	**241**	**239**
HIGH PHOSPHORUS	**230**	**246**	**238**
ORGANIC	**236**	**253**	**245**
MEAN OF SOIL FERTILIZERS	**224**	**241**	
$LSD_{0.05}$	INTERACTION=24.2 SPRAYING=14.0SULFUR =12.1		

TABLE 4. Effect of sulfur and some foliar fertilizers on broccoli leaf area in 2nd season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**205**	**231**	**218**
HIGH POTASH	**236**	**258**	**247**
HIGH PHOSPHORUS	**243**	**255**	**249**
ORGANIC	**248**	**267**	**258**
MEAN OF SOIL FERTILIZERS	**233**	**253**	
$LSD_{0.05}$	INTERACTION=29.1 SPRAYING=20.6 SULFUR = 14.6		

Table 5 and 6 show that application of agricultural sulfur to the soil caused a significant effect in increasing leaf chlorophyll content compared to control treatment

with an increasing percentage of1.87 and 1.61% in 1st and 2nd seasons respectively compared to control, while spraying foliar fertilizers and the interaction between soil and foliar fertilizers had no significant effect.

Table 7 and 8 show that application of agricultural sulfur to the soil caused a significant increase in broccoli head flower diameter with an increasing percentage of 14.7 and 11.7% in 1st and 2nd seasons respectively compared to control. On the other hand, spraying foliar fertilizers caused a significant increase in broccoli head flower diameter compared to control (without spraying), without significant differences between fertilizer kinds. The interaction between soil and foliar fertilizer had a significant effect in increasing head flower diameter in which sulfur fertilizer * spraying high phosphorus fertilizer gave the highest head flower diameter with a percentage increase of 35.7 and 31.8% in 1st and 2nd seasons respectively compared to control.

Table 9 and 10 show that application of agricultural sulfur caused a significant increase in weight of broccoli head flower with an increasing percentage of 14.1 and 9.0% in 1st and 2nd seasons respectively compared to control. On the other hand, spraying foliar fertilizers caused a significant increase in weight of flower head compared to control (without spraying), without significant differences between fertilizer kinds. The interaction between soil and foliar fertilizer had a significant effect in increasing leaf area in which sulfur fertilizer spraying organic fertilizer gave the highest flower head weight with an increasing percentage of 28.9 and 21.8% in 1st and 2nd seasons respectively compared to control.

TABLE 5. Effect of sulfur and foliar fertilizers on leaf chlorophyll content in 1st season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**74.5**	**75.1**	**74.8**
HIGH POTASH	**74.6**	**76.8**	**75.7**
HIGH PHOSPHORUS	**75.0**	**76.3**	**75.2**
ORGANIC	**75.1**	**76.5**	**75.8**
MEAN OF SOIL FERTILIZERS	**74.8**	**76.2**	
$LSD_{0.05}$	INTERACTION=N.S. SPRAYING= N.S. SULFUR =1.22		

TABLE 6. Effect of sulfur and foliar fertilizers on leaf chlorophyll content in 2nd season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**73.8**	**75.1**	**74.5**
HIGH POTASH	**74.0**	**75.5**	**74.8**
HIGH PHOSPHORUS	**74.7**	**76.0**	**75.4**
ORGANIC	**75.5**	**76.2**	**75.9**
MEAN OF SOIL FERTILIZERS	**74.5**	**75.7**	
$LSD_{0.05}$	INTERACTION=N.S. SPRAYING= N.S. SULFUR =1.13		

TABLE 7. Effect of sulfur and foliar fertilizers on flower head diameter in 1st season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	**1**3.83	15.16	**1**4.50
HIGH POTASH	15.44	18.06	16.75
HIGH PHOSPHORUS	15.52	18.77	17.15
ORGANIC	16.38	18.16	17.27
MEAN OF SOIL FERTILIZERS	**1**5.29	17.54	
$LSD_{0.05}$	INTERACTION= 1.84SPRAYING= 1.30 SULFUR = 0.92		

TABLE 8. Effect of sulfur and foliar fertilizers on flower head diameter in 2nd season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	14.12	15.20	14.66
HIGH POTASH	15.56	17.32	16.44
HIGH PHOSPHORUS	16.20	18.61	17.41
ORGANIC	16.44	18.52	17.48
MEAN OF SOIL FERTILIZERS	15.58	17.41	
$LSD_{0.05}$	INTERACTION= 1.66SPRAYING= 1.17 SULFUR = 0.83		

TABLE 9. Effect of sulfur and foliar fertilizers on flower head weight in 1st season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	31**1**	33**5**	323
HIGH POTASH	3**32**	38**7**	3**6**0
HIGH PHOSPHORUS	3**57**	39**2**	38**0**
ORGANIC	365	40**1**	383
MEAN OF SOIL FERTILIZERS	341	389	
$LSD_{0.05}$	INTERACTION= 41.2 SPRAYING= 29.1 SULFUR = 20.6		

Table 10: Effect of sulfur and foliar fertilizers on flower head weight in 2nd season

SOIL FERTILIZER / FOLIAR FERTILIZER	CONTROL	AGRICULTURAL SULFUR	MEAN OF SPRAYING FERTILIZERS
CONTROL	326	348	337
HIGH POTASH	345	372	359
HIGH PHOSPHORUS	351	391	371
ORGANIC	361	397	379
MEAN OF SOIL FERTILIZERS	346	377	
$LSD_{0.05}$	INTERACTION= 39.1SPRAYING= 27.5 SULFUR = 19.5		

It is appear that application of agricultural sulfur to the field of broccoli caused an increase in number of leaves, leaf area, leaves chlorophyll content, and flower head diameter and weight compared to control (table 1,2,3,4,5).This results are consistent with Khan *et al*. (2014) who reported that sulfur-containing metabolites, amino acids (cysteine and methionine), vitamins (biotin and thiamine), thioredoxin system, glutathione lipoic acid and glucosinolates have potential to promote or modify physiological and molecular processes under salinity stress in plants. And it is compatible with the findings of Schonhof *et al* (2007) who demonstrated that broccoli

crop yield will be influenced by sulfur supply which is a crucial importance in terms of crop management. Furthermore, sulfur application to broccoli field were essential to produce higher growth and yield with good quality flower heads (Elwan & El-Hamed, 2011) and due to that sulfur provide a highly effective antioxidant system (Jasim & Abu Al-Timman, 2014) which alleviate soil salt stress by attributed to radical scavenging and enzymatic decomposition of oxygen metabolites (Battin & Brumaghim, 2009), and enhance growth by increasing endogenous content of promoters plant hormones (IAA, GA3, ABA and Zeatine) and decreased the inhibitors one (ABA) (Jasim & Merhij, 2013). Also sulfur as acidic materials is regarded as a possible and economic way to improve nutrient availability and plant growth in salty soils (Singh & Chaudhari 1997; Dilmaghani *et al,* 2012).

Foliar fertilizer spraying caused an increase in number of leaves, leaf area, and flower head diameter and weight compared to control (table 1, 2, 4, 5). It is due to the role of K in enzymes activation, protein synthesis, photosynthesis, osmoregulation which reflected in plant growth, as well as energy transfer, phloem transport, cation-anion balance and stress resistance (Marschner, 2012). This results were supported with the findings of Jasim *et al* (2014), Jasim & Abu Al-Timman (2014) and Jasim & Merhij (2014) who demonstrated that the application of complete and high potash foliar fertilizer was highly effective in alleviating soil salt stress by improving activity of antioxidant enzymes that led to enhance plant growth of broccoli plants, and the finding of Heidari & Jamshidi (2011) who demonstrated that potassium treatment increased antioxidant activity in millet plants. Also it be referred to the role of P in phosphorylation process during photosynthesis. In addition, phosphorus play basal role in capture and transport of solar energy during photosynthesis and its role in phospho-lipids formation. This results was agreed with Islam *et al.* (2010) and Abou El- Magd *et al* (2013) who found that increasing phosphorus levels improved growth of broccoli plants. As well as nitrogen is an important constituent of protein and plays an important role in cell enlargement, cell division and photosynthesis which reflected on plant growth, and in turn in its products (El-Shakry, 2005).

Foliar organic fertilizer provide the plant with nutrients (Deore *et al,* 2010) and increasing cell membrane permeability (Sial *et al.,* 2007, Feleafel & Mirdad, 2014), in addition to the processing plant with auxin and gibberellins like substances which increase the endogenous content of promoters plant hormones (IAA, GA3, ABA and Zeatine) maintain the stability of cell membranes (Jasim & Merhij, 2013) that is reflected enhancing plant growth and yield. Increasing head diameter and weight may be due to the better availability of nutrients that produced healthy plants with large vegetative growth (leaf number and leaf area), which reflected in the head diameter and weight (Basel *et al.,* 2008). The interaction of sulfur application and foliar fertilizers had significant effect on leaves no., leaf area, and flower head diameter and weight compared to control (table 1,2,4,5). This results is agreed with Saeed *et al*

(2013) on wheat, and it is due to the concerted action of sulfur with foliar fertilizer in provision of nutrients needed by plant.

CONCLUSIONS

Broccoli can be grown better in saline soil when amended soil with sulfur fertilizer and foliar fertilizers, in which broccoli plants were shown vigorous vegetative growth (leaf number and leaf area), and high head diameter and weight compared to control.

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