Effect of elemental sulphur extracted from gas associated with oil production on yield and quality of tomato and onion

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ABSRACT

A field experiment was conduct at Basrah province south of Iraq, Al- Burjsia region west of Basrah center, during the growing season of 2019 - 2020 to study the effect of elemental Sulphur on performance of onion and tomato Plants. Two sulphur levels were used (0 and 80 kg S ha^{-1}) with four replicates for each treatment. Onion (Allium cepa L., var. Crestal) and tomato (Solanumlyco persicum L., var. Yassamin) were used. Onion bulbs and tomato fruits were collected from eight plants for each plots for estimating water content. Dried bulbs and tomato fruits were used to determine total N and S . Ascorbic acid content was estimated in fresh tomato fruits at full maturity stage and total weight of onion bulbs and tomato fruits for each plot were recorded for estimating total yield. The results showed a positive significant effect on sulfur concentration in tomato leaves and onion bulb. Same results were showed that addition of sulphur effects significantly increased nitrogen concentration at both plants. Results indicating that addition of elemental sulphur had no significant effects on N/S ratio and water content for both plants. Ascorbic acid content in tomato fruits significantly increased to 24.00 mg 100 g^{-1} F.W. compared with control treatment with a value of 18.25 mg 100 g^{-1} F.W. Application of elemental sulphur at rate of 80Kgha^{-1}had a significant effect on yield of tomato and onion and increased by 12.85 and 34.38 % with respect to the control treatment of tomato fruits and onion bulbs, respectively.

Keywords: sulphur, gas, oil production, tomato, onion

INTRODUCTION

Tomato is important source of lycopene in human nutrition and their utilization in food has been increasing word wide ,Lycopene is providing protection against various cancers and other chronic diseases, probably due to its anti-oxidative properties (Giovannucci, 1999) and it is mainly responsible for the red color of tomato fruits (Clinton, 1998).In the last decade of the last century S deficiency becomes widespread in world agriculture, namely as a consequence of reduction in sulphur dioxide emissions and also low S inputs with farm yard manure, the use of low S-containing fertilizers, high-yielding crop varieties and a declining use of S containing fungicides (Scherer, 2001). Sulfur is an important component of enzymes and other proteins, and is required for chlorophyll formation (Mengel and Kirkby, 1982).

Onion (Allium cepa L., 2n=16, Alliaceae), is an important bulb crop used as fresh vegetable, condiments and processed. Members of the Alliaceae family contain sulphur compounds, which give them their distinctive smell and pungency. Sulfur plays critical roles in the catalytic or electrochemical functions of the bio-molecules in cells (Saito, 2004). Sulfur is

useful for the formation of amino acids, oligopeptides, chlorophyll, certain enzymes, vitamins and cofactors, proteins and oils, and a variety of secondary products in Allium (Leustek, 2002; Stewart, 2010). Sulfur containing secondary products are act as signaling molecules for fundamental cellular functions (Matsubayashi et al., 2002) and believed to take part in defense mechanisms against pathogenic organisms (Bell, 1981). Sulphur has been found to increase the bulb yield of onion and improves its quality, especially pungency and flavor (Jaggi and Dixit, 1999). Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of onion (Ajay and Singh, 1994).

The original source of soil sulphur is metal sulphide minerals that when exposed to weathering, S^{-2} oxidizes to SO_4^{-2} and uptake of sulfur into roots from the soil is almost exclusively as sulfate uptake (Havlin et al., 2005). Soils, which are deficient in sulphur, cannot their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields. It is possible to provide sulphur to plants through artificial nutrition. Incidental sulphur returns to soil is possible through farmyard manure and the use of conventional sulphur containing fertilizers, such as ammonium sulphate , ammonium phosphate sulphate, potassium sulphate, gypsum and Elemental sulphur (90-99% S).

The aim of this experiments in south of Iraq (Basrah province) is to assess the response of different vegetable crops (tomato and onion) to added sulphur to increased growth and yield of these plants and availability of S in soil .

MATERIALS AND METHODS

A field experiment was carried out of Basrah province, south of Iraq at Al-Burjsia region ($30^{o}21^{-}56^{=}$N, 47^{o} 38^{-} $23^{=}$E) 21 km west of Basrah center, during the growing season of 2019 - 2020 to study the effect of elemental sulphur on performance of onion and tomato Plants. A composite surface soil samples(0-30 cm)were collected from experimental sites, air-dried, passed through 2mm sieve, then physio-chemical properties of soils were measured according to methods described in Richards (1954) and Page et al.(1982)and listed in table 1.

Table 1: Some physio-chemical properties of used soil

Property	Value		Unit
pH(1:1)	**7.46**		**-**
EC(1:1)	**10.93**		**dSm^{-1}**
Organic matter	**7.65**		**gm kg^{-1}**
Available-P	**20.46**		**mg kg^{-1}**
Available-K	**151.50**		
Available-Mg	**35.0**		
Available-SO_4^{-2}	**5.52**		
Soil particles			
Sand	**831.00**		**gm kg^{-1}**
Silt	**106.00**		

Clay	**63.00**		
Texture	**Loamy sand**		

Elemental sulfur was extracted from gas emission associated with oil production of Basrah oil fields. Two elemental sulphur levels were used (0 and 80 kg S ha^{-1}) with four replicates for each treatment. Onion (Allium cepa L., var. Crestal) and tomato (Solanumlyco persicum L., var. Yassamin) were used. Each treatment was replicate four times.The trial was carried out in private farm under randomized complete design for each crop. Field plowed perpendicularly. For both crops, the individual plots were a single row of 4m long and 0.4m width. Row spacing was 2.5 m, and plant density was 28 plant per plot. Cattle manure was applied for all plots at rate of 20 tons ha^{-1} by mixing method with 20cm upper layer of the row. Some characteristics of manure were assayed by using routine procedures describe table in Page et al.(1982)and listed in table 2. Whole amount of elemental S was applied by mixing with upper 20 cm layer. The manure and the elemental S were applied at 15 days before transplanting with continuous irrigation. Onion bulbs and tomato seedlings were transplanting to the field on 1st Nov. and 15th Oct., 2019 respectively. Nitrogen fertilizer (250 kg N ha^{-1} as urea 46% N) was added in equal doses at 10 days regular interval until 1st Dec. 2019, while phosphorus fertilizer (125 Kg P_2O_5 ha^{-1} as DAP 21%P) was added in equal dose at 15 days regular interval with 1st Dec. Well water was used for plants irrigation. Water characteristics were determined according to methods outlined by Standard Methods(APHA,2017)and listed in table 3 .All standard local practices were followed all over the season.

Table 2: Some properties of organic residue (cattle manure) used in experiment

E.C (1:5) dSm^{-1}	**pH (1:5)**	**O.M (%)**	**Total N ppm**	**Total P ppm**	**Total K ppm**	**Total Mg ppm**	**Total S ppm**	**Soluble ppm**		**C/N ratio**	**Bulk density Mg m^{-3}**
								P	**K**		
14.80	**7.32**	**39.40**	**19100**	**9920**	**11120**	**1350**	**2600**	**4.65**	**11.54**	**11.96**	**0.8**

Table 3: Some water characteristics of irrigation water used

Property		**Value**		**Unit**
		Nov.2019	**Feb.2020**	
pH		7.10	7.25	-
EC(iw)		1.2	1.0	dS m^{-1}
Soluble ions	Calcium	2.75	2.65	Mmole L^{-1}
	Magnesium	2.67	2.45	
	Sodium	2.08	2.00	
	Potassium	0.2	1.87	
	Sulfate	3.3	3.2	
SAR		0.893	0.890	

At full maturity stage, onion bulbs and tomato fruits were collected from eight plants for each plots for estimating water content by recording fresh weight and dry weight after oven drying

at 70^{o} C, then water content was calculated by subtracting the dry weight from the fresh weight.

Sub-samples of dried bulbs and tomato fruits were used to determine total N and S .For S determination ,samples were digested with acid mixture of HNO_3+$HClO_4$(Karla,1998),then S assayed spectrophotometry as described in Page et al.1982). For N determination, samples were digested with acid mixture of H_2SO_4+ $HClO_4$ (Cresser and Parsons, 1979), then N assayed by steam distillation procedure (Bremner, 1970).N/S ratio in bulb and fruit was calculated

Ascorbic acid content was estimated in fresh tomato fruits at full maturity stage by using 6% oxalic acid and titration with 2, 6 dichloro phenol indo phenol as described in AOAC(1970).Total weight of onion bulbs and tomato fruits for each plot were recorded for estimating total yield.

For each crop data were analyzed with analysis of variance (ANOVA) using GenSat procedure Library release PL.18.2 program. Differences among mean were evaluated with least significant differences test at 5% significant level.

RESULTS AND DISCUSSION

SULFUR CONCENTRATION

The results of tomato and onion plants indicated that application of elemental sulphur (80 kg S ha^{-1}) had a positive significant effect on sulfur concentration in tomato fruits and onion bulb, to reach 0.30%, 0.60% ,respectively . While its concentration in control treatments for studied crops were 0.22%, 0.42%, respectively with increasing percent 36.36%, 42.86%, respectively(tables 4 and 5). The addition of sulphur increased sulfate availability in soils, which induce plants to absorb it from soils, and increased crops tissues from sulfur.

Table 4: Effect of elemental sulphur on yield and fruits quality of tomato

Treatments	N%	S%	N/S	Fruits Yield (ton ha^{-1})	Ascorbic acid (mg $100gm^{-1}$ F.W)	Fruits water content (%)
S0	1.81b	0.220b	8.23	45.12b	18.25b	91.24a
S1	2.57a	0.300a	8.57	50.92a	24.00a	92.49a

S0: No addition of sulphur , **S1**: 80 Kg S ha^{-1} of Sulphur; differences letters indicated significant differences between means at level of 0.05.

Table 5: Effect of Sulphur on yield and bulb quality of onion

Treatments	N%	S%	N/S	Bulb yield (kg ha^{-1})	Bulbs water content (%)

S0	1.85b	0.420b	4.40	3100b	89.26a
S1	2.66a	0.600a	4.43	4166a	89.45a

S0: No addition of Sulphur ,**S1** : 80 Kg S ha^{-1}; differences letters indicated significant differences between means at level of 0.05 .

NITROGEN CONCENTRATION

Nitrogen concentration in tomato fruits and onion bulbs were affected by addition of elemental sulphur (Tables 4 and 5). The effects were significant at both plants with an increase percent 41.98 and 43.78 % for tomato and onion, respectively. The poitive effect of elemental S on N concentration may be attributed to an increase in soil N availability due to reduction in soil pH , and consequently reduce ammonia volatilization . The acidifying role of elemental S results from its microbial oxidation to sulphuric acid over time (Vidyalakshmi et al., 2009). Rahman et al. (2011) stated that in alkaline soils, decrease pH increased the availability of nutrients, as well as sufficient S is essential to prevent undesired N losses due to reduced nitrogen utilization. According to Potarzycki(2003), using of sulfur affects the greater the accumulation of N in the grain .T agreed with the finding of Motior et a.(2011) who found that increased N content in cucumber was obtained by element S application.

NITROGEN-SULPHUR RATIO(N/S)

In simplest form, the use of ratios in the interpretation of plant analysis results involves the evaluation of two essential elements together recognizing the effect of one element on the other. The most commonly used ratio is N: S (Nitrogen to Sulfur). The ideal N:S ratio for most crops is 10–15. As the N: S ratio approaches and exceeds 18, sulfur is limiting in relation to nitrogen .

The concentration of S is often used as indicator of S nutrition status in plants .It has been established that for every 15 parts of N in protein there is 1 part of S which implies that the N:S ratio is fixed within a narrow range of 15:1. The N: S ratio in the whole plant in general is 20:1 (Cram, 1990). The N:S ratio should be between 10 and 15 for optimum yields. Maintain the N: S ratio between 5:1 and 15:1(onion).

Results in tables 4 and 5 indicating that increasing rate of sulphur level to (80kg ha^{-1}) significantly increased sulfur and nitrogen contain of tomato fruits and onion bulb. The concentration of S in tomato fruits and onion bulb influenced by nitrogen – sulfur interaction, the usage of N/S ratio is better. Without added slphur, the N/S ratio of tomato fruits and onion bulb was 8.23 and 4.40, respectively. Adding sulphur increased slightly in tomato fruits and onion bulbs to reached 8.57 and 4.43, respectively.

The total S content in plant tissues varies among plant species. In current study tomato fruits and onion bulbs, the values of N/S increased with increasing of sulphur application, this results agree with results of Silva (2014). The ideal N:S ratio for most crops is 10 – 15. As the N:S ratio approaches and exceeds 18, sulfur is limiting in relation to nitrogen. The N: S ratio can be high when both nitrogen and sulfur concentrations are within the sufficiency ranges for these elements .

ASCORBIC ACID

Ascorbic acid content in tomato fruits significantly increased with addition of elemental sulpur as compared with control treatment (Table 4). The mean values were 24.00 and 18.25 mg g^{-1} F.W. for addition and without addition of sulphur , respectively. Ascorbic acid considered being of most important antioxidant in tomato plants which plays a major role in the adaptation of plants to stress condition. There are several factors affecting ascorbic acid content such as genetic background, environmental condition, seasons and a biotic stress (Dumas et al., 2003). Al-Zoaby (1985) stated that appropriate chemical fertilizers resulting in an increase in leaf area and carbohydrate production, then increase ascorbic acid levels in tomato fruits. Many studies have suggested that ascorbic acid content positively correlated with growth vigor and production of carbohydrates in plant (IPI, 2000; Qadri et al., 2015). Abdelgawad et al. (2019) also found that plant height, steam diameter, leaf number and yield of tomato were significantly correlated with ascorbic acid content in fruits.

In this study, the higher percentage of nitrogen (%N) and higher percentage of sulfur(S %) with high fruit yield were correlated in treatment of addition of sulphur, which recorded high content of ascorbic acid (Table 4), indicating a positive correlation between growth parameters and ascorbic acid content. This finding is in accordance with Yeboah (2011) and Abdullah and Kadim (2016) who reported that the addition of S increased ascorbic acid contents in tomato fruits. Abdullah and Kadim (2016) found that addition of 250 and 500 kg S ha^{-1} as elemental S increased ascorbic acid content in tomato fruits of 7.41 and 14.46%, respectively due to improvement of vegetative growth and increasing photosynthetic activity.

WATER CONTENT

Results of tables 4 and 5 indicated that there were no significantly differences of addition sulphar on water content of tomato fruits and onion bulbs. Water content of tomato fruits were 91.24 and 92.49% and for onion bulbs were 89.26 and 89.45% for control and 80 kg S ha^{-1} , respectively. These insignificant differences may attributed to high water supply by drip irrigation system for both crops as well as using polyethylene cover for tomato, which led to an increase of water content and covered the effect of sulfur addition in term of water content. Al-Hamadan and Al-Sadon (2004) stated that plants grown under high moisture conditions, such as under covering, resulting in high water content in fruits. Water content of vegetables crops is one potential criteria, which affects fruit quality because its effect on respiration and metabolic processes by decomposition of carbohydrates and fats (Kader et al., 1987). Our finding coincide with the finding of Abdullah and Kadim(2016)who found that addition of S had no significant effect on dry matter of tomato fruits as compared with control.

YIELD OF BULBS AND FRUITS

Application of Sulphur at rate of 80Kgha^{-1}had a significant effect on yield of tomato and onion (Tables 4 and 5). Yield was increased by 12.85 and 34.38 % with respect to the control treatment of tomato fruits and onion bulbs, respectively. This increase may be attributed to that application of S had an essential effect on yield by contributing to the appropriate

content of S and N , the development of shoot parts and the formation of root system (Podlesna , 2013) . Fotyma(2003) also emphasizes that S increases crop yield indirectly by influencing N transformation in the plant. The interaction of S and N at the levels needs of many plant metabolic processes is reflected in crop development, then affects yield level and quality. In our study , it can be seen from tables 4 and 5 that yield well correlated with S and N concentrations in fruits and bulbs . This result coincide with the findings Abdel Hafeez and Ewees (2018) for tomato and Meher et al.(2016) for onion.

CONCLUSIONS

1. Elemental S produced from emitted gas of oil production processes can be used successfully as a source of S to plants**.**
2. Application of sulphur at rate of 80 kg S ha^{-1} increased yields of tomato and onion, as well as enhanced yield quality.
3. The application of Sulphur fertilizer accompanied with increasing N and S availability and uptake for maximizing yield quality of crops.
4. Desert calcareous soils of Basrah region have a positive response to addition of Sulphur fertilizer at rate of 80 kg S ha^{-1}.

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