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Effects of elemental sulphur and organic manure on sulphur, zinc, and total chlorophyll contents of tomato in a calcareous sandy loam soil

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Abstract

A pot experiment was conducted to study the influence of elemental sulphur (S) and farmyard manure on sulphur (S), zinc (Zn) and total chlorophyll contents of tomato (*Lycopersicum esculentum*) grown in a calcareous sandy loam soil. Elemental sulphur and farmyard manure were mixed to the soil at six rates (0, 50, 100, 150, 200, 400 mg kg^{-1}), and two rates (0, 3 tones da^{-1}) respectively according to completely randomized design factorial with 4 replicates. After the experimental set up, soil samples were taken at 2 different periods to examine the rate of change of pH and EC. 3 weeks after applications, tomato seedlings were planted and 8 weeks later, the plants were harvested to determine the sulphur, zinc, total chlorophyll contents, and dry matter yield (g pot^{-1}).

Sulphur and farmyard manure applications reduced soil pH while it increased soil EC. These effects were particularly determined in the 1st soil sampling period (3 weeks after mixing the application materials with the soil) and the highest sulphur level. In the tomato plant, the effects of application materials were not significant on dry matter yield. Sulphur and total chlorophyll contents were increased and Zn content was decreased by the sulphur applications. However, farmyard manure applications reduced Zn and total chlorophyll contents and it did not affect the S content in the plant.

Introduction

High pH and the presence of $CaCO_3$ usually result in reduced micronutrients availabilities in soils. Elemental sulphur, which is biologically oxidized to H_2SO_4 under aerobic conditions. The oxidation of S to H_2SO_4 is particularly beneficial in alkaline soils to reduce pH, supply SO_4 to plants, make P and micronutrients more available, and reclaim soils (Burns, 1967). However, the response to sulphur amendment is unpredictable (Lindemann et al., 1991). Although improvement of micronutrient availability with sulphur application in calcareous soils, the response is often depend on the amount of $CaCO_3$ present (buffering capacity). No improvement was observed in studies in New Mexico (Lindemann et al., 1991); in these soils, sulphur was not completely oxidized, and H_2SO_4 produced was quickly neutralized by $CaCO_3$.

On the other hand, biomass, organic amendments and soil organic C content have been related to sulphur oxidation rates (Wainwright et al., 1986; Janzen and Bettany, 1987; Lawrence and Germida, 1988) suggesting that an increase in heterotrophic sulphur –oxidizer numbers following the additon of an organic substrate enhances sulphur oxidation. In calcareous soil with organic matter, addition of organic matter with sulphur stimulates sulphur oxidation (Cifuentes and Lindemann, 1993).

In this study, our objectives were to determine the influence of elemental sulphur (S) and farmyard manure on sulphur (S), zinc (Zn) and total chlorophyll contents of tomato (*Lycopersicum esculentum*) grown in a calcareous sandy loam soil.

Materials and Methods

A calcareous sandy loam soil was used in this experiment. Selected soil chemical and physical properties are given in Table 1.

Table 1. Physical and chemical properties of soil used

Parameter	Soil
Sand (%)	63.52
Clay (%)	18.48
Silt (%)	18
Texture	Sandy loam
PH	7.80
$CaCO_3$ (%)	18.92
EC (dS m^{-1})	2.07
Organic matter (%)	2.27
Total N (%)	0.049
Extractable-SO_4 (mg/kg)	2.40
DTPA-extractable Zn (mg kg^{-1})	3.02

Soil was air dried and passed through a 4 mm sieve. Elemental sulphur and farmyard manure were mixed to the soil at six rates (0, 50, 100, 150, 200, 400 mg kg^{-1}), and two rates (0, 3 tones da^{-1}) respectively according to completely randomized design factorial with 4 replicates. 3 weeks after applications, tomato seedlings were planted. During the growing period; 8.5 kg N da^{-1} (NH_4NO_3, 33 %), 3.7 kg P_2O_5 da^{-1} (MAP, 61 % P_2O_5), 10 kg K_2O da^{-1} (KNO_3, 46 % K_2O), 0.62 kg MgO da^{-1} ($MgNO_3$, 16 % MgO) and 1.73 kg microelement fertilizer da^{-1} (Hortrilon, 5 % Fe, 2.5 % Mn, 0.5 % Zn, 2.5 % Cu) were applied each pot. 8 weeks later, the plants were harvested to determine dry matter yields (g pot^{-1}), total chlorophyll contents (Williams, 1984) and the concentrations of sulphur (by using the turbidimetric $BaSO_4$ method) and zinc in dried shoots after wet digestions (Kacar, 1972).

The soil samples were taken at 2 different periods (3 weeks after the applications and at the harvest of tomato plant) to examine the rate of change of pH and EC.

The soil pH was measured in H_2O (1:2.5 soil:deionized water) and the soil EC value was determined directly on the saturation paste. The soil particle size analysis was done by using the hydrometer method (Bouyoucos, 1965) and the $CaCO_3$ content was determined by using a Schibler calcimeter. Organic matter was determined by using modified Walkley-Black Procedure (Black, 1965). The total nitrogen of soil was done by using modified Kjeldahl Procedure (Kacar, 1995). The extractable-SO_4-S of soil was determined by using the turbidimetric $BaSO_4$ method (Kacar, 1995). The DTPA soil test of Lindsay and Norvell (1978) was used to determine Zn content of the soil.

The data were analyzed by standart ANOVA procedures and their significances were always based on the $p<0.05$ level using the LSD tests.

Results and Discussion

Soil pH was highly significant ($p<0.01$) under the applications of sulphur, farmyard manure and S*F.Y.M. Both 1st and 2nd soil sampling period, soil pH was reduced by the sulphur and farmyard manure applications. Soil EC was significantly affected by the sulphur applications and it increased. These effects were particularly determined the highest sulphur level (Table 2). Addition of sulphur to two calcareous soils was found to significantly decrease the soil pH and increase the salinity (Abo-Rady et al., 1988). Similar results were reported by Kaplan and Orman (1998) such that while the soil pH was increased, soil EC was increased in the calcareous soil by the sulphur applications. The generated salinity was high after three weeks of sulphur application, which means that plants growing in such soils were faced high salinity problems for a long time.

In the tomato plant, the effects of application materials were not significant on dry matter yield. Sulphur and total chlorophyll contents were increased and Zn content was decreased by the sulphur applications. However, farmyard manure applications reduced Zn and total chlorophyll contents and it did not affect the S content in the plant (Table 3). Knudsen and Pedersen (1993) reported that the response to S was lower on the lightest soil in trials with applications of organic manure. However, reponses to additional applications of inorganic S remained high. On the soils with high clay contents, they discovered no relationship between an application of organic manure and the responses to inorganic S. They concluded that an application of organic manure did not prevent a S deficiency. Procopiu et. al (1976) indicated that zinc concentration in plants was reduced by the highest sulphur applications to soil. Topcuoğlu and Yalçın (1997) founded that total chlorophyll content in tomato plants was increased by the elemental sulphur applications to calcareous soil.

Table 2. Effects of different sulphur (S) levels with and without farmyard manure (F.Y.M) on soil pH and EC values

S Applied (mg kg^{-1})	pH						EC (dS m^{-1})					
	1st soil sampling			2nd soil sampling			1st soil sampling			2nd soil sampling		
	F.Y.M.0 0 (ton da^{-1})	F.Y.M.1 3 (ton da^{-1})	Means	F.Y.M.0 0 (ton da^{-1})	F.Y.M.1 3 (ton da^{-1})	Means	F.Y.M.0 0 (ton da^{-1})	F.Y.M.1 3 (ton da^{-1})	Means	F.Y.M.0 0 (ton da^{-1})	F.Y.M.1 3 (ton da^{-1})	Means
S_0 (0)	8.03 a[1],**A**[2]	7.85 a,**B**	7.94	7.92 a, **A**	7.93 a, **A**	7.93	4.20	4.59	4.39 d	2.38	2.60	2.49 e
S_1 (50)	7.83 b,**A**	7.81 b,**A**	7.82	7.80 bc,**B**	7.91a, **A**	7.86	5.06	4.58	4.82 c	2.91	3.03	2.97 d
S_2 (100)	7.76 c,**A**	7.76 cd,**A**	7.76	7.83 b, **B**	7.91 a, **A**	7.87	5.45	5.10	5.28 b	3.38	3.39	3.38 c
S_3 (150)	7.77 c,**A**	7.77 c,**A**	7.77	7.83 b, **A**	7.84 b, **A**	7.84	5.30	5.85	5.58 b	3.57	4.03	3.80 b
S_4 (200)	7.78 c,**A**	7.73 d,**B**	7.76	7.82 b, **A**	7.82 b, **A**	7.82	5.49	5.62	5.56 b	3.72	4.26	3.99 b
S_5 (400)	7.65 d,**A**	7.66 e,**A**	7.66	7.77 c, **B**	7.81 b, **A**	7.79	6.00	6.46	6.23 a	4.46	4.83	4.64 a
Means	7.80	7.76		7.83	7.87		5.25	5.37		3.40 **B**	3.69 **A**	
ANOVA[3]												
Sulphur (S)	**			**			**			**		
Farmyard manure (F.Y.M)	**			**			N.S.			**		
S*F.Y.M	**			**			N.S.			N.S.		

[1]Means in the same column followed by the same letter are not significantly different at 5 % probability level by LSD test.
[2]Means in the same row followed by the capital and bold same letter are not significantly different at 5 % probability level by LSD test
[3]Significance levels: *** $p<0.001$; ** $p<0.01$; N.S. $p>0.05$

Table 3. The concentrations of S, Zn, total chlorophyll and shoot dry matter yields of tomato plant grown in different sulphur (S) levels with and without farmyard manure (F.Y.M)

S Applied (mg kg^{-1})	S (%)			Zn (mg kg^{-1})			Total chlorophyll (mg g^{-1})			Shoot dry matter yield (g pot^{-1})		
	F.Y.M.$_0$ 0 (ton da^{-1})	F.Y.M.$_1$ 3 (ton da^{-1})	Means	F.Y.M.$_0$ 0 (ton da^{-1})	F.Y.M.$_1$ 3 (ton da^{-1})	Means	F.Y.M.$_0$ 0 (ton da^{-1})	F.Y.M.$_1$ 3 (ton da^{-1})	Means	F.Y.M.$_0$ 0 (ton da^{-1})	F.Y.M.$_1$ 3 (ton da^{-1})	Means
S_0 (0)	0.41	0.49	0.45 bc[1]	65.65	48.15	59.60 a	4.69	3.82	4.25 b	49.16	52.47	50.81
S_1 (50)	0.41	0.42	0.42 c	44.55	41.55	43.05 bc	5.96	3.92	4.94 ab	56.50	54.05	55.27
S_2 (100)	0.53	0.50	0.51 ab	47.20	41.10	44.15 bc	5.04	3.76	4.40 b	55.59	55.14	55.36
S_3 (150)	0.53	0.45	0.49 ab	41.75	37.55	39.65 c	4.75	3.77	4.26 b	54.67	56.12	55.40
S_4 (200)	0.52	0.46	0.49 ab	54.45	42.85	48.65 ab	6.98	4.06	5.52 a	55.32	55.43	55.37
S_5 (400)	0.59	0.50	0.55 a	64.40	42.35	53.38 a	4.62	3.97	4.29 b	54.53	53.66	54.09
Means	0.49	0.47		53.00 **A**[2]	42.26 **B**		5.34 **A**	3.88 **B**		54.29	54.48	
ANOVA[3]												
Sulphur (S)	**			**			*			N.S.		
Farmyard manure (F.Y.M)	N.S.			**			**			N.S.		
S*F.Y.M	N.S.			N.S.			N.S.			N.S.		

[1]Means in the same column followed by the same letter are not significantly different at 5 % probability level by LSD test.
[2]Means in the same row followed by the capital and bold same letter are not significantly different at 5 % probability level by LSD test
[3]Significance levels: *** $p<0.001$; ** $p<0.01$; N.S. $p>0.05$

Conclusions

Sulphur and farmyard manure applications reduced soil pH while it increased soil EC. These effects were particularly determined in the 1st soil sampling period (3 weeks after mixing the application materials with the soil) and the highest sulphur level. In the tomato plant, the effects of application materials were not significant on dry matter yield. Sulphur and total chlorophyll contents were increased and Zn content was decreased by the sulphur applications. However, farmyard manure applications reduced Zn and total chlorophyll contents and it did not affect the S content in the plant.

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