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Influence of elemental sulfur on nutrient uptake, yield and quality of cucumber grown in sandy calcareous soil

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Abstract

This study was carried out to investigate the effect of elemental sulfur (S^0) and sulfur oxidizing bacteria (*Paracoccus versutus*) on nutrient uptake, yield and quality of cucumber grown in sandy calcareous soils. Both elemental sulfur powder (S^0P) and pellets of sulfur powder-Tiger 90 (S^0T) were applied at rates of 0, 1, 5 and 10 t/ha at Al Hamraneya. On the contrary, S^0P was used at rates of 0, 1, 5 and 10 t/ha combined with or without *Paracoccus versutus* (*Pv*) at Al Kuwaitat, United Arab Emirates (UAE). Higher concentrations of N, P, S, Mn and Zn in leaves and yield of cucumber at both locations were obtained with application of S^0 at rates of 5 and 10 t/ha. Total soluble sugar (TSS) content and vitamin C was higher with the application of S^0 at rates of 5 and 10 t/ha. Application of *Pv* individually or with varying levels of S^0P had no positive effect on nutrients uptake, yield and quality of cucumber. A positive correlation was observed between shelf life and vitamin C. At Al Hamraneya S^0P performed better than S^0T. The results reveal that application of S^0P at the rate of 5 t/ha in sandy calcareous soils can enhance the nutrients uptake ability, increase yield and superior quality of cucumber at both locations in UAE.

Keywords: Calcareous soil, Elemental sulfur, Nutrients, Quality, Yield.
Abbreviations: N-nitrogen, Pv-*Paracoccus versutus*, S^0-elemental sulfur, S^0T-pellets of sulfur powder-Tiger 90, S^0P-elemental S powder, TSS-total soluble sugar, DAS-days after storage, UAE-United Arab Emirates.

Introduction

The cucumber (*Cucumis sativus* L.) is an annual herbaceous plant and can grow in different kinds of soil, but prefers light and humus-rich soils. Cucumber is a heat and moisture loving plant and moderately sensitive to soil salinity. It is characterized by high depletion of soil nutrients, particularly K and N. For the proper soil nutrient balance, it is very important to apply adequate amount of S in the soil along with other plant nutrients (Scherer, 2001). The role of S in soil is very crucial for plant growth and nutrition for optimizing crop yield and quality (Jez, 2008). High yields of good quality produce become possible only when crops have access to optimum amounts of S. The role of S in plants is to help in the formation of plant proteins, and it is essential for the formation of chlorophyll and improves root growth. Sulfur is involved in the formation of vitamins and enzymes required for the plant to conduct its biochemical processes (Scherer et al., 2008). Sulfur deficiency in the soil can not only reduce grain yield and quality of produce but also make a sharp impact in agro-based economy (Fismesa et al., 2000). Sulfur is accumulated in plants in low concentrations compared to N, but is an essential element as a constituent of proteins, cysteine-containing peptides such as glutathione, or numerous secondary metabolites (Scherer et al., 2008; Abdallah et al., 2010) and synthesis of vitamins and chlorophyll in the cell (Kacar and Katkat, 2007). The biochemical oxidation of S^0 produces H_2SO_4 which decreases soil pH and solubilizes $CaCO_3$ in alkaline calcareous soils to make soil conditions more favorable for plants growth including the availability of plant nutrients (Lindemann et al., 1991; Abdou, 2006; El-Tarabily et al., 2006). The agronomic effectiveness of reduced S fertilizer is directly related to oxidation rate that provides plant available sulfate following application. Elemental S is an insoluble hydrophobic particle that is dependent on microbial colonization of its surface and subsequent oxidation rates of S^0 is slow in cold and dry soils (Malhi et al., 2005a). Substantial information on S nutrition of plant is available (Fismesa et al., 2000) but the data related to S application in cucumber is insufficient in sandy calcareous soils of UAE. The role of S^0 as a soil amendment and as an essential nutrient to crops grown in calcareous sandy soils in arid region needs further exploration. Based on these observations, sufficient supply of S is required to maintain the optimum growth and nutrient uptake ability of plants. Therefore, the present study was undertaken to investigate the impact of increasing levels of S^0 fertilization on growth and nutrient uptake, yield and quality of cucumber grown in sandy calcareous soils of UAE.

Materials and methods

Experimental design, site and management

The greenhouse trails were carried out at Al-Kuwaitat, Al Ain (24°12′27″N 55°44′41″E) and Al Hamraneya, Ras-Al Khaimah (25°47′N 55°57′E) experiment stations, UAE. Physico-chemical properties of the soil are listed in Table 1. In this study two forms of S^0 such as elemental S powder (S^0P) and elemental S pellets (S^0T) at rates of 0, 1, 5 and 10 t ha^{-1} were used. Elemental S powder particle size was <150 μm and collected from TAKREER Company, Ruwais, Abu Dhabi, UAE. Elemental S pellets composed with 90% S and 10% bentonite (trade name:Tiger 90) and collected from Tiger Resources Technology Inc. Canada. Whole amount of S^0 fertilizers were applied at seven days before planting cucumber seeds and mixed thoroughly into soil as per treatment schedule. Local S-oxidizing bacteria *Pv* (CBS 114155) was used which was previously isolated from the western regions of the UAE (El-Tarabily et al., 2006). The *Pv* was added with 50 g of colonized peat moss and thoroughly dispersed in the soil supplement and applied into each plant in the respective treatments. Nitrogen, P and K fertilizers were applied at the rate of 200-100-200 kg/ha, respectively. Nitrogen 1/3, P and K fertilizers were applied as basal dose. The remaining 2/3 N fertilizer was applied as top dressing at the rate of 30-50 kg/ha at 30 days regular interval until end of the experiment. The experiment was carried out under randomized complete block design with four replications. Each unit plot was saturated by irrigation water for proper germination of seeds and plant growth. Line to line and plant to plant distance were maintained 1-m x 0.5-m, respectively. About 3-5 seeds of cucumber were planted in each spot and after germination one seedling was kept to determine yield and quality of cucumber.

Plant nutrient analyses

At flower initiation stage, 60 well developed upper leaves were collected randomly for nutrient analysis. Collected leaves were dried at 72°C for 48 hours. The dry leaves were crushed and passed through 20-mesh stainless steel sieve. Samples were digested by the dry ashing method as described by Jones and Case (1990). Total content of Fe, Mn and Zn were determined by using an atomic absorption spectrophotometer (Varian, model SpectrAA 220 FS). Sulfur content was measured using an ICP-AES (Varain model Vista MPX). Phosphorus was determined calorimetrically (Kuo, 1996) and N in leaves was determined after the wet digestion according to Jones and Case (1990) by steam distillation using the semi automatic Kjeldahl method. Fresh fruit harvesting was done several times and converted into kg/m^2.

Determination of cucumber quality

Cucumber quality was determined based on fresh dry matter percent, total soluble sugar (TSS) content, acidity and vitamin C contents in fresh cucumber and at 3 DAS which was designated as shelf life, respectively. Cucumber quality was determined from Al Kuwaitat only. Random samples of 20 edible size cucumbers were picked from each treatment of all replications and divided into two groups. Each group of 10 cucumbers per treatment was used for shelf life evaluation and the other 10 fruits were used for quality determination. Total soluble sugar concentration was measured in fruit juice with a hand refractometer. Acidity was determined from the juice by titrating with 0.1 N NaOH in the presence of phenolphthalein as an indicator (Ranganna, 1979) and the results were expressed as percentage of citric acid. Ascorbic acid concentration (vitamin C) was measured according to Ranganna (1979) by the oxidation of ascorbic acid with 2, 6 dichlorophenol indophenols dye and the results were expressed as mg/100 ml juice.

Statistical analysis

Statistical analysis was carried out by one-way ANOVA using general linear model to evaluate significant differences between means at 95% level of confidence. It was performed using the Statistical Analysis System (SAS, 2003). Following the differences among treatment means were determined using the Duncan's New Multiple Range Test (DMRT) comparison method. MS Excel was used for graphical presentations.

Results

Nitrogen, P, S, Fe, Mn and Zn concentration in cucumber leaves at Al Kuwaitat

Nitrogen, P, S, Fe, Mn and Zn concentrations of cucumber leaves were affected significantly by the treatment variations (Table 2). Higher N concentration in leaves was obtained with application of S^0P at rates of 5 and 10 t/ha. No significant differences were found with application of S^0P at the rate of 1t/ha individually and S^0P at the rate of 10t/ha combined with *Pv*. Minimum N concentration in cucumber leaves was recorded by control and *Pv* treatment. Phosphorus concentration of leaves was higher with the application of S^0P regardless of levels and S^0P at rates of 5 and 10 t/ha combined with *Pv*. Minimum P concentration of leaves were observed among control, *Pv* alone and S^0P at the rate of 1 t/ha combined with *Pv*. Higher S concentration in cucumber leaves was recorded with application of S^0P at rates of 5 and 10 t/ha individually and S^0P at rates of 10 t/ha combined with *Pv*. No significant variations were found among control, *Pv* and S^0P at the rate of 10 t/ha individually and S^0P at rates of 1 and 5 t/ha combined with *Pv*, respectively (Table 2). Maximum Fe concentration in cucumber leaves was obtained with the application of S^0P at rates of 5 and 10 t/ha individually and S^0P at the rate of 10 t/ha combined with *Pv*. No differences were observed among S^0P at the rate of 1 t/ha individually and S^0P at rates of 1 and 5 t/ha combined with *Pv*. The lowest Fe concentration of leaves was recorded from control treatment. Manganese concentration in leaves was higher with application of S^0P at rates of 5 and 10 t/ha individually. Lower concentration of Mn in leaves was recorded by control and *Pv*. Higher Zn concentration of leaves was recorded by S^0P at rates of 5 and 10 t/ha and S^0P at the rate of 5 t/ha combined with *Pv*. Minimum Zn concentration of leaves was found in control and *Pv* treatment (Table 2).

Nitrogen, P, S, Fe, Mn and Zn concentration and yield of cucumber at Al Hamraneya

Nitrogen, P, S, Fe, Mn and Zn concentrations in cucumber leaves were significantly influenced with application of both S^0P and S^0T. Maximum N concentration of leaves was obtained with application of both S^0P and S^0T at rates of 5

Table 1. Soil properties of green houses in Al Hamraneya and Al Kuwaitat.

Soil properties	Al Hamraneya soils	Al Kuwaitat soils
EC (d Sm^{-1})	11.07	4.43
pH	7.53	7.28
Total $CaCO_3$ %	43.48	31.64
Active $CaCO_3$ %	5.60	3.60
O.C. %	0.17	1.41
Texture:		
Sand %	86.62	99.73
Silt + clay %	13.38	0.27
Soluble cations (meq L^{-1}):		
Ca	44.20	27.20
Mg	51.80	23.60
Na	75.41	25.58
K	5.69	2.15
Soluble anions (meq L^{-1}):		
Cl	65.00	15.60
SO_4	9.80	16.41
HCO_3	63.20	15.20
CO_3	1.60	0.00

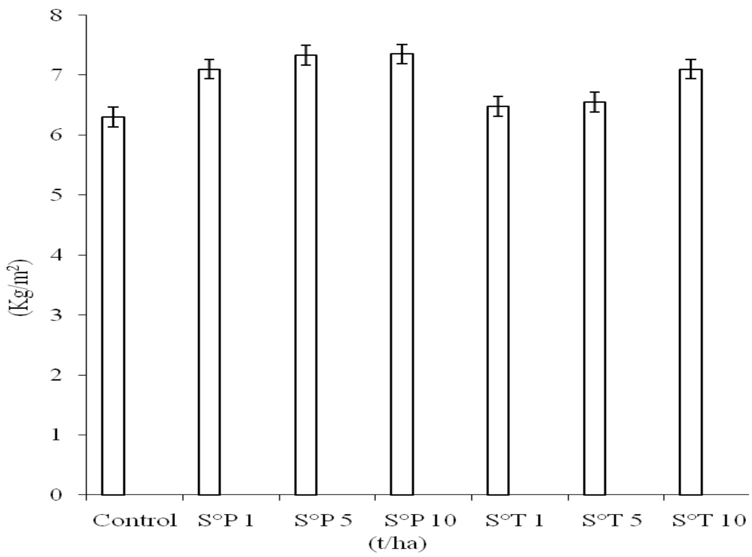

Fig. 1. Fruit yield of cucmber as affected by elemental S at Al Hamraneya, S°P= elemental sulfur powder, S°T= elemental sulfur Tiger 90; Error bars denoted SE±

and 10 t/ha. The lowest N concentration of leaves was recorded in the control treatment. Phosphorus concentration of leaves was higher with application of S^0P at rates of 5 and 10 t/ha and S^0T at the rate of 10 t/ha. Minimum P concentration of leaves were observed in control and no significant differences were observed among *Pv*, S^0P at the rate of 1 t/ha and S^0T at rates of 1 and 5 t/ha. Maximum S concentration of leaves was obtained with application of S^0P at rates of 5 and 10 t/ha and S^0T at the rate of 10 t/ha. Minimum S concentration of leaves was recorded by control treatment (Table 3). Higher Fe concentration of cucumber leaves was obtained with application of S^0P at rates of 5 and 10 t/ha and it was significantly different from others. Control treatment and S^0T at the rate of 1 t/ha recorded minimum Fe concentration of leaves. Manganese concentration of leaves was higher with application of S^0P at rates of 5 and 10 t/ha and moderate concentration was observed from S^0T at rates of 5 and 10 t/ha. The lowest Mn concentration of leaves was recorded in control treatment. Maximum Zn concentration of leaves was recorded with application of S^0P at rates of 5 and 10 t/ha. The lowest Zn concentration of leaves was observed in control treatment (Table 3). Cucumber yield was influenced significantly with the application of both S^0P and S^0T. Maximum yield was produced with the application of both S^0P and S^0T at rates of 5 and 10 t/ha. Control treatment recorded minimum yield which was identical to S^0P at the rate of 1 t/ha and S^0T at rates of 1 and 5 t/ha (Fig. 1).

Yield and quality of cucumber at AL Kuwaitat

Cucumber yield was significantly influenced with the application of S^0P (Table 4). Maximum yield was obtained with the application of S^0P at rates of 5 and 10 t/ha individually. No significant differences were found among

Table 2. N, P, S, Fe, Mn and Zn contents in cucmber leaves as affected by elemental Sand sulfur oxidizing bacteria at Al Kuwaitat

Treatment	N (%)	P (%)	S (%)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Control	4.44e	0.37c	1.09c	68.97d	23.30bc	48.24c
Pv††	4.47e	0.37c	1.10bc	71.53c	23.90bc	48.92c
*S^0P 1 t/ha	4.69b	0.40ab	1.12b	74.57bc	24.73b	50.26b
S^0P 5 t/ha	4.78a	0.43a	1.14ab	80.70a	26.13a	52.79a
S^0P 10 t/ha	4.76a	0.44a	1.18a	81.23a	27.13a	52.46a
S^0P 1 t/ha+ *Pv***	4.56d	0.38c	1.07c	72.00c	24.47b	50.57b
S^0P 5 t/ha+ *Pv*	4.62c	0.41b	1.10bc	74.57bc	24.50b	51.86ab
S^0P 10 t/ha+ *Pv*	4.67b	0.43a	1.14ab	77.67b	25.33ab	50.07b

*S°P= elemental sulfur powder, **Pv-*Paracoccus versutus,*

Same letter (s) does not differ significantly at 5% level by Duncan's Multiple Range Test (DMRT)

S^0P at rates of 1 t/ha alone and S^0P at rates of 5 and 10 t/ha combined with *Pv*. The lowest yield was obtained from control treatment. Shelf life of cucumber fruit was determined using dry matter content (%) over time and it had significant effect on treatments variation. Just after harvest of cucumber fruit, maximum dry matter contents (%) were obtained by individual application of S^0P at rates of 1, *Pv* and control treatment. Minimum dry matter content was recorded with the application of S^0P at the rate of 10 t/ha singly or combined with *Pv* (Table 4). Dry matter content (%) increased at 3 DAS (shelf life) regardless of treatments and significantly higher dry matter content (%) was observed in S^0P at rates of 5 and 10 t/ha singly or combined with *Pv*. The TSS was affected significantly by treatments variation both at just after harvest and at 3 DAS. The concentration of TSS decreased with application of both S^0P alone or combined with *Pv*. Minimum TSS concentration were found in cucumber fruit when fertilized with S^0P at rates of 10 t/ha alone and combined with *Pv* (Table 4). The TSS concentration was increased significantly at 3 DAS with application of S^0P individually or combined with *Pv* while slightly decreased in *Pv* and control treatment. Acidity was influenced significantly by the treatments variation. After harvesting, the highest acidity was obtained with application of S^0P 10 t/ha followed by 5 t/ha combined with *Pv*. However, it increased slightly at 3 DAS in all treatments including control (Table 4). The concentration of vitamin C was affected significantly by the treatments. Higher vitamin C was obtained with application of S^0P singly regardless of levels. Regardless of treatments vitamin C concentration was increased significantly at 3 DAS (Table 4).

Discussion

Nitrogen is considered the major macronutrient required at early growth stages of cucumber and its translocation to the upper parts starts soon after N uptake by plant roots at the vegetative stage. On the contrary at the reproductive stage rapid N translocation into reproductive parts takes place to support fruit development. Therefore, emphasis was placed on nutrient concentration in the leaf and quality of cucumber fruit in the present study. Both forms of S^0 regardless of levels had a positive effect on leaf N concentration in cucumber. Application of S^0P and S^0T with varying levels increased significantly ($P<0.01$) the total N concentration of cucumber leaves compared to control plants. Higher application of both S^0P and S^0T produced significantly higher N concentration of cucumber leaves. The results coincide with the findings of Chaubey et al., (1993). They found that increased N contents of linseed grain and straw was obtained by S application in sandy loam soils. In this study, N concentration was comparatively higher with higher levels of S^0 application than the lowest level of S^0. N concentration was slightly higher at Al Hamraneya and this is probably due to the physicochemical properties of soil (Table 1) and considering soil fertility especially soluble cations and soil texture. For sustainable production of cucumber sufficient supply of S is necessary in order to produce good quality of fruit. Thus S application is not only important with cucumber growth but also necessary for fruit quality. Alike N concentration in leaves, higher levels of S^0 recorded superior P concentration of leaves. The results of the present findings clearly indicate that amendment of soil with higher levels of S^0P or S^0T had beneficial effects on P concentration in cucumber plants. Applications of S^0 in alkaline soils supplies SO_4 to plants and make P more available through oxidation (Cifuentes and Lindemann, 1993). Kaplan and Orman (1998) reported that addition of S^0 at the rate of 2 t/ha increased P uptake by shoots of sorghum plants grown in the pots or fields of calcareous soils in Turkey. Application of S at rates 0, 10, 20, 30 and 40 kg/ha to irrigated cotton and sunflower grown in rotation in sandy loam soil under field conditions showed increased yield for both crops and increased P content in cotton seeds (Singh and Kairon, 2001). The concentration of S in cucumber leaves increased at higher levels of S^0P application. Slightly higher S concentration in cucumber leaves was observed with application of S^0P than S^0T. This gap in S content in cucumber plant is probably attributed to the difference in particle size between S^0P and S^0T. Fine particles of S^0 have been an effective material for providing S for proper plant growth. Particle size of S^0 is one of the most important determinant factors for the rate of oxidation. The larger the particles size the slower the oxidation. Smaller particle size of the S^0 resulted in higher oxidation rates due to the increased surface area. Fine particles of S^0 are highly beneficial in calcareous soil to supply SO_4 and make nutrients more available. These results coincide with the findings of Lefroy et al., (1997). They observed that S uptake increased with application of fine particles of S than with the coarse particles. Application of S^0 in calcareous soil increased Fe concentration of cucumber leaves. Slightly higher Fe concentration (5.75–37.55%) of leaves was produced by S^0P than S^0T. Higher levels of S^0 having fine particles performed well in respect of Mn concentration in cucumber leaves. The results showed that S^0P was more effective in increasing Mn concentration comparing to S^0T. The fine particle of S^0P at rates of 1, 5 and 10 t/ha increased appreciably Mn concentration in the leaves, respectively compared with S^0T and control. Fe and Mn

Table 3. N, P, S, Fe, Mn and Zn contents in cucmber leaves as affected by elemental S at Al Hamraneya

Treatment	N (%)	P (%)	S (%)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Control	5.23d	0.39c	1.04d	73.50c	41.59d	43.38c
*S^0P 1 t/ha	5.27c	0.42b	1.12bc	78.73b	46.57c	49.93b
S^0P 5 t/ha	5.52a	0.45a	1.16a	83.86ab	51.56a	52.59a
S^0P 10 t/ha	5.58a	0.46a	1.18a	86.40a	53.11a	53.59a
**S^0T 1 t/ha	5.27c	0.42b	1.12bc	74.80c	46.63d	49.59b
S^0T 5 t/ha	5.53a	0.41b	1.10c	79.17b	49.83c	49.18b
S^0T 10 t/ha	5.54a	0.46a	1.14ab	81.60b	47.00b	50.41b

*S°P= elemental sulfur powder, **S°T= elemental sulfur Tiger 90

Same letter(s) does not differ significantly at 5% level by Duncan's Multiple Range Test (DMRT)

Table 4. Effect of elemental sulfur on yield, dry matter, total soluble sugar, acidity and vitamin C of cucumber fruits at Al Kuwaitat

Treatment	Yield (kg/ha)	Shelf life Dry matter (%)		Total soluble sugar (%)		Acidity (%)		Vitamin C (mg/100g)	
		AH†††	3 DAS†	AH	3 DAS	AH	3 DAS	AH	3 DAS
Control	8.95d	6.63a	6.65c	4.88a	4.83b	1.36c	1.51b	6.70cd	7.92d
Pv††	9.10c	6.65a	6.78c	4.88a	4.75b	1.39c	1.51b	6.71cd	8.36cd
S0P 1 t/ha	9.49b	6.73a	6.95bc	4.75b	4.83b	1.43bc	1.52b	7.37ab	8.2cd
S0P 5 t/ha	9.85a	6.26b	7.33ab	4.75b	4.88b	1.44bc	1.53b	7.33ab	8.51bc
S0P 10 t/ha	9.70a	5.80d	7.37ab	4.50d	4.88b	1.45bc	1.56ab	7.77a	9.75a
S0P 1 t/ha+ *Pv*	9.10c	5.67c	6.78c	4.83b	4.88b	1.36c	1.54b	6.01e	8.95b
S0P 5 t/ha+ *Pv*	9.30b	5.63c	7.50a	4.63c	4.87b	1.47ab	1.57ab	6.31de	9.39a
S0P 10 t/ha+ *Pv*	9.35b	5.34d	7.60a	4.50d	5.33a	1.54a	1.61a	6.97bc	9.53a

††-Paracoccus versutus, †††-after harvest, †- 3 days after storage

Same letter(s) does not differ significantly at 5% level by Duncan's Multiple Range Test (DMRT)

concentration was appreciably higher at Al Hamraneya compared to Al Kuwaitat. This might be due to soil properties. Al Hamraneya lower soil pH and $CaCO_3$ content had a positive influence on increasing the concentration of Fe and Mn of cucumber leaves. The result coincides with the findings of Modaihsh et al., (1989). They observed that decrease in soil pH and the increase in Fe and Mn upon S-addition were higher with lower $CaCO_3$ content. Regardless of S^0 levels, S^0P and S^0T recorded 49.4-86.1% and 10.1-62.0% higher Zn concentration of leaves, respectively compared to control. This result coincides with the findings of Kayser et al., (2001) who observed that soil amendment by S^0 increased the Zn solubilization and Zn concentration in sunflower shoot. Similar results were reported in peanut plants (Singh et al., 1990). In most of the cases, the combined effect of S-oxidizing bacteria with S^0P had no significant influence on nutrients uptake. The higher dry matter content (%) and higher concentration of acidity and vitamin C during shelf life might be due to the loss of water (93-95%) from the fresh fruit that occurred at 20^0C which led to more concentrated juice in all the measured parameters. The results coincide with the findings of Nil et al., (2004).

They found that the moisture content of fresh sea cucumber decreased from 85% to 6.5% when it was processed using the method of evisceration by cutting the anus, while the post-processing water content using the same method by cutting along the length of the body came out to be 6%. Cucumbers also have moisture binding, moisture regulating properties. Water consumption of cucumber is very high. Mannini (1988) found that the yield was highest with 150% of the maximum evapotranspiration. This corresponded to 360–420 mm of water when cucumbers were grown in greenhouse in sandy soil. Adequate water supply is needed to enhance strong vegetative growth and to ensure a high capacity for photosynthesis. Water availability is also one potential factor affecting fruit quality, and in particular, firmness (Terhi and Tapio, 2005). Cucumber yield was slightly higher at Al Kuwaitat than Al Hamreneya but the yield trend was similar at both locations. At Al Kuwaitat, *Pv* did not show any significant effect on nutrient concentration, yield and quality of cucumber compared with application of S^0P individually. These findings clearly indicated that native S-oxidizing bacteria with the application of S^0 application are sufficient for S oxidation in the present investigation. Similar findings were observed in nutrient uptake of maize as affected by S^0 and *Pv* in sandy calcareous soils in UAE (Abdou, 2006). S^0P was used at both locations although *Pv* and S^0T tested in one location each. Based on the two locations findings, S^0P at the rate of 5 t/ha was found more suitable than S^0T in respect of nutrient uptake, yield and quality of cucumber.

Conclusion

Concentration of nutrients increased significantly and varied with the application of varying rates of S^0 application at both locations. Cucumber grown in amended soil by S at rates of 5 and 10 t/ha recorded higher uptakes of N, P, S, Fe and Mn compared to non amended soil and lower levels of S^0 application in both locations. The results suggest that S^0 application in sandy calcareous soils may be a good alternative for amendment of soil which can enhance the nutrients uptake ability, yield and quality of cucumber. From an economic point of view application of S^0P at the rate of 5 t ha^{-1} is suitable to grow cucumber at Al Hamraneya and Al Kuwaitat soils in UAE.

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