Egyptian J. Desert Res., **74**, No. 1, 109-127 (2024)

IMPACT OF COMPOST AND SULFUR APPLICATIONS ON GROWTH, YIELD AND CHEMICAL COMPONENTS OF BITTER GOURD (*MOMORDICA CHARANTIA* L.)

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The influence of compost and sulfur on the growth, yield and chemical components of bitter gourd (*Momordica charantia* L.) was investigated during 2021 and 2022 in Ras Sudr Region, South Sinai Governorate, Egypt. Compost (0, 10 and 20 m^3 fed^{-1}) and sulfur (0, 350 and 700 kg fed^{-1}) were used. The compost and sulfur were applied as soil additions either alone or in combination, and the following data were recorded: vine height, number of branches, number of fruits per plant, fruit weight, yield per plant, yield per square meter, plant content of N, P, K, and S, as well as phytochemical investigations, and qualitative and quantitative chromatographic investigations of flavonoids and phenolic compounds. The results indicated that, all the growth and yield characteristics were superior for the combined compost at 20 m^3 fed^{-1} and sulfur at 700 kg fed^{-1}. The combination of compost and sulfur addition significantly enhanced the nutrient element contents (N, P, K, and S). Phytochemical investigations of the plant powder treatments and the crude extract that had the best treatment response to compost and sulfur (20 m^3 fed^{-1} × 700 kg fed^{-1}) showed high concentrations of all the chemical constituents. The concentrations of gallic acid, syrengenic acid, genestic acid, myrictine, catechein and quercetin-3-*O*-glucoside were better investigated using HPLC. The treatment with a combination of compost at 20 m^3 fed^{-1} and sulfur at 700 kg fed^{-1} gave the best results for maximizing the growth and yield of bitter gourd.

Keywords: Bitter gourd, *Momordica charantia*, compost, sulfur, chemical components

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is a member of the Cucurbitaceae family and is found in Bangladesh, Malaysia, China, India, and tropical Africa. From ancient times to the present, *Momordica charantia* has supplied several cures for many maladies. It has been used in several Asian traditional remedies to treat anemia, cholera, diarrhea, blood illnesses, dysentery, colic, gonorrhea rheumatism, ulcers, gout, worms, liver and spleen disease, cancer, and diabetes (Joseph and Jini, 2013). Many phytochemical reports have shown that plants have phytochemical constituents such as alkaloids, phytosterols, glycosides, phenolic acids, saponins, lipids, proteins, fixed oils, and flavonoids (Ahmad et al., 2016 and Moghith, 2022). *Momordica charintia*, a well-known plant called bitter melon, has been shown to have antibacterial, antidiabetic, and antiviral properties against human immunodeficiency virus (HIV) infection (Adedayo and Famuti, 2023). These ingredients give the plant antibacterial, antifungal, antiviral, antiparasitic, antifertility, hypoglycemic, antitumor and anticarcinogenic properties (Saeed et al., 2018). Consequently, in continuation of our phytochemical and pharmacological research (Abdelgawad et al., 2021). According to the available plant data, most of the previous studies worldwide have evaluated the percentage of secondary metabolites in these wild plants, except for those from Egypt. Therefore, in this study, the total active ingredient of the cultivated plant under Ras Sudr conditions (dryness and salinity) and its influence on the phytochemical components after fertilization with sulfur and compost were investigated.

In arid and semiarid environments, improving calcareous soil is crucial for maintaining the biological environment and increasing agricultural yields (Abou Hussien et al., 2020). By lowering the pH of the soil, the added organic matter increases the amount of micronutrients that are truly accessible (Abu-Elela, 2002). Adding organic amendments to soil enhances its physical and chemical characteristics, initiates the cycle of nutrients, and creates an environment conducive to plant growth. Organic acids generated from compost provide an ideal environment for macro- and micronutrient solubilization (Nada, 2011). The increases in cation exchange capacity (CEC) result from increases in total C in the form of organic matter, which increases the number of exchange sites for readily accessible mineral nutrients for plant absorption (Pandey and Shukla, 2006). After cultivation, the addition of compost to sandy calcareous soil enhanced the availability of N, P, and K in the soil, while the pH value significantly decreased (Mohamed et al., 2008).

One of the vital elements needed for plants to thrive and flourish to their full potential is sulfur. Amino acids, vitamins, cofactors and protein disulfide bonds all contain sulfur as a structural element. Because the majority of sulfur in the soil is contained in organic materials, plants cannot reach this material. Sulfur is one of the vital elements needed for plants to grow and develop to their full potential. Sulfur is a structural component of protein disulfide bonds, amino acids, vitamins and cofactors. The amino acid, vitamin, cofactor and protein disulfide bond compositions are all structurally dependent on sulfur (Narayan et al., 2022). The soil profile pH and EC values markedly decreased, particularly in the soil that had more sulfur (El-Sherbiny, 2007). Applying organic matter in conjunction with sulfur significantly increased the amount of N, P and K that was accessible and enhanced the growth and yield of sesame and its constituent parts (Zaman et al., 2011; Fathi et al., 2015 and Abou Hussien et al., 2020). Given the importance of the bitter gourd plant and its recent introduction into Egyptian agriculture, this study examined the impact of compost and sulfur on the growth, yield and chemical components of bitter gourd (*Momordica charantia*) plant.

MATERIALS AND METHODS

Field experiments were performed at the Experimental Ras Sudr Station, Desert Research Center, Egypt (30°34'N, 31°34'E), during the growing summer seasons of 2021 and 2022 to investigate the effects of compost and sulfur and their interaction on the growth, yield, and chemical components of bitter gourd. Mature fruits cultivated in the Floriculture Nursery of the Horticulture Department, Faculty of Agriculture, Benha University, were used to gather the seeds of bitter gourd. Seeds were planted in seedling trays, lightly covered and kept in a polyethylene greenhouse until they germinated. The seedling trays were relocated under a saran greenhouse (63% shade) after germination until they reached the optimum size for transplanting, which took approximately 50 days. Seedlings with 2-3 pairs of true leaves and a height of 7 cm were transplanted into the open field. The compost and sulfur treatments were applied before cultivation. The soil of the cultivation location was saline and calcareous, and its texture was sandy loam. The irrigation water and soil were analyzed and are presented in Table (1) according to Burt (2004).

Table (1). Chemical analysis of the soil and water used during the two successive seasons.

Sample	**Depth**	**pH**	**EC dS m^{-1}**	**O.M.**	**Soluble cations (meq l^{-1})**				**Soluble anions (meq l^{-1})**			
					Ca^{2+}	**Mg^{2+}**	**Na^+**	**K^+**	**CO_3^{2-}**	**HCO_3^-**	**Cl^-**	**SO_4^{2-}**
Soil	0-30	7.48	4.70	0.8	3.09	8.80	3.51	1.59	0	3.16	8.57	1.90
Water	-	7.8	3.64	0	6.44	1.20	1.62	1.80	0	2.20	4.48	2.92

This experiment, as factorial experiments in a split-plot design, included nine treatments, which were combinations of three levels of compost (0, 10 and 20 m^3 fed^{-1}) and sulfur (0, 350 and 700 kg fed^{-1}) arranged in a split-plot design with three replications. Compost was assigned to the main plots, and sulfur was assigned to the subplots.

Leaf samples were air-dried in the shade to determine the percentage of nutrient elements. The modified micro-Kjeldahle technique, as reported by AOAC (1970), was used to measure nitrogen. Phosphorus was determined using the ammonium molybdate method, according to Murphy and Riley (1962). Potassium was estimated using the flam photometric method according to Cottenie et al. (1982). Sulfur content was estimated by the turbidimetric method, according to Rowell, (1993).

Phytochemical Investigations

1. Determination of Total Phenolic and Flavonoid Contents

The total phenolics and flavonoid contents of bitter gourd aerial parts were determined colorimetrically using Foline Ciocalteu reagent as described previously (Gorinstein et al., 2007 and Pasko et al., 2009, respectively).

2. Quantitative Test for Terpenoids

For a whole day, 100 mg (wi) of dried plant powder from bitter gourd aerial parts was soaked in 9 ml of ethanol (Indumathi et al., 2014). After filtration, the extract was removed using a separating funnel and 10 ml of petroleum ether. The ether extract was separated into preweighed glass vials and allowed to dry completely (wf). After evaporating petroleum ether, the yield (%) of the total terpenoid content was calculated using the following formula:

$$wi - wf \Big/ wi\ x\ 100$$

3. Estimation of Total Alkaloids

The technique outlined by Harbone (1973) was used to quantify the total alkaloids in the aerial parts of bitter gourd. The alkaloids content of the plant samples was determined and is reported as a percentage per gram of dry weight.

4. Determination of Total Saponin Contents

Twenty five ml of 20% ethanol was added to approximately 50 mg of powdered dry bitter gourd leaves. The sample was heated to 55°C on a magnetic stirrer for four hours while being continuously stirred. The process of extracting and calculating the total saponin content was performed according to Ajiboye et al. (2013).

5. Qualitative and Quantitative Chromatographic Investigation of Flavonoids and Phenolic Compounds Using HPLC

Using the method described by Jakopič et al. (2009), the concentrations of flavonoids and phenolic acids in the aerial portions of bitter gourd were measured. A high-performance liquid chromatography (HPLC) system equipped with a column compartment, autosampler, quaternary pump degasser, and variable wavelength detector was used (Agilent, Germany 1100). The chromatographic parameters (mobile phase, gradient program, and column temperature) were similar to those reported by Schieber et al. (2001). The analyses were conducted on a C18 reverse phase (BDS 5 µm, Labio, Czech Republic) packed stainless-steel column (4×250 mm, i.d.). Every chromatogram was plotted at 280 nm for flavonoids and 330 nm for the estimated phenolic acids. By comparing peak regions with outside standards, every component was located and measured.

The data for both seasons were combined and statistically analyzed by analysis of variance (ANOVA) using the MSTATC program. The L.S.D. test was used to compare means at the 0.05 level according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

1. The Vine Height and Number of Branches Per Plant

Data presented in Table (2) illustrate that, vine height and the number of branches of bitter gourd (*Momordica charantia*) were enhanced by increasing the level of compost compared to untreated treatment (C0). The sulfur addition treatment data indicated that vine height and the number of branches per plant were significantly impacted by all the sulfur addition treatments compared to those of the control (S0) in both seasons. The highest level of sulfur (S2) was associated with the greatest vine height and this level was equal to the sulfur level (S1) in the case of the number of branches.

Furthermore, the combination effect between compost and sulfur treatments, data in Table (2) reveale that, all combinations between compost and sulfur increased vine height and the number of branches of bitter gourd over control during both seasons. However, the highest values of these parameters were recorded by using the combined treatment between the compost level (C2) and sulfur level (S2) for vine heights, but the sulfur levels (S1xS2) gave the same significant vaule of number of branches plant^{-1} when were combined with the level of compost (C2). Conversely, the control (C0xS0) scored the lowest for these characteristics in both seasons.

Table (2). Effect of compost, sulfur and their interaction treatments on vine length and number of branches of bitter gourd during 2021 and 2022 seasons.

Treatments		**Vine height (cm)**		**The number of branches plant^{-1}**	
Compost (m^3 fed^{-1})	**Sulfur (kg fed^{-1})**	**2021**	**2022**	**2021**	**2022**
C0		152.2	153.7	6.81	7.26
C1		167.8	169.6	7.96	8.48
C2		193.0	195.2	10.15	9.85
LSD $_{\text{at } 0.05\ \%}$		7.75	5.97	0.86	0.99
	S0	165.7	167.4	7.59	7.85
	S1	171.2	173.1	8.41	8.59
	S2	176.1	178.0	8.93	9.15
LSD $_{\text{at } 0.05\ \%}$		2.98	3.34	0.77	0.77
C0	S0	149.3	150.3	6.33	6.78
	S1	152.3	153.8	6.78	7.11
	S2	155.0	157.0	7.33	7.89
C1	S0	161.0	163.7	7.44	8.00
	S1	168.3	170.3	8.33	8.78
	S2	174.0	174.7	8.11	8.67
C2	S0	186.7	188.2	9.00	8.78
	S1	193.0	195.0	10.11	9.89
	S2	199.3	202.3	11.33	10.89
LSD $_{\text{at } 0.05\ \%}$		5.16	5.78	1.36	1.34

C0= control (0 compost); C1= compost at 10 m^3 fed^{-1}; C2= compost at 20 m^3 fed^{-1}; S0= control (0 sulfur); S1= sulfur at 350 kg fed^{-1}; S2= sulfur at 700 kg fed^{-1}

2. Number of Fruits Plant^{-1} and Fruit Weight (g)

According to the data presented in Table (3), addition of compost to the plants significantly enhanced the number of fruits plant^{-1} and fruit weight when compared to the control (without compost) in both seasons. Referring to the used sulfur treatments, they progressively increased the number of fruits plant^{-1} and the fruit weight of bitter gourd when compared to the control (S0) in both seasons. Therefore, in the first and second seasons of this study, the greatest values of the previously stated parameters were obtained by S2.

Moreover, data in Table (3) show that, for all the interactions between compost and sulfur, the combined treatment between compost at the highst level had the best values for both the number of fruits plant^{-1} and the weight of the fruit when combined with sulfur at any level of sulfur whether the second or third level in both seasons.

Table (3). Effect of compost, sulfur and their interaction treatments on the number of fruits plant^{-1} and fruit weight of bitter gourd during 2021 and 2022 seasons.

Treatments		Number of fruits plant^{-1}		Fruit weight (g)	
Compost (m^3 fed^{-1})	**Sulfur (kg fed^{-1})**	**2021**	**2022**	**2021**	**2022**
C0		15.33	16.04	44.64	45.47
C1		21.26	21.93	54.26	55.52
C2		24.45	25.04	63.35	64.54
LSD at 0.05 %		1.24	0.81	4.92	2.75
	S0	18.78	19.48	50.93	51.87
	S1	20.52	21.11	54.16	55.42
	S2	21.74	22.41	57.17	58.24
LSD at 0.05 %		1.31	0.99	2.84	2.33
C0	S0	13.11	14.00	42.99	43.67
	S1	15.56	16.11	44.53	45.33
	S2	17.33	18.00	46.40	47.42
C1	S0	19.67	20.33	48.58	49.24
	S1	21.56	22.11	54.90	56.83
	S2	22.55	23.33	59.31	60.50
C2	S0	23.56	24.11	61.21	62.72
	S1	24.45	25.11	63.04	64.10
	S2	25.33	25.89	65.79	66.80
LSD at 0.05 %		2.27	1.71	4.91	4.03

C0= control (0 compost); C1= compost at 10 m^3 fed^{-1}; C2= compost at 20 m^3 fed^{-1}; S0= control (0 sulfur); S1= sulfur at 350 kg fed^{-1}; S2= sulfur at 700 kg fed^{-1}

3. Yield Plant^{-1} and Yield/m^2

As shown in Table (4), the highest level of compost (C2) significantly enhanced the yield per plant and yield per square meter compared to the control treatment (C0) in both seasons. In contrast, the yield per plant and yield per square meter of bitter gourd were more affected by all levels of sulfur treatment than by the control (S0) in both seasons. Among these metrics, the second sulfur level (S2) had the highest value in both growing seasons.

The interaction effect between compost levels and sulfur treatment significantly affected yield per plant and yield per square meter in both seasons (Table 4). The highest values were obtained from the combination treatment between C2 and S2 in both seasons. This was followed in decreasing order by the combined C2 x S1 treatment in both seasons. In contrast, the lowest values were obtained from the control (C0 x S0) treatment during both seasons.

Table (4). Effect of compost, sulfur and their interaction treatments on yield plant^{-1} and yeild/m^2 of bitter gourd during 2021 and 2022 seasons.

Treatments		**Yield Plant^{-1} (g)**		**Yield (kg m^{-2})**	
Compost (m^3 fed^{-1})	**Sulfur (kg fed^{-1})**	**2021**	**2022**	**2021**	**2022**
C0		687.0	731.9	1.64	1.74
C1		1156.3	1222.4	2.75	2.91
C2		1551.2	1617.2	3.69	3.85
LSD at 0.05 %		148.8	92.86	0.35	0.23
	S0	987.2	1041.3	2.35	2.48
	S1	1137.0	1198.0	2.71	2.85
	S2	1270.0	1332.1	3.03	3.17
LSD at 0.05 %		76.89	64.87	0.19	0.16
C0	S0	564.6	611.6	1.35	1.46
	S1	692.1	729.8	1.65	1.74
	S2	804.1	854.2	1.92	2.03
C1	S0	954.2	1000.2	2.27	2.38
	S1	1177.2	1255.4	2.80	2.99
	S2	1337.0	1410.0	3.19	3.36
C2	S0	1443.0	1512.0	3.44	3.60
	S1	1541.0	1609.0	3.67	3.83
	S2	1670.0	1731.0	3.98	4.12
LSD at 0.05 %		133.2	112.4	0.32	0.27

C0= control (0 compost); C1= compost at 10 m^3 fed^{-1}; C2= compost at 20 m^3 fed^{-1}; S0= control (0 sulfur); S1= sulfur at 350 kg fed^{-1}; S2= sulfur at 700 kg fed^{-1}

The results for all the aforementioned parameters are in agreement with those of Motior et al. (2011), Abd El-Wahab et al. (2014), Hamaiel et al. (2015), Shalaby (2018), Abou El-Goud and Yousry (2019), Alhasnawi et al. (2020), Masoodi and Hakimi (2021), Carnimeo et al. (2022), El-Mesairy et al. (2022) and Farraga and Omara (2022).

The advantages of compost include enhancing the physical and chemical characteristics of soil, as well as its exchangeable soluble nutrients and absorption. Nutrients, such as nitrogen, phosphorous and potassium, are also provided by increasing the amount of organic matter in the soil. In addition, nutrients applied to nutrient-depleted soil can restore the structure, cation exchange capacity, and soil availability of N and enhance plant N status. These findings are consistent with Chen and Wu (2005), Doung, (2013), Abou-El-Hassan et al. (2019) and Dhankar (2019).

Sulfur may greatly increase plant production, and other researchers have demonstrated the advantages of using sulfur. Meena et al., (2013) attributed the impact of sulfur administration on many physiological systems, such as nutritional status, energy production, enzyme activity, and carbohydrate metabolismm to the overall enhancement of plant development. Sulfur treatment can mitigate the negative effects of salt on plants by increasing the amount of nutrients available in the soil, as well as the concentration of proline, soluble protein, chlorophyll content, activities of peroxidase enzymes, and photosynthetic processes (Abbas et al., 2015). Moreover, Nazar et al. (2011) reported that sulfur application stimulates the plant's internal defense system through glutathione synthesis, which serves a defensive purpose in plants under stress. As a result, plants may require additional sulfur under salt stress to activate their defense mechanisms and fend off negative effects. Furthermore, Capaldi et al., (2015) reported that sulfur is a significant reducing agent that reacts throughout the abiotic stress phase.

4. The N, P, K and S Contents of Leaves

From data in Fig. (1 a, b, c and d) it could be concluded that, the treated plants by compost significantly enhanced the percentage of N, P, K, and S in the leaves of bitter gourd in comparison to the plants that were not treated (control) in both seasons. The sulfur treatment data indicated that, all the sulfur treatments significantly increased the contents of N, P, K, and S in the leaves of bitter gourd, compared to those in the levels of the untreated plants (control) in both seasons. The highest level of sulfur had the greatest value among the two seasons.

Moreover, the data in Fig. (1 a, b, c, and d) demonstrate that, all of the interactions between compost and sulfur significantly increased the contents of N, P, K and S in the leaves of bitter gourd plants; in particularly when contrasted with the control treatment in both seasons, the combined treatment of the highest level of compost (S2) and the highest level of sulfur (S2) produced the significantly highest values of N, P, K and S in both seasons. These findings are comparable to those of the following studies: Susila and Locascio (2001), Meena et al. (2013), Abd El-Wahab et al. (2014), Lasmini et al. (2015), Pradhan et al. (2015) and Shalaby (2018).

Lasmini et al. (2015) found that, adding compost to soil increased its levels of organic carbon, N, and P. Moreover, Sarwar et al. (2010) reported that, when compost was applied, the soil's mineral nutrients (Ca, Mg, K, P, and Cl) icreased. Madi and Al-Shibani (2020) discovered that compost significantly increased the leaf content of N, P and K. Overall, the findings indicated that application of sulfur enhanced the uptake of nutrients (N, P, K, and S). The impact of sulfur on soil pH may be the cause of its beneficial effects on nutrient uptake. Sanderson et al. (1996) and Susila and Locascio (2001) discovered that sulfur applied to the soil lowers the soil pH by 0.3 units; sulfur also enhances the soil structure, facilitating nutrient absorption and stimulating and maintaining plant physiological activities in saline environments (Pradhan et al., 2015). According to Capaldi et al. (2015), there is a significant correlation between the absorption and assimilation of N and S; when they are coupled, proteins and amino acids are produced.

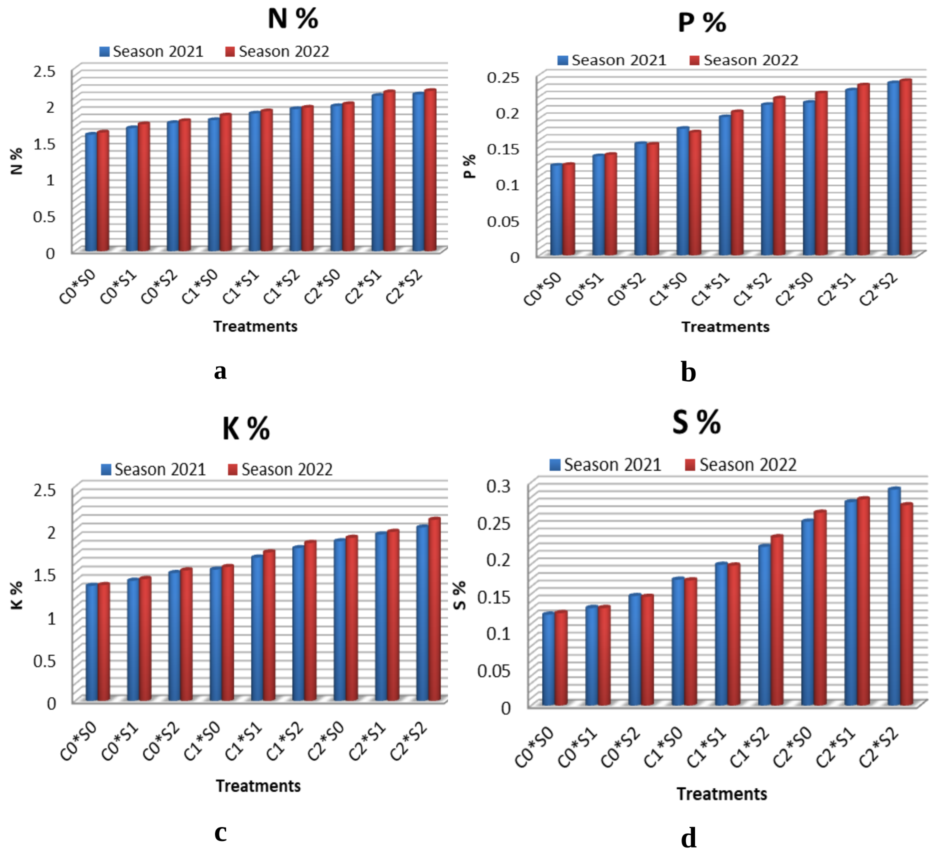
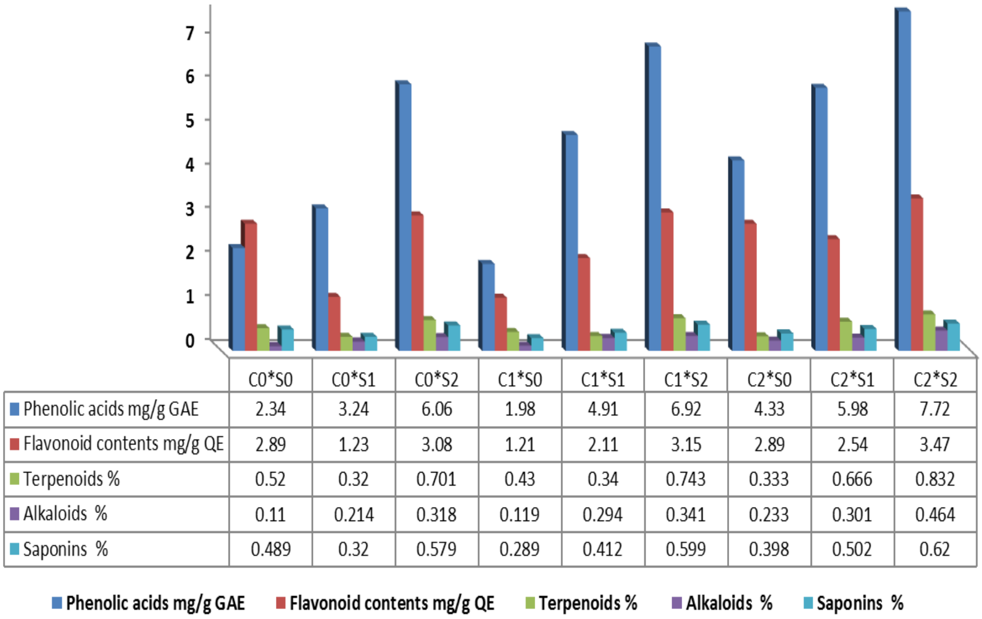


Fig. (1). Effect of compost, sulfur and their interaction treatments on **a.** N percentage, **b.** P percentage, **c.** K percentage and **d.** S percentage, in the dry leaves of bitter gourd during the 2021 and 2022 seasons.

C0= control (0 compost); C1= compost at 10 m^3 fed^{-1}; C2= compost at 20 m^3 fed^{-1} ; S0= control (0 sulfur); S1= sulfur at 350 kg fed^{-1}; S2= sulfur at 700 kg fed^{-1}

5. Phytochemical investigations

Many studies have been performed in the last five years on the medicinal importance of the bitter gourd herbal plant as a promoter of antidiabetic therapeutic drugs, particularly for its neuroprotective, anti-obesogenic, antioxidant, anti-inflammatory, antimalarial, antimicrobial, and allelopathic activities (Oliveira et al., 2018). Therefore, numerous studies have been launched to identify the chemical components that may be the major reason for the medicinal importance of the plant. Analyses of the phytochemical constituents of the *Momordica charantia* plant revealed the presence of alkaloids, flavonoids, saponins, tannins, cardiac glycosides and steroids as described previously (Mada et al., 2013 and Oragwa et al., 2013). The outlined data in Fig. (2) show the concentration of each component after the plants were harvested under the different fertilization treatments involving sulfur and compost. There were nine treatments, in which the total concentration of phenolic acids and flavonoid constituents ranged from 1.98 to 7.72 mg GAE g^{-1} dry wt, and from 1.21 to 3.47 mg QE g^{-1} dry wt, respectively. On the other hand, the percentages of total terpenoids, alkaloids and saponins ranged from 0.243 to 0.843, 0.11 to 0.464 and 0.23 to 0.62, respectively.



	C0*S0	C0*S1	C0*S2	C1*S0	C1*S1	C1*S2	C2*S0	C2*S1	C2*S2
■ Phenolic acids mg/g GAE	2.34	3.24	6.06	1.98	4.91	6.92	4.33	5.98	7.72
■ Flavonoid contents mg/g QE	2.89	1.23	3.08	1.21	2.11	3.15	2.89	2.54	3.47
■ Terpenoids %	0.52	0.32	0.701	0.43	0.34	0.743	0.333	0.666	0.832
■ Alkaloids %	0.11	0.214	0.318	0.119	0.294	0.341	0.233	0.301	0.464
■ Saponins %	0.489	0.32	0.579	0.289	0.412	0.599	0.398	0.502	0.62

Fig. (2). Total active constituents of bitter gourd after treatment with compost and sulfur.

C0= control (0 compost); C1= compost at 10 m^3 fed^{-1}; C2= compost at 20 m^3 fed^{-1}; S0= control (0 sulfur); S1= sulfur at 350 kg fed^{-1}; S2= sulfur at 700 kg fed^{-1}, GAE: Gallic acid eqinelate; Q: Quuercetin

The C2 x S2 treatment had higher concentrations of all component phenolic compounds, flavonoid acids, terpenoids, alkaloids and saponins (7.72 mg GAE g^{-1}, 3.47 mg QE g^{-1}, 0.832, 0.464 and 0.620%, respectivly) than did the other treatments, followed by C1 x S2 (6.92, mg GAE g^{-1}, 3.15 mg QE g^{-1}, 0.743, 0.341 and 0.599%, respectively) and C0 x S2 (6.06 mg GAE g^{-1}, 3.08 mg QE g^{-1}, 0.701, 0.318 and 0.579%, respectively). The variation in the concentrations of all the components in all the treatments was due to the different responses of each plant treatment to fertilization by sulfur and compost. They are very important nutrients that can help improving crop yield and growth and play a role in a number of important plant processes. The high nutrient content of the organic matter compost led to improved soil health and fertility. In the present study, the response of C2 x S2 to fertilization with compost and sulfur was better than that to other treatments; this difference was reflected in the phytochemical constituents that afforded the best concentrations followed by C1 x S2 and C0 x S2. As in the case of C2xS2, fertilization with sulfur and compost may decrease the soil salinity, improve the water absorption in plant tissue and increase the growth factor of the plant due to the motivation of the cell to produce chlorophyll, carotenoids and other phytochemical components. It also increases the level of sulfur-containing compounds, such as amino acids, vitamins, and antioxidants, in plants, which improve plant health and resistance to stress. The results showed that, the percentages of total phenolics and flavonoids had the highest concentrations, therefore phenolic and flavonoid components of the best treatment (C2 x S2) were investigated using HPLC.

6. Qualitative and quantitative chromatographic investigation of flavonoids and phenolic compounds using HPLC

Previous studies have shown that, plant extracts contain numerous flavonoids and phenolic compounds. Only a small number of flavonoids and phenolic acids were available as standard samples for HPLC at the Regional Center for Mycology and Biotechnology (RCMB), Al-Azhar University, Cairo, Egypt. Table (5) and Figs. (3 and 4) show that 18 flavonoids (flavon and flavan) and 11 phenolic acids were identified in the plant

Tweleve of eighteen flavonoid compounds were the flavonol skeleton and six of them were flavanan structures. Myrictine, quercetin-3-*O*-glucoside and rutin had the highest concentrations of flavonol at 711.23, 432.91 and 395.46 µg g^{-1}, respectively. Catechein had the highest concentration of flavanan skeleton 532.12 µg g^{-1}. Moreover, gallic acid and syringenic acid had the highest concentrations of phenolic acids at 421.40 and 245.34 µg g^{-1}, respectively.

Table (5). Investigation of phenolic acids and flavonoid constituents of the aerial parts of bitter gourd plants.

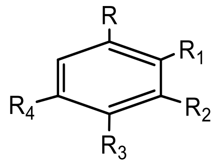
Phenolic acids	**R.T. (min)**	**Conc. (µg g^{-1})**	**Flavonoid compounds**	**R.T. (min)**	**Conc. (µg g^{-1})**
Syringenic acid	5.01	245.34	Myrictine	4.552	711.23
Gallic acid	7.062	421.40	Catechein	8.065	532.12
Protocatchoic acid	8.427	21.20	Epicatechein	8.520	154.32
Chlorogenic acid	10.180	96.81	Luteolin-7-*O*-glucoside	9.014	312.10
ρ- Coumaric acid	11.616	6.27	Naringin	11.747	108.21
Ferulic acid	11.900	4.57	Hesperidin	12.167	235.82
Genestic acid	12.518	243.05	Quercetin-3-*O*-glucoside	12.520	432.91
Ellagic acid	13.473	116.21	Rutin	12.932	395.46
Cinnamic acid	15.323	85.55	Apigenin-7-*O*-glucoside	13.129	287.32
Salicylic acid	16.348	89.82	Quercitrin	13.935	271.20
Synapic acid	16.782	16.25	Quercetin	14.387	345.51
			Chrysoeriol	14.945	265.94
			Narengenin	15.037	224.23
			Hesperitin	16.207	168.45
			Kaempferol	16.316	354.28
			Rhamnetin	16.532	117.30
			Apigenin	17.574	211.06
			Acacetin	18.767	345.21

R.T.= Retention time; min.= Minute; Conc.= Concentration

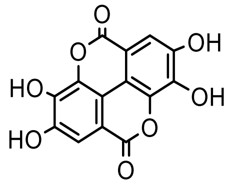
Catechein	$R=R_1=R_2=$ OH,		$R_3=$ H,
Epicatechein	$R=R_1=R_2=$ OH,		$R_3=$ H,
Hesperidin	$R_1=$OH,	$R_2=$ OCH_3,	$R_3=$ rutinoside
Naringin	$R_2=$ OH,	$R=R_1=$H,	$R_3=$ rutinoside
Narengenin	$R_2=$ OH,	$R=R_1=$H,	
Hesperitin	$R_1=$OH,	$R=R_3=$ H,	$R_2=$ OCH_3,

Myrictine	$R=R_1=R_2=R_3=$ OH,	$R_7=$H	
Luteolin-7-O-glucoside	$R_1=R_2=$ OH,	$R=R_3=$ H,	$R_7=$ glucoside
Quercetin-3-O-glucoside	$R_1=R_2=$ OH,	$R_3=R_7=$ H,	R= O-glucoside
Rutin	$R_1=R_2=$ OH,	$R_3=R_7=$ H,	R= O-rutinoside
Apigenin-7-O-glucoside	$R_2=$ OH,	$R=R_1=R_3=$ H,	$R_7=$ glucose
Quercetin	$R=R_1=R_2=$ OH,	$R_3=R_7=$H	
Quercitrin	$R_1=R_2=$ OH,	$R_3=R_7=$ H,	R=O-rhamnoside
Chrysoeriol	$R_2=$ OH,	$R_3=R_7=$ H,	$R_1=$ OCH_3
Kaempferol	$R=R_2=$ OH,	$R_1=R_3=R_7=$H	
Rhamnetin	$R=R_1=R_2=$ OH,	$R_3=$ H,	$R_7=$ CH_3
Apigenin	$R_2=$ OH,	$R=R_1=R_3=R_7=$ H	
Acacetin	$R=R_1=R_3=R_7=$ H		$R_2=$ OCH_3

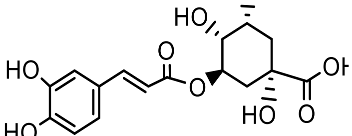
Fig. (3). Flavonoid structures of identified compounds from bitter gourd aerial parts extract using HPLC.



Syringenic acid	R= COOH,	R_1=H, R_3= OH, R_2=R_4= OCH_3
Gallic acid	R= COOH,	R_1=H, R_2=R_3=R_4= OH
Protocatchoic acid	R= COOH,	R_1= R_4=H, R_2=R_3= OH
***p*- coumaric acid**	R = CH=CHCOOH,	R_1=R_3=R_4= H, R_3=OH
Ferulic acid	R = CH=CHCOOH,	R_1=R_2= H, R_3=OH, R_4= OCH_3
Cinnamic acid	R = CH=CHCOOH,	R_1=R_2= R_3=R_4=H
Salicylic acid	R= COOH, R_1=OH,	R_2= R_3=R_4=H
Synapic acid	R = CH=CHCOOH,	R_1=H, R_3=OH R_2=R_4=OCH_3



Ellagic acid



Chlorogenic acid

Fig. (4). Phenolic acids structure of identified compounds from bitter gourd aerial parts extract using HPLC.

Therefore, treatment with a combination of compost at 20 m^3 fed^{-1} and sulfur at 700 kg fed^{-1} gave the best results for maximizing the growth and yield of bitter gourd.

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تأثير إضافة الكمبوست والكبريت على النمو، المحصول والمكونات الكيميائية للقرع المر *Momordica charantia* L.

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تم دراسة تأثير السماد والكبريت على النمو والمحصول والمكونات الكيميائية لنبات القرع المر (*Momordica charantia* L.) خلال موسمى ٢٠٢١ و٢٠٢٢ في منطقة رأس سدر، محافظة جنوب سيناء، مصر. استخدم الكمبوست بمعدلات ٠، ١٠ و٢٠ م^{٣}/فدان والكبريت بمعدلات ٠، ٣٥٠ و٧٠٠ كجم/فدان. أضيف كلا من الكمبوست والكبريت كإضافة أرضية للتربة إما بمفردهما أو مجتمعين، وتم تسجيل البيانات التالية: إرتفاع الكرمة، عدد الأفرع، عدد الثمار لكل نبات، وزن الثمرة، محصول النبات، إنتاجية المتر مربع، محتوى النبات من النتروجين، الفسفور، البوتاسيوم والكبريت بالإضافة إلى المكونات الكيميائية للنبات، والتقديرات الكروماتوغرافية النوعية والكمية للفلافونويدات والمركبات الفينولية. أشارت النتائج إلى تحسن جميع صفات النمو والإنتاج عند التسميد بالكمبوست بمعدل ٢٠ م^{٣}/فدان والكبريت عند معدل ٧٠٠ كجم/فدان. أدى الجمع بين إضافة السماد والكبريت إلى تحسين محتوى العناصر الغذائية النتروجين، الفسفور، البوتاسيوم والكبريت، كما أظهرت نفس المعاملة تركيزات عالية لجميع المكونات الكيميائية حيث كان تركيز gallic acid, syrengenic acid, genetic acids, myrictine, catechein and quercetin-3-*O*-glucoside هي الأفضل عند تقدير المركبات الفينولية والفلافونويدات بإستخدام جهاز HPLC. ولذلك، فإن المعاملة بالكمبوست بمعدل ٢٠ م^{٣}/فدان والكبريت بمعدل ٧٠٠ كجم/فدان أعطت أفضل النتائج لزيادة نمو وإنتاجية القرع المر.