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ORIGINAL ARTICLES

Plant Growth And Flowering Of Cape Jasmine (*Gardenia Jasminoides*, Ellis) In Various Substrates Amended With Sulphur

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ABSTRACT

Growth and flower production of gardenia plant (*Gardenia jasminoides*, Ellis.) were studied to find out the appropriate growing media amended with sulphur. Rice straw, sawdust and clay used as growing substrates, were amended with four (0, 1/2, 1 and 2% w/w) levels of sulphur. The experiment was laid out in split-plot design using substrates as main plot and sulphur amendment in sub-plot with 4 replications. The experiment was carried out in successive two growing season in 2004/2005 and 2005/2006. The findings revealed that both growing media and sulphur amendment alone and in combination significantly affected vegetative and reproductive growth of gardenia plant. Rice straw was the best media followed clay and sawdust. Out of four doses of sulphur amendment, $^1/_2$% S application showed best result which was identically followed by 1% sulphur in most of the cases. However, considering the interaction effect, rice straw amended with 1% sulphur proved to be the best combination in producing tallest plant(34.69 cm), maximum number of leaves(70), widest stem (4.4 mm), maximum fresh shoot-root weight (37.46 g) and maximum dry shoot-root weight (12.83 g). In contrast, rice straw combined with 2% sulphur application was the best for obtaining maximum number of flower (9/plant) and maximum weight of individual flower (3.53 g) and total flower per plant (31.79 g) in first growing season. Similar trend of results were observed for both the growing season. These results indicate that gardenia plant can be grown on rice straw media amended with sulphur for having a good flower production in pot culture.

Key words: Gardenia, Clay, Rice straw, Sawdust, and Sulphur

Introduction

Gardenia jasminoides, (common gardenia, cape jasmine or cape jessamine) is a fragrant flowering evergreen tropical plant, a favorite in gardens worldwide. It originated in Asia and is most commonly found growing in Vietnam, Southern China, Taiwan, Japan and India. It has been in cultivation in China for at least a thousand years, and was introduced to English gardens in the mid 18th century. Many varieties have been bred for horticulture, with low growing, and large- and long-flowering forms. As a tropical plant, gardenia thrives best in warm temperatures in humid environments. Getting those conditions is rather hard when in non tropical latitudes, reason for which gardenias are usually cultivated indoors or in greenhouses. In warm places, though, it can be grown outdoors. Either way, it prefers bright indirect sunlight or partial shade, rather than direct sunlight. Apart from the difficulties in creating the suitable conditions for the plant to live, Gardenias need to be planted in an acidic soil (it is an acidophile plant). Its needs a moist soil with good drainage and desirable growing median pH between 4.5-5.5 (Florist Home, 2006 and Desert-tropicals, 2006). If the soil is not acid enough, many of its nutrients (especially iron compounds) will not be available for the plant, since they would not dilute in water and therefore cannot be absorbed through roots. If this happens, gardenias start to develop chlorosis having yellowing of leaves with its main symptom.

Local clay is used as cheap and available medium by the normal farmers for growing different ornamental flowers and shrubs. However, some amendments are required in order to eliminate the undesirable properties of clay such as alkalinity. Besides, certain substrates as sawdust and rice straw could be used as organic light weight media. Meanwhile, composting of these growing media is necessary for overcoming some of their inadequate properties; such as high pH value, phytotoxicity, and low oxygen content that basically prevents the

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direct use of these materials as growing media. Therefore, more originally acidic nature media such as peat moss are recommended for growing Ornamental plants, but it's being highly expensive, making it unaffordable for the normal farmers to use. The expenses of importing sufficient amounts of peat have made it a highly expensive medium. Therefore, searching for more cost-effective alternatives is always under prime aspects for the scientists.

The pH value (7.0–8.0) of the irrigation water and of the available substrates represents a limiting factor to the ex vitro acclimatization of native plants, growing naturally in acid soils. Elemental sulfur is considered as an adequate and cost effective amendment for lowering the pH value of the substrate for growing of growing plants and flowers (Kampf *et al*. 2006).High values of pH may represent a limitation for the agricultural use of the composts, not only when used as soil-less substrate but also as soil amendment in high pH soils. The addition of elemental S during the maturation phase of the composting process was evaluated as suitable method to reduce pH of the composts under the organic agriculture regulations (Roig *et al*. 2004). Agricultural sulphur is recommended for lowering pH of growing media by couple of studies (Gariglio *et al*. 2002; Abdel-Kader 2005). Thus for reducing the pH of the aforementioned substrates, the cheep pH reducing agent as sulphur is essentially necessary. Moreover, the application of sulphur is usually accompanied with various favorable changes in the nutrient status of plant and soil.

The present study aimed to examine the amending each of clay as local medium besides sawdust and rice straw as cheap alternatives with certain levels of sulphur to improve their physical and chemical characteristics on growth, flowering

Materials and Methods

The experiment was carried out during 2004/2005 and 2005/2006 seasons at the Floriculture Experimental Farm, Faculty of Agriculture, Assiut University, Assiut, Egypt. The experiment was designed in split-plot design using three substrates as main plot and four levels of sulphur amendment viz., 0 (control), 1/2, 1 and 2% (w/w) as sub-plot with 4 replications. Each replicate had 12 treatments each treatment has 5 plants grown in 5 individual pots. Healthy homogenous gardenia (*Gardenia jasminoides*, Ellis.) plants of 11 cm. long having an average of 10 leaves on two branches with sufficient root system were used in this experiment. Rice straw, sawdust and clay were used as growing substrate. Both rice straw and sawdust were composted for 45 days prior to use as substrate as recommended by Ibrahim (2006). Rice straw was shredded into small pieces (2-5 cm length) and sawdust was purified from big wood chops. Then, those were wetted and kept in (where?) to maintain a moisture about 50-60% for 45 days. Composting process was followed according to Hoitink and Poole (1979). Nutrient status of the substrate used were analyzed before and after composting (Table 1).

Table 1: Chemical analysis of the rice straw and sawdust before and after composting.

Chemical Properties	Before composting		Composted for 45 days	
	Rice straw	Sawdust	Rice straw	Sawdust
N%	0.50	0.38	0.63	0.46
P%	0.155	0.120	0.200	0.185
K%	0.620	0.560	0.688	0.601
C%	42.34	50.35	36.26	41.50
C/N	84.68	132.5	57.55	90.21
Organic Matter %	82.09	97.78	70.16	80.44
pH	8.04	7.97	8.00	7.94

Highly uniform plants were chosen and transplanted on September 15th into 20 cm diameter different earthen pots filled with composted sawdust, rice straw and clay soil. Plants were grown under plastic house with average minimum air temperature of 16ºC and maximum air temperature 28ºC under 73% shading and kept under same conditions until the end of the experiment. The plants received 5 doses (2 gm/plant) of NPK (17-17-17) per month starting from October to February. In addition, Agrowmore fertilizer (13 - 4 - 42 + 1) NPK + MgO was applied weekly at a dose of 2 g/L to all experimental plants irrespective of treatments as foliar application. Other intercultural practices were performed as and when needed. The same procedure was followed for repeating the experiment next year. During the growing period data were collected on various vegetative and reproductive traits. Data were subjected to statistical analysis using F test according to Snedecor and Cochran (1973) and LSD value for comparisons according to Gomez and Gomez (1984).

Results and Discussion

a. Vegetative growth:

The performances of gardenia plant affected by the three growing media have been shown in table 2 and fig. (1-2). Growing media has significant effect on all the growth parameters studied.

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Table 2: Effect of growing media on vegetative growth of gardenia plant.

Growing media	Plant height (cm)		No. of branches/ plant		No. of leaves		Stem diameter (mm)	
	Growing season		Growing season		Growing season		Growing season	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Clay	27.83	25.82	2.94	2.66	52.00	49.98	3.56	3.42
Rice straw	33.36	32.08	3.30	2.98	65.79	63.44	4.01	3.90
Sawdust	21.55	19.63	2.26	2.33	28.86	27.13	2.32	2.21
LSD(0.05)	0.39	0.56	0.29	0.50	0.56	1.77	0.20	0.31

Rice straw resulted in pronounced enhancing effect however; sawdust depressed the growth leaving clay in between rice straw and sawdust. The tallest plant (33.3cm), highest number of branches (3.3) and leaves (65.8) per plant, maximum stem diameter (4 cm), highest amount of shoot (18.9 g and 7.2 g) and root (12.6 g and 4.1g) both in fresh and dry basis were produced by the plant grown in rice straw in first growing season. The result followed the same trend for both the growing season.

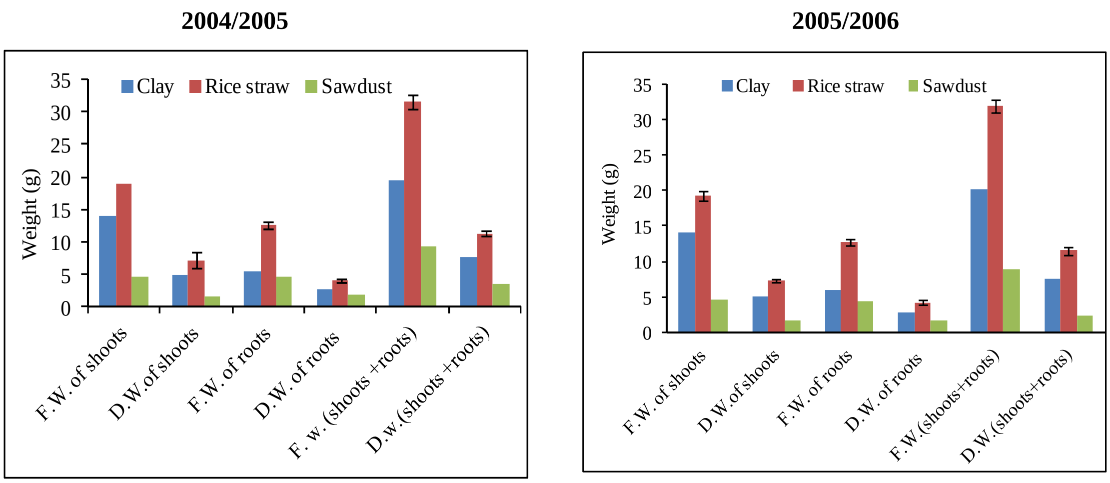

Fig. 1: Biomass production of gardenia plant affected by growing substrates during the 2004/2005 and 2005/2006 seasons. Vertical bars indicate $LSD_{(0.05)}$

In contrast , clay resulted in the highest shoot-root ratio both in fresh and dry weight basis while saw dust the lowest with rice straw in between for both the growing season (fig 2). High porosity and aeration compared to that of clay medium might facilitate for increasing root growth in rice straw medium.

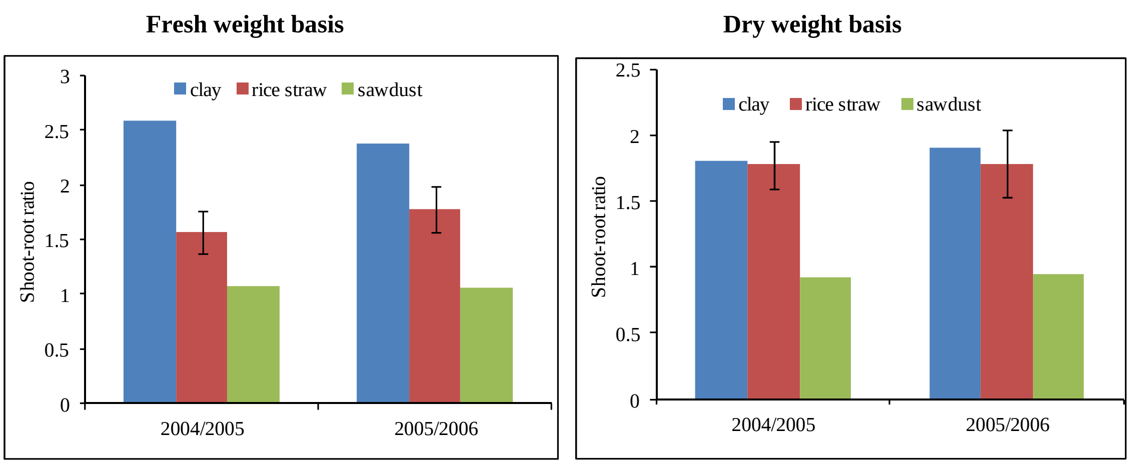

Fig. 2: Shoot-root ratio of gardenia plant on fresh and dry weight basis affected by growing media during the 2004/2005 and 2005/2006 seasons. Vertical bars indicate $LSD_{(0.05)}$

These results can be supported by Jong Myung *et al.*, (2000) who found that the air space of sawdust was low (4%) indicating that aeration could be a problem for container-grown plants in this substrate. The data in table (1) as shown in the materials and methods indicated the inferiority of physical and chemical properties of sawdust even though after composting. Salas (2002) found that chips and sawdust comprised the worst substrate for the growth of *Alnus glutinose*, *Fraxinus excelsior*, *Salix alba* and S. *matsudana.* Best seedling quality can be obtained in the mixture of 60% decomposed rice hull, 10% zeolite, 30% vermiculite (Mo CeHui *et al.*,1997 and Lee JiWon *et al*,.2000. Similarly, according to Abdelhamid *et al.* (2004), compost of rice straw with poultry manure and oilseed rape cake significantly improved growth and yield characteristics of faba bean (*Vicia faba L.*). Clay substrate as a growing media may be inappropriate for gardenia growth, it may be attributed to its high pH and partially to physical properties which affect root growth and consequently aerial parts because gardenia is acid loving plant. Gardenia performs best in rich, moisture-retentive, acid soils (Edward, 1999). Similar results were obtained by El-Sallami (2002) on poinsettia plant which indicated that clay medium alone was the inferior one in relation to vegetative growth.

Sulphur application had significant effects on gardenia growth. Table 3 shows vegetative growth of gardenia affected by sulphur at different levels. Using 1/2% of sulphur had the best result which was identically followed by 1% sulphur. Meanwhile, the highest level of sulphur (2%) had a negative effect resulting in lower growth even than the control (0% sulphur) in some cases.

Table 3: Effect of sulphur amendment of growing media on vegetative growth of gardenia plant.

Levels of Sulphur	Plant height (Cm)		No. of branches/ Plant		No. of leaves		Diameter of stem (mm)	
	Growing season		Growing season		Growing season		Growing season	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	26.52	25.02	2.81	2.65	48.75	46.77	3.05	2.97
$^1/_2$% S	29.75	27.1	3.15	2.87	53.12	51.67	3.53	3.45
1%S	28.04	26.48	2.87	2.77	51.02	49.93	3.46	3.26
2%S	26	24.78	2.5	2.34	42.64	39.57	3.15	3.03
$LSD_{(0.05)}$	0.39	0.56	0.29	0.50	0.56	1.77	0.20	0.31

Sulphur application also significantly affected the biomass production of gardenia plant (fig.3). Maximum amounts of biomass were produced by the plants experienced $^1/_2$% sulphur application accept root fresh weight. At the same time the effect of $^1/_2$% sulphur application was found statistically identical with 1% sulphur.

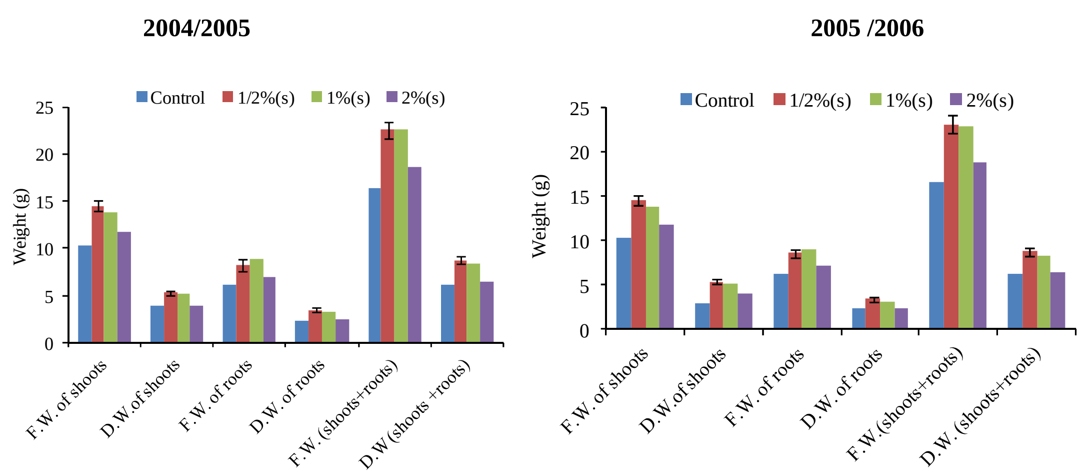

Fig. 3: Biomass production of gardenia plant affected by substrate amendment with sulphur during the 2005/2006 and 2005/2006 seasons. Vertical bars indicate $LSD_{(0.05)}$

Plant growth and development depends on mineral nutrients availability, physical properties of the soil and soil pH plant response. The substrates used in this study characterized with high pH however, adding sulphur to the substrates and subsequent microbial oxidation resulted in reducing soil pH. Furthermore gardenia plants prefer acidic type of growing substrate (Gough, 1984 and Davidson, 1989 b). Thus sulphur application had positive effects on gardenia growth.

Table 4: Interaction effects of growing media and sulphur amendment on vegetative growth of gardenia plant

Treatments		Vegetative growth parameters during 1st and 2nd seasons													
Media	Sulphur Level	Plant height (Cm)		No. of leaves		Stem diameter (mm)		Total fresh weight (shoots + roots)(g)		Total dry weight (shoots + roots)(g)		Shoot- root ratio (fresh weight basis)		Shoot- root ratio (dry weight basis)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Clay	0	26.31	25.44	55.06	53.43	3.34	3.28	14.95	15.26	5.77	5.81	1.668	1.619	1.394	1.451
	1/2% S	32.06	29.06	59.69	58.94	4.06	4.02	24.25	25.78	9.84	9.90	2.613	2.352	1.802	1.923
	1%S	28.25	26.06	53.94	51.73	3.57	3.25	20.85	21.77	8.57	8.45	3.153	2.813	1.879	2.040
	2%S	24.69	22.73	39.31	35.83	3.28	3.12	17.63	18.01	6.31	6.31	2.897	2.742	2.162	2.217
Rice straw	0	32.00	30.38	62.81	60.87	3.62	3.56	25.62	26.06	9.88	10.02	2.005	1.971	2.125	2.127
	1/2% S	33.44	31.50	67.06	64.69	4.03	3.96	31.72	32.06	12.05	12.28	1.649	1.648	1.710	1.718
	1%S	34.69	33.88	70.19	68.69	4.40	4.22	37.46	37.57	12.83	13.15	1.267	1.294	1.659	1.701
	2%S	33.31	32.56	63.12	59.50	3.99	3.87	31.60	32.28	10.28	10.61	1.371	1.362	1.626	1.601
Sawdust	0	21.25	19.25	28.37	26.00	2.18	2.06	8.83	8.53	2.89	2.94	1.067	1.115	0.989	0.945
	1/2% S	23.75	20.75	32.62	31.38	2.50	2.37	11.80	11.52	4.34	4.26	0.982	0.983	0.873	0.841
	1%S	21.19	19.50	28.94	27.75	2.40	2.31	9.54	9.20	3.81	3.41	0.991	0.985	0.896	0.928
	2%S	20.00	19.04	25.50	23.38	2.19	2.10	6.67	6.26	2.58	2.32	1.231	1.155	0.942	1.063
$LSD_{(0.05)}$		1.26	1.17	1.68	2.04	0.36	0.32	1.47	1.69	0.69	0.78	0.252	0.285	0.279	0.326

The interaction effect of growing media and sulphur application was found to be significant for all the character except number of branches per plant (table 4). Despite the priority of 1/2 % sulphur level, plants grown in rice straw amended with sulphur at 1% proved to have the best growth characteristics (plant height, leaf number, stem diameter, fresh weight of shoots and roots) as data shown in table 4. Using 1/2% sulphur seemed to be not adequate to diminish rice straw-pH (8.00) to a proper level. Probably, increasing that level to 1% had the best combination with rice straw facilitate nutrient availability and consequently better plant growth leading to the best vegetative growth.

The interaction between sulphur application and growing medium could be interpreted according to the behavior of sulphur after incorporation, which was strongly affected with physical and chemical properties of the medium. The reducing effect of sulphur on substrate pH depends on microbial activity, added amount of sulphur and substrate physical and chemical properties under fixed environmental conditions. Roig *et al*., (2004) indicated that an increase in sulphur added led to a greater decrease in pH, but the addition of large amounts of sulphur would have negative effects. The high quantities of sulphur in soils may reduce microbial and fungal biomass activities and may have negative effects on different soil enzymes. Also, a high concentration in SO4-2, as a result of sulphur oxidation, could increase sensibly EC of the composted materials. Thus, rice straw pH responded better to sulphur addition than clay and sawdust. Similar results were obtained by El- Keltawi *et al*., (1979) on *Mentha piperita* and *Origanum majorana* when added sulphur to clay soil at (1250 ppm) of soil weight, resulted in best fresh and dry weight of leaves and shoots.

b. Flower characteristics:

Reproductive performance of gardenia plants was significantly affected by various growing media. Among the three media rice straw was the superior medium followed by clay in both the growing season with similar trend of flower production. Meanwhile, sawdust was the most inferior one regarding flower production. Maximum (7) flower/plant and largest flower with a diameter of 6.73cm were produced by the plants grown in rice straw in 2004/05 growing season (table 5).

Table 5: Effects of growing media on reproductive growth of gardenia plant

Growing media	Number of flowers/plant		Flower diameter (cm)	
	Growing season		Growing season	
	1st	2nd	1st	2nd
Clay	3.56	2.62	5.49	5.37
Rice straw	7	6	6.73	6.51
Sawdust	1.94	1.25	4.24	4.08
$LSD_{(0.05)}$	0.46	0.32	0.15	0.18

Flower quality was also significantly affected by growing media. Regarding mean individual flower weight and total flower weight per plant, rice straw was the best media followed by clay (Fig 4).

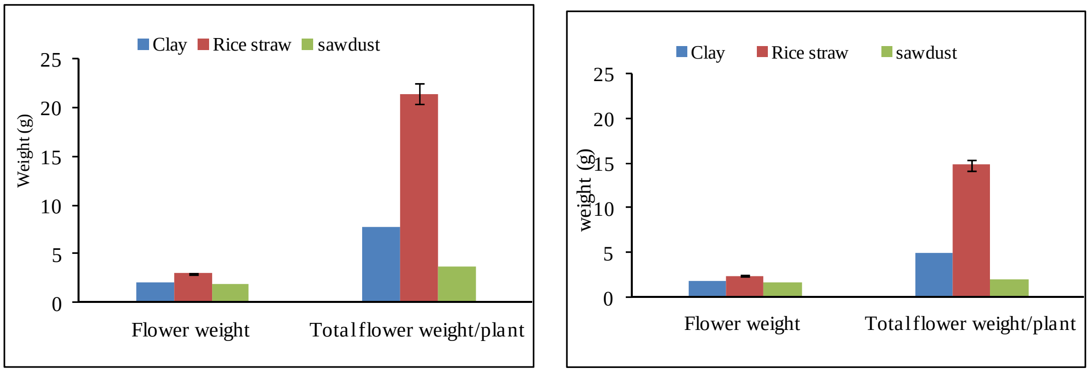

Fig. 4: Flower production of gardenia plant affected by growing media during the 2005/2006 and 2005/2006 seasons. Vertical bars indicate $LSD_{(0.05)}$

The inferiority of sawdust medium is in agreement with the finding of Hicklenton (1983) who found that chrysanthemum plants grown in unheated sawdust produced the thinnest and shortest stems. On the contrary, Worrall (1981) found that *Brassica oleraceae var. capitata*, *Lactuca sativa* and *Matthiola incana* plants grown in sawdust had no a significant effect on either number of flowers comparing with plants grown in sphagnum peat.

Concerning the amending of gardenia growing media with sulphur, no significant differences were found among the sulphur concentration applied regarding no of flowers per plant (table 6), while significant results were found in other flower characters. Using sulphur at 1/2 % proved to be the best concentration for producing larger flower with the highest diameter of 5.96 cm.

Table 6: Effect of sulphur amendment of growing media on reproductive growth of gardenia plant

Sulphur level	Number of flowers/plant		Flower diameter (cm)	
	Growing season		Growing season	
	1st	2nd	1st	2nd
0	4	2.92	4.9	4.71
½% S	4.25	3.25	5.96	5.76
1%S	4.08	3.25	5.88	5.69
2%S	4.33	3.75	5.22	5.12
$LSD_{(0.05)}$	N.S.	0.43	0.14	0.20

On the other hand using sulphur at 1/2 % was the best in producing heaviest flower (2.54 g) and sulphur at 2% was the best concentration for production of highest amount (13.08 g) of flower per plant (fig 5). Similar trend was observed in both the growing season.

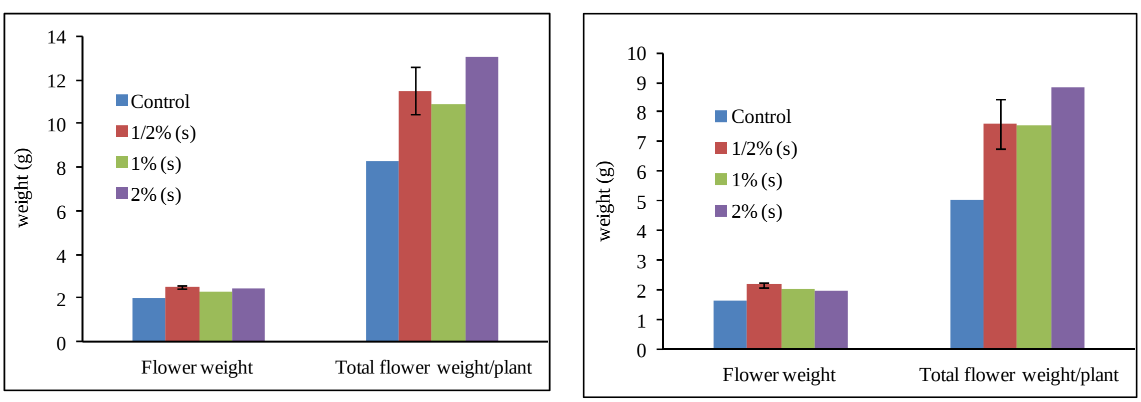

Fig. 5: Flower production of gardenia plant affected by sulphur amendment during the 2005/2006 and 2005/2006 seasons. Vertical bars indicate $LSD_{(0.05)}$

Significant interaction effect was also observed between growing media and sulphur application on flower characters (table 7). Amending rice straw with 2% sulphur was the best combination for flower characteristics.

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Table 7: Interaction effects of growing media and sulphur amendment on reproductive growth of gardenia plant

Treatments		Flowering growth parameters during 1st and 2nd seasons							
Media	Sulphur Levels	Number of flowers/plant		Flower diameter (cm)		Mean of flower weight in gm		Total flower weight in gm per plant	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Clay	0	4.25	3.25	4.45	4.25	1.88	1.59	7.99	5.15
	1/2% S	4.50	3.50	6.55	6.37	2.78	2.32	12.52	8.02
	1%S	3.00	2.00	5.85	5.75	1.88	1.88	5.68	3.76
	2%S	2.50	1.75	5.10	5.10	1.83	1.70	4.63	3.00
Rice straw	0	5.25	4.00	6.15	5.90	2.33	1.98	12.30	7.90
	1/2% S	6.25	5.00	6.82	6.60	2.90	2.53	18.14	12.67
	1%S	7.50	6.50	7.52	7.22	3.14	2.58	23.58	16.80
	2%S	9.00	8.50	6.45	6.32	3.53	2.57	31.79	21.82
Sawdust	0	2.50	1.50	4.10	3.97	1.85	1.33	4.61	1.98
	1/2% S	2.00	1.25	4.50	4.30	1.93	1.66	3.87	2.08
	1%S	1.75	1.25	4.28	4.10	1.90	1.64	3.34	2.04
	2%S	1.50	1.00	4.10	3.95	1.88	1.65	2.81	1.65
$LSD_{(0.05)}$		0.69	0.75	0.24	0.35	0.10	0.13	1.89	1.47

Sulphur is considered as the most important amendment element for alkali soil reclamation. In general sulfur seems to promote rhizosphere activity (Huang *et al*., 1997; Paparozzi,1999 and Macz *et al*., 2001). Gardenia plants flourish well in acidic soils with good drainage (Florist Home, 2006; Desert-tropicals, 2006 and Edward, 1999). The positive effect of sulphur on flowering was also observed by Joshi *et al*. (2002) on *Rosa damascene*, demonstrated that elemental sulphur at 4g/plant recorded the highest values for flower diameter and flower yield. Therefore, the present investigation showed that growth of gardenia plants in rice straw amended with sulphur reflected on flowering leading to the production of quality flower.

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