Application of Humic and Fulvic Acids in Nutrient Solution Affects Postharvest Characteristics of *Gerbera jamesonnii* L.

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Abstract

The effect of humic substances (humic (HA) and fulvic acid (FA)) on growth and postharvest life of gerbera (*Gerbera jamesonii* L.) 'Lourdes' were examined. HA and FA applied to solution in six combinations including control, 80% HA+20% FA (100 mg/L), 60% HA+40% FA (100 mg/L), 40% HA+60%FA (100 mg/L), 100% FA (100 mg/L) and 100% FA (50 mg/L). Although HA and FA application did not significantly improve yield (number of harvested flowers per plant) or visual quality (flower diameter, flower weight, shoot length and diameter of scapes), these substances enhanced the postharvest life. The results showed that 50 mg/L FA was the most effective treatment and extended the vase life by 5.5 days and prevented and delayed bent neck incidence. On the other hand all HA and FA treatments could decrease water loss after 12 days in comparison to the control. It seems that the hormonal effects along with nutritional improvement by humic substances were efficient in improving the postharvest quality of harvested flowers.

INTRODUCTION

Gerbera (*Gerbera jamesonii* L.) is presently a major cut flower crop in the world. Greenhouse growers typically use high nutrient concentrations in an attempt to maximize crop yield and quality especially to decrease bent neck incidence, which is a major postharvest problem of gerbera (Mencarelli et al., 1995; Zheng et al., 2004).

There are environmental concerns associated with increased fertilizer use with continuous growth of the horticultural industry. The use of humic substances (HS) as a promising natural resource could increase, or at least maintain, production quality of ornamental plants with reduced fertilizer inputs (Nikbakht et al., 2008). HS include two main fractions, humic acids (HA) and fulvic acids (FA) and are the most important components of non-living soil organic matter (Tan, 2003). They are produced by the decay of organic materials (Sharif et al., 2002).

Having adequate mineral nutrition, root and shoot growth stimulation has been commonly observed in plants treated by HS (Pertuit et al., 2001; Reynolds et al., 1995). Also HS have beneficial effects on seed germination, root initiation, crop production and plant photosynthesis (Chen and Aviad, 1990; Piccolo et al., 1991; Nardi et al., 2002; Cangi et al., 2006). Some other positive effects of HS are correlated with indirect effects such as enhanced nutrient uptake as well as their ability to complex transition metals such as Cu, Zn, Fe and Mn (Chen and Aviad, 1990; David et al., 1994; Adani et al., 1998). Bohme and Thi Lua (1997) reported that HA had beneficial effects on nutrient uptake by plants and was particularly important for the transport and availability of micronutrients.

Taking advantage of the complexing properties, various micronutrients are further complexed with HS to form chelates. HA have been complexed with sodium (Na), potassium (K), magnesium (Mg), zinc (Zn), calcium (Cu), iron (Fe), cupper (Cu) and with various other elements to overcome a particular element deficiency in soil (Aiken et al., 2002). Several researchers have observed that FA is the most effective component of soil organic matter in complexing metals due to high contents of oxygen-containing functional groups (Schnitzer and Khan, 1978).

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Zhang and Ervin (2004) showed HA has cytokinin activity and their application resulted in improving creeping bentgrass drought resistance. These natural products have been shown to delay senescence and improve turf quality (Zhang and Schmidt, 2000). Pizzeghello et al. (2001) measured auxin-like and gibberellin-like activity in HA. Previous experiments with gerbera plants (Nikbakht et al., 2008) showed that HA increased the number of harvested flowers per plant and extended the vase life of harvested flowers due to Ca accumulation in scapes and hormone like activity. In the present study we compared the effect of two kinds of HS including HA and FA to see how they affect yield, visual quality and postharvest life of gerbera.

MATERIALS AND METHODS

'Lourdes' gerbera plants were grown in a commercial greenhouse at Isfahan University of Technology, Isfahan (32°38'N; 51°39'E) Iran. Plants were grown in 90 6-L pots containing a mixture of straight with peat moss, perlite and lica (6:3:1). Three replications per treatment were arranged in a randomized complete block design. Each experimental plot included 5 gerbera pots. The pots were irrigated from upper part with nutrient solution (Savvas and Gizas, 2002) prepared with distilled water and the concentrations of nutrients in all treatments were as follows (macronutrients in meq/L, micronutrients in μM): K (5.84), Ca (6.56), Mg (2.2), ammonium (NH_4; 1.1), nitrate (NO_3; 11.2), sulfate (SO_4; 2.54), phosphorus (P; 1.2), Fe (35), Mn (5), Zn (4), Cu (0.75), and boron (B; 30). Iron was added as Fe-ethylenediamine-di-O-hydroxyphenilacetic acid (EDDHA). Macronutrients (N, P, K) were primarily added from Traflex F (SQM, Belgium). Other fertilizers were added from a separate stock solution. The electrical conductivity of the nutrient solution (EC) was 1.8-1.9 and pH was set at 5.6 in all treatments. Different levels of HS were applied to nutrient solution. HA and FA prepared from an Australian company. Treatments were as follows: 0; control (nutrient solution only), 1; 80% HA+20% FA (100 mg/L), 2; 60% HA+40% FA (100 mg/L), 3; 40% HA+60% FA (100 mg/L), 4; 100% FA (100 mg/L) and 5; 100% FA (50 mg/L).

Each plant was receiving exactly 350 ml (August to October) or 175 ml (November to April) nutrient solution daily. The plants were spaced 30 cm apart. Mean air temperature in the greenhouse was 29±2°C/24±3°C (day/night) and relative humidity varied between 70.5±5 and 44.5±5.5%. Number, initial fresh weight of flowers, head and scape diameter and length of scapes were taken from the produced flower in the following 3-month period from appearance of the first flower.

For postharvest experiment uniform flowers were broken from the rhizome when 2-3 rows of disc florets had matured. Scapes were trimmed under distilled water to a uniform length of 30 cm. The flowers were kept in 500 ml distilled water at 26±2°C, 60±5% relative humidity, and 16/8 h photoperiod. The flower bending incidence (bending of capitulum over 90°) and vase life (vase life terminated by bending or petal wilting) were recorded daily on 12 flowers per treatment. Every three day flowers were removed and weighted while renewing water. Data were analyzed by the LSD comparisons of means using procedure within the SAS statistical system.

RESULTS AND DISCUSSION

Characteristics of Harvested Flowers

Table 1 shows the effect of HS on characteristics of harvested flowers. The application of HS had no significant effect on number of harvested flowers per plant, flower weight, shoot length and head and scape diameter. These results do not agree with Nikbakht et al. (2008) on gerbera which reported a beneficial effect of HA on the number of flowers per plant. They obtained the highest number of flowers from 500 mg/L HA. Lower levels of HA (100 mg/L) increased the number of harvested flowers but did not differ significantly from the control. The current results could be mainly due to HS concentration and type of HS. Chen and Aviad (1990) reported that the appropriate concentration of HS varying from 25 to 300 mg/L in different examined plants when applied in nutrient solution. Also it might be related to the difference between species, growing media and mode of HS application.

Postharvest Life of Harvested Flower

HS application significantly affected vase life of harvested flowers (Table 2). Vase life of flowers ranged from 16 to 21.8 days. 50 mg/L FA increased the vase life of flowers by 5.5-5.8 days with respect to control and highest FA level. Other levels of HA and FA increased vase life compared with the control. This enhancement in vase life might be due to an increase Ca accumulation in scapes. In an attempt to increase postharvest life and decrease bent neck incidence Nikbakht et al. (2008) applied different levels of HA in nutrient solution of gerbera plants and showed HA application increased Ca content of flower shoot. They concluded that Ca accumulation in scapes influenced the postharvest life and bent neck incidence of cut gerbera (Nikbakht et al., 2008).

Moreover HS application significantly influenced weight loss of flowers (Table 2). Different levels of HA and FA significantly decreased weight loss of flowers after 12 days ($P<0.05$) although no differences were observed in weight loss of flowers after 6 days among the various HA and FA levels. 50 mg/L FA decreased weight loss of flowers after 12 days by 54.3% compared with the control. These effects seem to be due to hormone-like activities of HS through its involvement in cell respiration and antioxidant and other enzymatic reactions (Chen and Aviad, 1990). Zhang and Ervin (2004) reported that natural products such as HA contain cytokinins and their application result in an increase in endogenous cytokinin levels, possibly leading to improved creeping bentgrass drought resistance. Piccolo et al. (1991) also reported hormone-like activity corresponding to indoleacetic acid (IAA), gibberellic acid (GA_3) and benzylaminopurine (BAP) from leonardite-derived HA.

FA is more active than HA (Chen and Aviad, 1990). That might be the reason why FA could influence postharvest life of the flowers more than HA. 100 mg/L FA did not affect vase life. It might be due to a decrease in some macro- and micro-elements uptake. Ayuso et al. (1996) reported excessive concentrations of HS can inhibit growth. Also they reported these inhibitory effects have been correlated with the presence of excessive ligands, which reduce micronutrient availability to plant roots.

CONCLUSIONS

Gerbera responded favorably to HS when added to nutrient solution by improving postharvest life of flowers up to 5.5 days. Optimal gerbera vase life and water loss would be expected using 50 mg/L FA. The data presented in this paper indicate that HS are promising compounds in hydroponic production of cut flowers specially gerbera to benefit from improving postharvest life. Further studies may, however, be required to determine HS application rates for optimal response of flower production and postharvest life.

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Tables

Table 1. Effect of HA and FA on characteristics of harvested gerbera flowers.

Treatment	Number Flowers per plant	Weight (g)	Length (cm)	Head diameter (cm)	Scape diameter (mm)
1	3.80	14.68	36.474	9.41	4.28
2	2.87	14.80	38.443	9.49	4.33
3	2.73	14.59	34.828	9.16	4.43
4	2.87	13.83	36.609	9.03	4.11
5	2.80	13.03	36.513	9.15	4.05
6	2.80	13.30	38.053	9.28	3.81
Probability	ns	ns	ns	ns	ns

* $P<0.05$ and ns, non significant. Values in the same column followed by the same letters are not significantly different by LSD test (n=12).
Treatments: HA + FA (mg/L), 1: Control (0), 2: 80% HA+20% FA (100), 3: 60% HA+40% FA (100), 4: 40% HA+60% FA (100), 5: 100% FA (100), 6: 100% FA (50).

Table 2. Effect of HA and FA on gerbera flower fresh weight and vase life of harvested flowers.

Treatment	Vase life (day)	Weight loss after 6 days (% of day-0)	Weight loss after 12 days (% of day-0)
1	16.33 d	11.74	18.20 a
2	19.33 bc	5.98	9.40 b
3	21.17 ab	8.27	13.99 ab
4	17.67 cd	5.73	11.41 ab
5	16.00 d	3.87	8.32 b
6	21.83 a	5.22	10.73 b
Probability	***	ns	*

*** $P<0.001$, * $P<0.05$ and ns, non significant. Values in the same column followed by the same letters are not significantly different by LSD test (n=12).
Treatments: HA + FA (mg/L), 1: Control (0), 2: 80% HA+20% FA (100), 3: 60% HA+40% FA (100), 4: 40% HA+60% FA (100), 5: 100% FA (100), 6: 100% FA (50).