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Growth Responses and Mineral Uptake of *Narcissus* 'Golden Harvest' Plants Grown in Municipal Solid Waste Compost - Amended Media

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Abstract: Using Municipal solid waste Compost (MSWC) as an organic fertilizer for each agricultural crop needs to be studied first. Then, it can be recommended for commercial production. This study is aimed at comparing the MSWC–amended substrates and soil substrate on quantitative and qualitative characteristics of *Narcissus*. The experiment was arranged in a completely randomized design with three replicates. The unique bulbs were planted in five different media including Current Soil Substrate and also 0, 25, 50 and 75% of MSWC in 1perlite: 1vermicolite: 1sand (v/v) base medium. At first, physical properties were measured in all substrates. Then vegetative characteristics, Macro elements concentration in leaves and some qualitative factors of flowers were determined. Compost improved physical and chemical properties of growing media so Chlorophyll index, photosynthesis, dry weight of leaves, length of flower stems and concentration of N in leaves were improved in compost containing media. Chlorophyll index and photosynthesis of leaves grown in 50% MSWC-amended media were increased by 7.2% and 61% more than the plants in soil base media respectively. The highest value for dry weight of leaves (2.33 g) was observed in 50% MSWC-amended media treatment. Our results indicate that a composition containing 50% MSWC can be applied successfully to soilless culture of *Narcissus* instead of soil culture.

Key words: Compost · *Narcissus* · Substrate · Soilless culture · Photosynthesis · Nutrients

INTRODUCTION

There are billion tones of Municipal solid waste materials which are generated in Iran annually. Although recycling is encouraged, large amounts of domestic waste are incinerated or dumped in landfills. The former method can have adverse effects on human health, mainly through direct and indirect exposure to contaminants, e.g., via polluted air or the ingestion of contaminated foods [1]. Furthermore, it is becoming more difficult to find new landfill sites so it seems to be vital to find new methods to get rid of these disposals.

The recycling of MSW has increased in recent years as cities strive to reduce their utilization of limited landfill space. Present-day municipal wastes that are recomposted usually include biosolids (sewage sludge) yard trimmings (chips from trees and brush, grass clippings and leaves) and food processing factories wastes. The greatest potential commercial use for these materials is agricultural compost and using it in growing media [2]. The use of Municipal solid waste Compost (MSWC) as an organic amendment for agricultural substrates is one of the best solutions to reduce urban wastes volume.

On the other hand, it has been proven that a suitable media must have good drainage, high water holding capacity and enough nutrient content that supply with using organic materials [3]. In order to rise good quality plants these factors especially for potting mixes are so important. Due to some difficulties with soil-based media in transformation, soil-born pests and diseases, high Electrical conductivity, etc., many of producers tend to try soilless media which include peat, perlite, vermiculite, sand, bark and other materials like composts which can provide aforementioned plants needs [4]. Although some organic components of growing media such as peat moss are well-known in beneficial effects and widely used in the production of container-grown ornamental plants, there are some reasons for today's increasingly popularity of using composts among growers: Most of soilless mixtures are nutrient free and can not cover all period of plants growth, especially when they are used

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for potted plants then some chemical fertilizers need to be added. But some economical and environmental policies about using chemical fertilizers make researchers responsible to find alternative nutritional sources [5]. Peat, the most widely used growing medium, is a non-renewable resource unavailable and expensive [6]. Mature compost may also be suppressive to soil borne pathogens but peat is conductive [7]. In many cases non-edible crops such as ornamentals, forest and garden trees and shrubs etc. can serve as a safe outlet for composts that may be considered as undesirable for food crop production [8].

As a result, growers are looking for alternatives to the substrates currently used. There have been several studies on using MSWC in different plants media. Gogue and Sanderson used different ratios of compost in *chrysanthemum* substrate and observed that compost improved growth parameters such as flower diameter, plant dry weight, length and weight of flowers in this plant [9]. Fisher and Schmits, reported that mixture of 25% compost and 75% peat could make a suitable growing media for potted poinsettias nutritionally and physically [10]. Growing substrates containing 30 to 60% compost made from urban waste materials successfully were used to grow a variety of bedding plants such as *Dianthus* and *Begonias* by Klock-Moore [11]. Fitzpatrik *et al.* mentioned that mixing compost with substrate did not provide enough nutrition for fast growing plants and some chemical fertilizer should be added but compost amended substrate could be used for slow growing plants [12].

Nevertheless, most of growers believe that since there are several problems in growing each plant related to substrates, every substrate with a new formulation should be first evaluated by researchers to determine whether it can provide that plant's needs or not, then economical aspects need to be concerned and finally it can be suggested to producers [4]. Most producers are interested in growing *Narcissus* which is a favorable flower for spring and New Year, not only due to its different colors, but also because it's flowering timing may be manipulated [13].

The present paper studied the effects of applying 0, 25, 50, 75% MSWC on growth, yield, physiological and nutritional status of potted *Narcissus* plants growing in a soilless substrate with a perlite, Vermiculite and Sand base. Results were compared with those obtained both without the application of organic matter (Control) and with the application of a commercial soil substrate.

It was expected that mixing different ratios of MSWC with base might result in different media with different physical and chemical properties and improve qualitative traits of plants.

MATERIALS AND METHODS

Non moist unique bulbs of *Narcissu*s 'Golden harvest' were stored in a dark incubator (Shimaz Co. Iran) at 7±0.5°C for sixteen weeks before planting, in order to receive their cold requirement. MSWC provided by Tabriz organic fertilizer company (Tabriz, Iran) was passed from a 10 mm sieve and medium sized compost was prepared. Using coarse grade perlite (1 mm), Medium grade vermiculite (2-4 mm) and sand (3mm) different media were prepared. 0, 25, 50 and 75% of MSWC in 1perlite 1vermicolite: 1sand (v/v) base medium were used. Also, a Soil Substrate (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation), which growers conventionally use, was prepared. Bulk density, percent pore space, percent air space, water holding capacity and container capacity of the substrates were determined on three samples of each substrate treatment at the beginning of the experiment. Columns with determined volume were filled with substrates and saturated with water for 24 h. A fine cloth was attached to the columns base then allowed to drain for 2 hours. Columns were weighed, dried at 105°C and weighed again. Different substrate physical properties were calculated using equations described by Reed [14].

Bulbs were dipped in Benomyl fungicide solution ($1 g.L^{-1}$) for 15 minutes and were planted [13]. Pots were leached with water to reduce the amount of salt and Electrical Conductivity (EC) in substrates. EC was analyzed using a 1: 2 dilution. Four bulbs were planted in each 15-cm standard pot and grown in an isolated growth chamber.

Temperature was controlled in accordance with plants requirement in different growth stages. It was set at 9±1°C in root growth stage and increased to 19±2°C gradually as plants were growing [13]. Plants received a medium light intensity ($500\ W^{-1}\ m^{-2}\ s^{-1}$), an 11h light and 13h dark cycle, which was similar to natural condition in *Narcissus* growth season. None of treatments received fertilizer in order to make nutritional studies easier. Plants were irrigated using 300 cc water weekly.

Vegetative characteristics such as relative chlorophyll content and photosynthesis were measured using chlorophyll meter (SPAD 502, Minolta, Japan) and portable photosynthesis meter (HCM-100, Walz, Mess- und Regeltechnik, Germany) respectively in the middle of the experiment which leaves were expanded. CO_2 concentration in photosynthesis meter was determined equal to the environmental CO_2 (350ppm). Temperature and relative humidity in the growth chamber were 20±2°C and 70% respectively [13]. Photosynthetic active rate (PAR) was measured at 450 $Wm^{-2}\ s^{-1}$ during the photosynthesis measurement.

Flower qualitative characteristics such as exterior petals, length and diameter of flower stem, fresh and dry weight of flower were determined in flowering stage. At the end of the flowering stage, leaves were harvested. Leaf area was measured using leaf area meter (LI-3100, LI-COR, Inc. Lincoln, Neb. USA). For dry matter determination, leaves were dried at 80°C in a forced-draught cabinet oven (Shimaz Co. Iran) to constant weight. Dried leaves were ground to powder in a stainless steel mill (Moulinex, Irland) and stored for chemical analysis. Prior to the analytical process, the ground samples were dried again at 105°C for 4 h. The N content was determined following a semimicro-Kjeldal digestion method. Concentration of P and K in leaves was measured in Vanadat-Molibdate colorimetric method and Atomic Emission Spectrometry methods in laboratory of Tabriz University.

The experiment was arranged in a completely randomized design with three replicates. Data were analyzed using the GLM Procedure (SAS statistical software 8.02, SAS Institute, Cary, NC.). Treatment means were separated by Fisher's Least Significant Difference test (LSD) and Duncan's Multiple Range test, 5% significant level.

RESULTS AND DISCUSSION

Substrates Properties: All substrates with compost had a greater Bulk density, Container Capacity and Moisture content than the control and it increased as the compost content increased. But the highest value occurred at soil-based substrate (Table 1). Although Soil substrate had the most pore space, but the percent Air space which is important for root's respiration was the lowest. Whereas, as the amount of compost increased in substrate, not only pore space raised but Air space in all compost-mixed media was more than the soil-based substrate. As the amount of mixed compost in the base medium increased, total pore space enhanced but the Air space percentage reduced. Presumably because of filling base substrates large pores (Air pores) with small articles of compost and change to small pores (Water pores), it could be helpful to maintain more water in media pores for plant's roots.

The recorded data of physical properties of substrates was in agreement with previous findings. Bunt found out total pore space of substrates decreased as the bulk density increased [15]. Also Bazzofi *et al.* [16] and Abou-Hadid *et al.* [17] mentioned positive aeration effects of using compost in substrates. Serra-Wittling *et al.* pointed out that using compost normally improved important physical properties such as porosity and water holding capacity when it was added to the soil [18].

All MSWC containing substrates had greater EC than the control. Also, EC climbed as the rate of MSWC was increased possibly due to the higher amount of nutrient elements (Figure 1). Therefore, EC can be a good index for evaluating nutritional condition. 75 % MSWC-amended substrate was in the maximum point, about 70% more than the control. The difference between soil-based substrate and MSWC-amended substrate was not significant. Rising EC as a consequence of increasing the amount of MSWC in media was reported by Hidalgo *et al.* [19]. Nelson reported that an EC level of about 2 to 4 $ds.m^{-1}$ was suitable for most crops [4].

Plant Properties: Average leaf growth was significantly greatest for plants grown in 50% compost, about 20% increases more than the lowest amount for Control. But leaf area measurement revealing no difference among treatments may indicate the genetic-dependant characteristic of this factor (Table 2).

Table 1: Physical properties measured at the first of the experiment in different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers)

Growing Media	Container Capacity ($g.cm^{-3}$)	Bulk density ($g.cm^{-3}$)	Moisture Content (% V)	Total porosity (% V)	Water pore (% V)	Air pore (% V)
0 %	28.28	0.55	33.88	41.40	28.24	13.16
25 %	33.16	0.56	37.04	44.60	31.15	11.45
50 %	35.20	0.60	37.17	46.08	35.24	10.84
75 %	38.87	0.61	39.75	46.88	38.87	8.01
Soil based	48.09	0.68	41.46	51.33	48.09	3.24

Table 2: Effects of using different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers) on *Narcissus* 'Golden harvest' leaves characteristics

Growing Media	Leaf length (Cm)	Leaf area (Cm^2)	Dry weight (g)	N ($mg.g^{-1}$)	P ($mg.g^{-1}$)	K ($mg.g^{-1}$)
0%	23.04 a	289.74 a	1.72 b	32.85 b	5.56 a	24.92 a
25%	26.98 a	318.15 a	2.09 ab	34.32 a	4.96 a	29.86 a
50%	28.76 ab	341.66 a	2.33 a	33.71 a	5.73 a	23.11 a
75%	25.85 ab	304.71 a	1.75 b	35.77 a	5.14 a	24.51 a
Soil based	25.11 b	262.28 a	1.80 b	29.96 b	4.63 a	28.58 a
Significance	*	NS	*	**	NS	NS

Means separation using least significant differences (LSD) test at $P \leq 0.05$

NS Not significant, * significant at $P \leq 0.05$, ** significant at $P \leq 0.01$

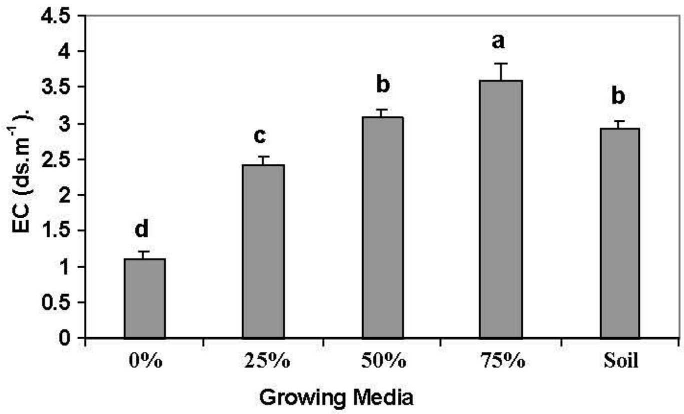

Fig. 1: Effects of using different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers) on Electrical conductivity ($P \leq 0.05$). Bars indicate standard errors.

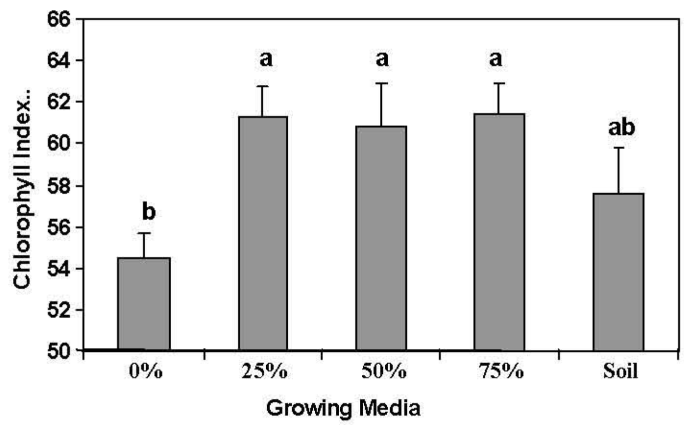

Fig. 2: Effects of using different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers) on *Narcissus* 'Golden harvest' leaves chlorophyll index ($P \leq 0.05$). Bars indicate standard errors.

Plants grown in MSWC-amended substrates had higher chlorophyll index than in the control substrate (Figure 2). 75% MSWC-amended substrate had the greatest value (61.44 $mg.g^{-1}$) and the control had the least (54.41 $mg.g^{-1}$). It has been indicated that light and nutritional elements can affect the amount of chlorophyll index of leaves [20]. Since, light providing was the same for all treatments, it can be concluded that nutrients especially Nitrogen, as it showed a highly significant curvilinear relationship with chlorophyll index, plays an important role in chlorophyll synthesis (Figure 3).

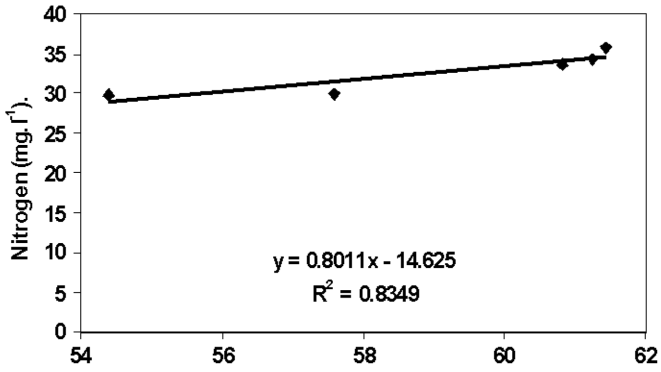

Fig. 3: Significant curvilinear relationship between chlorophyll index and *Narcissus* 'Golden harvest' leave's N content

For plants grown in substrate containing 50% MSWC, dry weight of leaves reached to the highest point and in comparison with the Control was greatly enhanced (45.5%), possibly due to the higher container capacity and nutrition supply in compost-amended media (Table 1&2). Abou-Hadid *et al.* showed that addition of compost supplies to substrates increased the cucumber seedlings dry weight [17]. It seems that, because of improper physical and chemical properties, plants grown in soil-based substrate and 75% MSWC substrates produced less leaves dry weight than plants in 50% MSWC substrate.

No significant differences due to treatment were found in the P and K content in leaves. Haynes recorded that Compost generally improved the chemical properties of container substrates by increasing pH, cation exchange capacity and concentrations of plant-available nutrients. However, most nutrients in compost are not readily soluble and are released gradually as the organic material breaks down [21].

Concentration of N in plant leaves from MSWC-amended treatments was significantly higher ($p \leq 0.01$) than in the soil-based substrate and control possibly because MSWC could contribute relatively high amounts of available-N to the substrate-plant system (Table 2). Iglesias-Jimenez indicated that the MSWC cannot be considered as a poor-release N mineral when it has a high degree of maturity [22]. Likewise, he reported that the MSWC significantly increased both yield and plant-N concentration with respect to un-amended substrate.

In addition, it should be stated that N shortage could inhibit the growth of *Narcissus* because the stored N in bulbs at the time of planting is not sufficient to cover the full period of growth. Ohyama *et al.* observed that 90% of the total N was in the scales at planting [23]. After rooting, the roots took up N from the substrate. Most of the N was in the shoots during growth period but had trans-located to the new scales by harvest.

On the other hand, despite containing organic matter, soil-based substrate had the lowest amount of N, possibly due to the high proportion of water pore to air pore and lack of oxygen which is vital for N mineralization mediator microbes. Also root respiration decreasing in this situation might result in nutrient absorption decline including N [24].

Comparing achieved data, it can be concluded that improving Average leaf growth might be affected by the higher amount of Nitrogen, chlorophyll index and photosynthesis rate in MSWC substrates. Ruamrangsri Showed that plants cultivated in nitrogen-free solution showed retarded growth [25]. Also he pointed out that *Narcissus* growth with the N-free treatment was restricted and that the N supply was important to promote growth. Containing more Nitrogen, MSWC could produce more chlorophyll index in leaves. However, there was no difference in chlorophyll index between soil-based substrate and substrates containing MSWC. Mac *et al.* mentioned that chlorophyll index in *Spathiphyllum* leaves increased with increasing N concentration in substrate [26].

It can be seen in Figure 4 that Plants grown in MSWC-amended substrate had the highest value of Photosynthesis rate, about 60% more than the Control, possibly in relation with the effect of higher amount of nutrients and also as a consequence of more chlorophyll index in leaves. The lowest value among all MSWC media occurred in 75 % MSWC-amended substrate perhaps as a result of prohibitive high salt (EC) effects. Plants in 0 % MSWC could do Photosynthesis slightly although they did not receive any kind of nutrients from

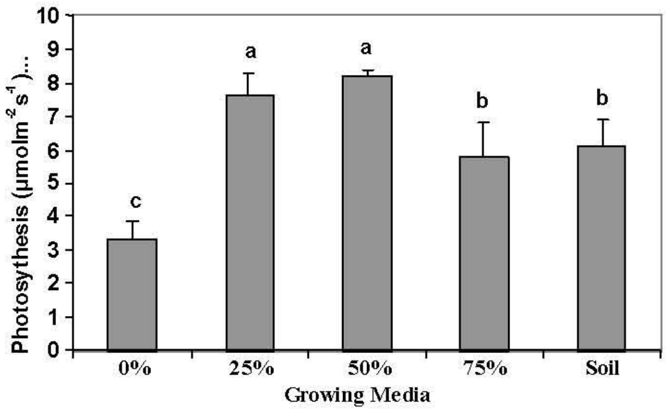

Fig. 4: Effects of using different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers) on *Narcissus* 'Golden harvest' plants photosynthesis rate ($P \leq 0.05$). Bars indicate standard errors

Table 3: Effects using of different growing media (0%, 25%, 50% and 75% MSWC in a 1 perlite: 1 vermiculite: 1 sand base medium and a soil based medium (2 loam soil: 1 Manure: 1 sand: 1 Leaf mould (v/v) formulation) which has been conventionally used by growers) on *Narcissus* 'Golden harvest' flower characteristics

Growing Media	Crown length (Cm)	Petal length (Cm)	Crown diameter (Cm)	Flower diameter (Cm)	Stem height (Cm)
0 %	2.61 a	2.71 a	3.03 a	6.60 a	32.58 b
25 %	2.60 a	2.81 a	2.97 a	6.98 a	43.16 a
50 %	2.64 a	2.75 a	3.04 a	6.79 a	40.87 a
75 %	2.71 a	2.73 a	2.68 a	6.61 a	40.08 a
Soil based	2.71 a	2.88 a	3.03 a	6.96 a	40.21 a
Significance	NS	NS	NS	NS	*

Means separation using least significant differences (LSD) test at $P \leq 0.05$

[NS] Not significant, * significant at $P \leq 0.05$, ** significant at $P \leq 0.01$

the media; it likely referred to this idea that the amount of nutrients in the bulbs can support the growth to some extent but not totally.

There were no significant differences in flower characteristics among plants grown in all substrates with an exception about flower stem length (Table 3). Plants grown in MSWC substrates and soil-based substrate produced longer flower stems than the Control treatment. De Hertogh wrote in his book that most of flower segments had been formed completely inside the bulbs before planting [27], so they can not be affected by treatments. Also, Ruamrangsri *et al.* observed that N deficiency hardly affected the flower quality i.e., length of flower stalk and color of petals [28].

It has been indicated that temperature and water availability could be the possible affecting factors on *Narcissus* growth and development especially flower stem length [29]. Since temperature was similar in all treatments, it can be concluded that higher amount of water availability or percentage of moisture in soil-based substrate and MSWC growing media resulted in taller flower stems as plants in 25% MSWC treatment produced stems which were 24.5% taller than the Control. It is obvious that cut flowers with taller stems are more concerned in market because of their higher life length.

CONCLUSION

Compost addition supplied additional organic matter which improved some effective factors on Photosynthesis such as: Oxygen, Water and macro nutrients in root zoon. Since, other effective factors on Photosynthesis rate such as light, temperature, CO_2 and O_2 concentration in the air were the same for all treatments during the experiment, aforementioned factors played the role in Photosynthesis inequality. The more plants received the initial effective Photosynthesis factors, the more photosynthesis, average leaf growth, leaf dry weight and flowers with tallest stems they had. Plants that were grown in MSWC substrate in 50% ratio totally showed the best results even much better than the soil substrate which, in spite of several difficulties, is used in our country now. In addition, *Narcissus* substrates using MSWC should be formulated with no more than 50% in order to avoid prohibitive effects of high salt content.

Composting of MSW is relatively new in Iran. Additional research is needed to identify MSW composting practices that optimize compost characteristics for specific horticultural uses and that clearly document the economic and environmental value of compost use.

REFERENCES

1. Cullen, A.C., 1995. The Sensitivity of Probabilistic Risk Assessment Results to Alternative Model Structure: A Case Study of Municipal Waste Incineration. J. Air Waste Management Association, 45(7): 538-546.
2. Parr, J.F. and S.B. Hornick, 1993. Utilization of municipal wastes. In: F.B. Metting, (ed.). Soil Microbial Ecology: Application in Agriculture, Forestry and Environmental Management. Marcel Dekker, New York.
3. Riseman, A., Ch. Jensen and M. Williams, 2001. Stomatal Conductivity and Osmotic Adjustment during Acclimation to Multiple Cycles of Drought Stress in Potted Miniature Rose. J. Horticultural Science and Biotechnol., 76(2): 138-144.
4. Nelson, V.P., 1991. Greenhouse Operation and Management 4th ed. Prentice Hall, Upper Saddle River, N.J.
5. Dole, J.M. and H.F. Wilkins, 1999. Floriculture, Principles and Species. Prentice Hall Inc. New Jersey, USA.
6. Raviv, M. and Y. Chen, 1986. Peat and Peat Substitutes as Growth Container-Grown Plants. In: Chen and Avnimelech (Eds.), the Role of Organic Matter in Modern Agriculture. Martinus Nijhoff, Dordrecht, The Netherlands, pp: 257-287.
7. Hoitink, H.A.J., Y. Inbar and M.J. Boehm, 1991. Status of Compost-Amended Potting Mixes Naturally Suppressive to Soil Borne Diseases of Floricultural Crops. Plant Disease, 75(9): 869-873.
8. Raviv, M., 1998. Horticultural Uses of Composted Material. Acta Horticulture, 450: 225-234.
9. Gogue, G. and C. Sanderson Kenneth, 1975. Municipal Compost as a Medium Amendment for Chrysanthemum Culture. J. American Society Horticultural Sci., 100(3): 213-216.
10. Fisher, P. and H.J. Schmit, 1997. Composts from Residues of Anaerobically Treated Household Waste and Their Suitability in Growing Media. Acta Horticulture, 450: 229-235.
11. Klock-Moore, K.A., 1999. Bedding plant growth in greenhouse waste and biosolids compost. HortTechnol., 9(2): 210-213.
12. Fitzpatrik, G.G., R. Duke Edwin and A. Klock-Moore, 1998. Use of Compost Products for Ornamental Crop Production: Research and Grower Experiences. Hort Sci., 33(6): 941-944.
13. De Hertogh, A.A., 1998. *Narcissus* (Daffodil and Paper white). Red Book.
14. Reed, D.W., 1996. Water, Media and Nutrition for Greenhouse Crops. Ball Publishing, Batavia, IL.
15. Bunt, A.C., 1983. Physical Properties of Mixtures of Peats and Minerals of Different Particle Size and Bulk Density for Potting Substrates. Glasshouse Crops Research Institute, Little Neamption, Acta Horticulture, 150: 143-153.
16. Bazzoffi, P., S. Pellegrini, A. Rocchini, M. Morandi and O. Grasselli, 1998. The Effect of Urban Refuse Compost and Different Tractors Tires on Soil Physical Properties, Soil Erosion and Maize Yield. Soil & Tillage Res., 48: 275-286.
17. Abou-Hadid, A.F. and M. Amin, 1998. The Effect of Available Water Content and other Physical and Chemical Properties of Soil Substrates on Germination of Cucumber. Acta Horticulture, 469: 245-252.
18. Serra-Wittling, C., S. Houot and E. Barriuso, 1995. Soil Enzymatic Response to Addition of Municipal Solid Waste Compost. Biology and Fertility of Soils, 20: 226-236.
19. Hidalgo, R.P. and L.R. Harkess, 2002. Earthworm Castings as a Substrate for Poinsettia Production. HortSci., 37(2): 304-308.
20. Kramer, P.J., 1983. Water Relation of Plants. Academic Press Inc.
21. Haynes, R.J., 1986. Mineral Nitrogen in the Plant Soil System. Academic Press, Orlando, Fla.
22. Iglesias-Jimenez., E. and C.E. Alvarez, 1993. Apparent Availability of Nitrogen in Composted Municipal Refuse. Biology and fertility of Soils, 16: 313-318.
23. Ohyama, T. and K. Kumazava, 1979. Assimilation and Transport of Nitrogenous Compounds Originating from 15N2 Fixation and 15NO3 Absorbtion. Proceedings of the Third International Conference. Academic Press, pp: 329-335.

24. Heuberger, H., J. Livet and W. Schnitzler, 2001. Effect of Soil Aeration on Nitrogen Availability and Growth of Selected Vegetables-Preliminary Results. Acta Horticulture, 563: 147-154.
25. Ruamrangsri, S., T. Ikarashi and T. Ohyama, 1997. Uptake, Translocation and Fractionation of Nitrogen in *Narcissus* Organs by Using 15N. Acta Horticulture, 430: 73-78.
26. Mac, Y.T.A. and M.D. Yeh, 2001. Nitrogen Nutrition of Spathiphyllum "Sensation" Grown in Sphagnum Peat and Coir Based Media With Two Irrigation Methods. HortSci., 36(4): 645-649.
27. De Hertogh, A. and M. Le Nard, 1993. The Physiology of Flower Bulbs. Elsevier Science Publishers. Amsterdam, the Netherlands.
28. Ruamrungsri, S., T. Ohyama, T. Konno and T. Ikarashi, 1996b. Deficiency of N, P, K, Ca, Mg and Fe Mineral Nutrients in Narcissus 'Garden Giant'. Soil Science and Plant Nutrition, 42: 809-820.
29. Hanks, R.G., 1996. Variation in the growth and development of Narcissus in relation to meteorological and related factors. J. Horticultural Sci., 71(4): 517-532.