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Agricultural and municipal waste as potting media components for the growth and flowering of *Dahlia hortensis* 'Figaro'

Usman TARIQ[1,*], Shoaib ur REHMAN[1], Muhammad Aslam KHAN[1], Adnan YOUNIS[1], Muhammad YASEEN[2], Muhammad AHSAN[1]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad 38040-PAKISTAN

[2]Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad 38040-PAKISTAN

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Abstract: This research project was conducted to evaluate the use of different waste materials as potting media for the dwarf variety *Dahlia hortensis* 'Figaro.' A total of 10 treatments were used where each treatment, consisting of 9 plants, was replicated 3 times. The results associated with plant growth parameters indicated that the maximum values for plant height, number of side shoots per plant, number of tubers per plant, flower diameter, and least days to flower emergence were observed in media containing coconut coir; the maximum corm weight per plant, however, was found in T_8, where rice hull was added to silt. The number of flowers per plant was increased in T_9, where silt, coconut coir, dust, sewage sludge, spent mushroom compost, and rice hull were used together in equal proportions. The media containing sewage sludge alone and in combination with silt showed minimum results for these parameters. Sewage sludge, with its higher pH, produced the least results for all plant growth parameters when 50% or more sewage sludge was added to the potting media.

Key words: Dahlia, potting media, coconut coir, rice hull, sewage sludge

Introduction

Natural soil and peat are the most used growing substrates for the container production of annual and perennial ornamental plants. Peat is the most widely used substrate for potted plant production in nurseries and it accounts for a significant portion of the material used to grow potted plants (Marfa et al., 2002; Ribeiro et al., 2007). Soil is fine for plants in gardens but it is not a good choice for plants in containers because the frequent water demanded by container plants will cause most soil to compact into a tight, brick-like mass. On the other hand, the high cost and low availability of quality peat limit its use. In recent years, researchers have shown an interest in reducing the use of peat as a component of growing media in container production (Abad et al., 2001; Guerin et al., 2001; Hicklenton et al., 2001; Garcia Gomez et al., 2002).

Potting medium is an important factor that plays a key role in the production of quality dahlia flowers. For appropriate growth, a root medium must fulfil 4 functions: 1) continuously supply water; 2) provide nutrients; 3) allow the exchange of gases to and from the roots; and 4) offer support for the plants (Nelson,

* E-mail: usmanflori@yahoo.com

1991). The equilibrium of these demands varies, however, depending on the plant being grown and the phase of growth. It is necessary to find alternative growing materials. Agricultural and municipal wastes could be feasible organic nutrient sources for container plant production. These byproducts are cheaper, readily available, and could be used to develop artificial soil-based media for container plants. Organic materials from agriculture, forestry, green areas, and livestock farming as well as residues from municipal and industrial waste are rich sources of different nutrients (Khan et al., 2012) and all have been strongly recommended for use as renewable resources in pot production, an effort that would help to palliate their harmful impact on local and global environmental degradation.

Potting soil mixes are the most important factors for the quality production of flowers in floriculture. Ornamental floral species tend to have a higher global demand, depending on people's preferences (Kashihara et al., 2011). In the last few years, farmers and nursery workers have been very concerned about potting medium, as it plays an important role in plant production. Research to date has suggested that peat has been satisfactorily replaced in container media with some organic waste materials including bark and wood fibre, coconut coir, and compost. Bio-solids like sewage sludge from municipal wastewater have also been extensively used as a soil base growing medium (Sanchez-Monedero et al., 2004). Waste materials offer a potential substitute for peat in sustainable horticulture production. There is a continuing interest in using various agricultural byproducts as an organic nutrient source for plants due to rising consciousness of environmental issues, including the need to manage and make use of increasing quantities of waste (Grigatti, 2008; Riaz et al., 2008).

The first objective of this research was to evaluate different potting mixes for the growth and flowering of *Dahlia hortensis* 'Figaro.' This project explored the use of different types of media such as silt, coconut coir, dust, sewage sludge, spent mushroom compost, and rice hull used both alone and in different combinations for the production of dahlias. Along with studying the growth and flowering of dahlias, the chemical properties of the media, such as the availability of nutrients and the pH, were also evaluated.

Material and methods

The comparative research was carried out at the floriculture research area of the Institute of Horticultural Sciences, University of Agriculture in Faisalabad during 2009-2010 to evaluate the use of agricultural and municipal waste as potting media for *Dahlia hortensis* 'Figaro,' the dwarf variety. Seeds were sown in 20 cm (diameter from top) clay pots on 20-10-2009 for nursery raising. Seedlings were transplanted after 40 days at the 4-leaf stage in 20 cm clay pots. Different waste materials such as coconut coir dust, sewage sludge, spent mushroom compost, and rice hull were used alone and in different proportions with silt as potting soil. The treatments for this experiment were T_0, silt (S); T_1, coconut coir dust (CD); T_2, sewage sludge (SS); T_3, spent mushroom compost (SMC); T_4, rice hull (RH); T_5, silt + coconut coir dust (1:1); T_6, silt + sewage sludge (1:1); T_7, silt + spent mushroom compost (1:1); T_8, silt + rice hull (1:1); and T_9, silt + coconut coir dust + sewage sludge + spent mushroom compost + rice hull (1:1:1:1:1). Treatment T_0, which contained silt only, was considered the standard condition as it is commercially used for ornamental plant production. Different waste materials were compared with the control while other management practices like irrigation, weeding, and fertiliser and pesticide application were the same for all treatments. Fertigation of soluble NPK (19-19-19) fertiliser was done once after transplantation with 2 g of fertiliser for each pot. The experiment was laid out with a completely randomised design (CRD), with 3 plants as the experimental units in a single replication. Each treatment consisted of 3 replicates with 3 plants in each replicate. The total number of plants was 90. The data were collected fortnightly during the research period.

Plant characteristics

The morphological parameters studied were plant height (cm), days to flower emergence (days), number of flowers plant^{-1}, flower diameter (cm), number of side shoots plant^{-1}, number of tubers plant^{-1}, and tuber weight plant^{-1} (g).

Chemical analysis

Chemical properties of the potting media such as nitrogen, phosphorus, potassium, electrical conductivity (EC), and pH were tested. The total nitrogen in the soil sample was determined by distillation in Kjeldahl's apparatus and titration was carried out with standard H_2SO_4. Boric acid and methyl red were used as indicators (Jackson, 1962; Bremner & Mulvaney, 1982). Olsen's method was used to determine the available phosphorus in the media (Watanabe & Olsen, 1965; Olsen et al., 1984; Younis et al., 2010) and for the assessment of potassium the United States Salinity Laboratory Staff's (1954) method of flame photometer was used. Electrical conductivity (EC) was measured in dS m^{-1} with a conductivity meter and a pH meter (digital ion analyser) was used to measure the pH of the potting media (Sparks et al., 1996).

Statistical analysis

The collected data for the morphological traits of the plants and the chemical and physical characteristics of the potting media were statistically analysed by using analysis of variance (ANOVA) to check any differences between the means. Significant means were compared using Duncan's multiple range test (DMRT) at a 5% probability level (Steel et al., 1997).

Results

Plant characteristics

The quality production of ornamental plants can be attained by the use of appropriate potting media, which have a prominent effect on growth (Vendrame et al., 2005). In order to attain this objective, different mixtures of silt, coconut coir dust, sewage sludge, spent mushroom compost, and rice hull were tested. The collected data regarding the morphological traits and the chemical analysis of the media were analysed statistically at a 5% probability level. The ANOVA showed highly significant results and treatment means were compared using DMRT. The maximum significant ($P < 0.05$) plant height of 23.51 cm was obtained in T_1 (coconut coir) followed by 21.78 cm in T_5 (silt + coconut coir) and 21.59 cm in T_0 (silt), while T_9, T_8, T_6, and T_7 (at heights of 18.78, 18.73, 17.85, and 17.55 cm, respectively) were found to be significantly similar to one another. The lowest height value, 11.3 cm, was recorded in T_2, where sewage sludge was used alone (Figure 1).

When coconut coir dust was mixed with silt in T_5, it produced flowers earlier (113.33 days) than all other treatments. The maximum number of days (170.33) or delayed flowering was observed in T_2, where sewage sludge was used (Table 1). Figure 2 shows a maximum flower diameter of 7.20 cm in T_1 (coconut coir dust) followed by T_7, where silt and spent mushroom compost (1:1) were used. The smallest flower diameter (4.47 cm) was reported in T_2 (sewage sludge) although T_6 (silt + sewage sludge, 1:1) and T_4 (rice hull) also produced flowers with small diameters (4.92 and 5.01 cm, respectively).

The maximum number of flowers, 12.33 and 10.78, were obtained in T_9 (silt + coconut coir dust + sewage sludge + spent mushroom compost + rice hull, 1:1:1:1:1) and T_5 (silt + coconut coir dust, 1:1), respectively. Results indicate that T_1 (coconut coir dust), T_0 (silt), and T_3 (spent mushroom compost) were significantly similar to one another, with 8.78, 7.67, and 7.11 flowers, respectively, while the minimum number of flowers was recorded in T_2, where only sewage sludge was used (Table 1). The

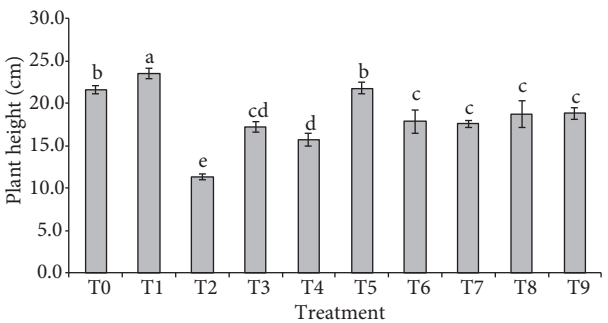

Figure 1. The effect of different potting media on plant height.

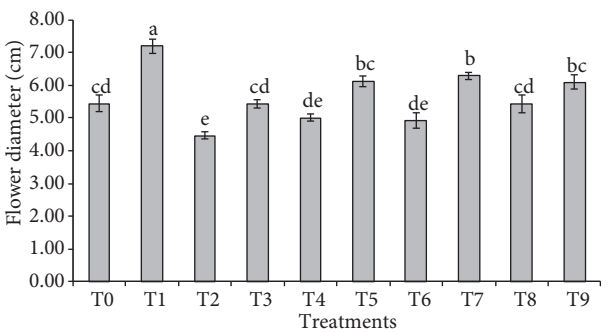

Figure 2. The effect of different potting media on flower diameter.

Table 1. The effect of medium on flowering and tuber formation.

Treatments	No. of flowers per plant	Days to flower emergence (days)	No. of tubers per plant	Tuber weight per plant (g)
T_0	7.67 ± 0.50^{b}	118.2 ± 1.36^{cd}	2.89 ± 0.39^{c}	4.86 ± 0.54^{cd}
T_1	8.78 ± 0.46^{b}	132.8 ± 1.01^{b}	6.00 ± 0.75^{a}	6.27 ± 0.25^{b}
T_2	3.00 ± 0.37^{e}	170.2 ± 9.99^{a}	1.00 ± 0.24^{e}	2.28 ± 0.46^{e}
T_3	7.11 ± 0.51^{b}	132.2 ± 3.19^{b}	4.56 ± 0.18^{b}	4.94 ± 0.27^{cd}
T_4	5.11 ± 0.68^{d}	132. 6 ± 2.83^{b}	2.44 ± 0.56^{cd}	3.90 ± 0.58^{d}
T_5	10.78 ± 1.46^{a}	113.2 ± 1.41^{d}	3.44 ± 0.80^{bc}	5.02 ± 0.37^{cd}
T_6	4.22 ± 0.52^{de}	116.7 ± 6.08^{d}	1.11 ± 0.11^{de}	2.72 ± 0.14^{e}
T_7	7.00 ± 0.78^{bc}	128.3 ± 2.74^{b}	2.44 ± 0.41^{cd}	4.57 ± 0.22^{cd}
T_8	5.22 ± 0.57^{cd}	126.1 ± 1.75^{bc}	3.00 ± 0.37^{c}	8.85 ± 0.50^{a}
T_9	12.33 ± 0.96^{a}	126.6 ± 2.68^{bc}	3.56 ± 0.29^{bc}	5.19 ± 0.11^{c}

coconut coir dust (T_1) alone gave the maximum number of shoots per plant (15.67) compared to other treatments and the least number of side shoots (3.11) was recorded in T_2 (sewage sludge) while few side shoots (3.44) were also produced in T_4, with rice hull (Figure 3).

The maximum corm weight, 8.85 g, was obtained in T_8, where silt + rice hull (1:1) were used; T_1 (coconut coir dust) was found to give the second highest result, at 6.27 g. The minimum tuber weight per plant of 2.28 g was recorded in T_2 (sewage sludge) whereas T_6 (silt + sewage sludge, 1:1) also produced a low tuber weight of 2.72 g. The comparison indicated that T_5, T_3, T_0, and T_7 were not significantly different from one another, with results of 5.02, 4.94, 4.86, and 4.57, respectively. The maximum number of tubers, 6.00, was obtained in T_1 (coconut coir dust) followed by 4.56 tubers in T_3, which contained spent mushroom compost (Table 1).

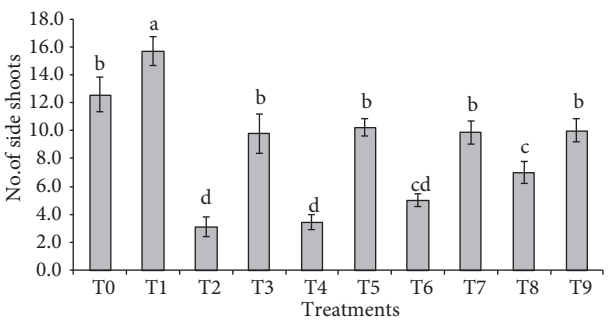

Figure 3. The effect of different potting media on the number of side shoots per plant.

Chemical analysis

An analysis of the chemical properties of the tested media with regard to pH showed that T_2 (sewage sludge) resulted in a maximum pH of 8.57 followed by T_6 (silt + sewage sludge, 1:1) at 8.17 pH. The minimum pH, 6.50, was observed in T_4 (rice hull).

The overall response of dahlia in terms of the different growth parameters varied with the pH of the media. Analytical data regarding total nitrogen showed the superiority of T_2 over other treatments. T_2, where sewage sludge alone was used, had a maximum nitrogen level of 2.40% and was followed by T_3 (spent mushroom compost), at 1.97% nitrogen. The lowest nitrogen value, 0.09%, was observed in T_0 where only silt was present. T_2 (sewage sludge) had the highest nitrogen value among all of the tested media but it had negative effects on plant growth (Table 2).

Results showed that the maximum available phosphorous was present in T_9 (silt + coconut coir dust + sewage sludge + spent mushroom compost + rice hull, 1:1:1:1:1); T_0, which had only silt, was ranked second and the lowest amount of phosphorus

Table 2. Chemical properties of the potting media studied.

Treatments	pH	Total nitrogen (%)	Phosphorous (ppm)	Potassium (ppm)
T_0	7.60 ± 0.12^{c}	0.09 ± 0.01^{g}	93.2 ± 1.66^{b}	494.6 ± 41.65^{cd}
T_1	7.02 ± 0.11^{d}	0.40 ± 0.04^{ef}	68.1 ± 2.13^{cd}	591.3 ± 75.72^{bc}
T_2	8.57 ± 0.09^{a}	2.40 ± 0.06^{a}	57.1 ± 2.91^{def}	580.6 ± 21.30^{bc}
T_3	7.53 ± 0.09^{c}	1.97 ± 0.09^{b}	45.2 ± 2.54^{fg}	633.3 ± 24.04^{b}
T_4	6.50 ± 0.15^{e}	0.48 ± 0.05^{e}	39.2 ± 2.24^{g}	423.0 ± 16.75^{d}
T_5	7.23 ± 0.18^{cd}	0.28 ± 0.01^{f}	71.9 ± 2.90^{c}	665.3 ± 29.24^{b}
T_6	8.17 ± 0.09^{b}	1.44 ± 0.13^{c}	63.4 ± 10.18^{cde}	576.0 ± 13.97^{bc}
T_7	7.57 ± 0.12^{c}	1.08 ± 0.02^{d}	57.1 ± 3.76^{def}	840.0 ± 17.01^{a}
T_8	6.94 ± 0.18^{d}	0.31 ± 0.03^{f}	53.3 ± 2.79^{ef}	569.3 ± 46.77^{bc}
T_9	7.33 ± 0.12^{cd}	1.06 ± 0.021^{d}	107.2 ± 3.54^{a}	599.3 ± 29.70^{bc}

was observed in T_4, where rice hull was used alone. Analytical data regarding available potassium showed the superiority of T_7 over the other treatments. T_7 (silt + spent mushroom compost, 1:1) had a maximum value of 840 ppm available potassium followed by T_5 (silt + coconut coir dust), with 665.33 ppm potassium. The lowest potassium value, 423 ppm, was observed in T_9 (Table 2).

Discussion

A balanced rooting medium that contains an adequate supply of nutrients is essential for plants to attain maximum height. It was observed from this experiment that, compared to other media, sludge alone should be considered low ranking as a potting medium for plant height. Results showed that coconut coir alone and in combination with silt contributed to produce maximum plant height. Plant height is also greatly affected by the environment, especially root medium. Results indicated that using different substrates in differing proportion as potting mix had different effects on plant height. These findings are in line with the findings of Awang et al. (2010), who found that plants grown in 100% cocopeat (CP), 70% CP and 30% burnt rice hull, and 70% CP and 30% perlite demonstrated maximum plant height. These results are also in accordance with the findings of Treder (2008), who reported maximum plant height in media containing cocopeat. The number of side shoots per plant indicated vigorous vegetative growth and nutrient-rich potting media promoted vegetative growth in dahlia. Treatments containing coconut coir dust enhanced vegetative growth, as seen by the fact that plants in media that featured coconut coir dust produced a higher number of shoots compared to other treatments. These results are in accordance with the findings of Riaz et al. (2008), who noted the highest number of side branches in coconut compost when combined with silt and leaf manure. The number of side shoots decreased when sludge alone was used.

Flowers are the vital element in ornamental and flowering plants and they look terrific in the landscapes where we live. Balanced potting soil plays an important role in flower production. A high number of flowers indicate suitable environmental conditions for growing plants. The maximum number of flowers in *Dahlia hortensis* 'Figaro' were produced when silt, coconut coir dust, sludge, spent mushroom compost, and rice hull were used together in T_9 at a 1:1:1:1:1 ratio by volume. These results support the findings of Awang and Ismail (1997), who observed that more flowers were produced in *Zinnia elegans* and marigold when the growing medium contained coconut coir. The fewest flowers were observed when

sludge was used as a potting medium, a result which is in accordance with the findings of Wilson et al. (2002). Those researchers found that *Lysimachia congestiflora* had poorer growth and flowering when sewage sludge was present in the growth medium. The combination of coconut coir dust and silt induced early flowering in dahlia when compared to other treatments. These results are in line with the findings of Evans and Stamps (1996), who observed that marigold plants flowered earlier in coir-based substrates than in peat-based substrates, and Grassotti et al. (2003), who also observed reduced flowering time in media containing coconut fibre mixed with clay pellets or peat. These results are also supported by the findings of Treder (2008), who observed early flowering in oriental lily (star gazer) when cocopeat was used as the growth medium. The above results regarding flower diameter showed that media containing coconut coir dust are the best for the growth of dahlias. These results support the findings of Riaz et al. (2008), who observed that the largest average flower size was significantly produced in coconut compost alone as compared to the other media examined in that study.

Dahlia bulbs feature a subterranean root system comprising many distinct tubers, each a separate lump. Tubers are the most important part of Dahlia Figaro because they are used for its propagation. The growth and quality of tubers are influenced by many environmental factors: soil type and the availability of nutrients are the most important factors for increasing tuber number and weight. Potting medium is an important aspect for proper root and tuber growth and it must be formulated to provide a balance between solid particles and pore spaces. An increased amount of coconut coir dust in pots produced the maximum number of tubers in dahlia whereas the minimum number of tubers was produced in T_2, where sewage sludge was used. These findings are in accordance with those of Treder (2008), who reported that the bulb root system was significantly better developed in lilies grown on cocopeat. The higher root grades in media containing coir dust occurred despite those media having lower initial air-filled pore space and higher water-filled pore space and water-holding capacity than other media (Stamps & Evans, 1997). Sludge also produced the least number of tubers due to its being compact and the least aerated media; roots growing in poorly aerated media are weaker than roots growing in well aerated media (Ingram & Henley, 1991).

Nitrogen is one of the important elements required for plant growth and reproduction. It ranks after carbon, hydrogen, and oxygen in total quantity needed and is the mineral element most demanded by plants. Sewage sludge contained a maximum amount of nitrogen but overall it had no contribution to plant growth. This is because macro- and micronutrient availability may not be sufficient to support plant growth when the pH of the growth medium is high. These results are supported by Altland (2006), who reported reduced growth in Japanese maple (*Acer palmatum* var. atropurpureum Thunb.), hydrangea (*Hydrangea macrophylla* Thumb.), and leucothoe (*Leucothoe axillaris* Lam.) caused by a pH-induced reduction of available nitrogen, phosphorus, and micronutrients in the growing media.

The number of flowers has a positive correlation with soil phosphorus content because the adequate supply of phosphorus in T_9 produced more flowers per plant (Table 1). These results are in line with Strojny and Nowak (2004), who noted a greater number of flowers in organic residues with a high phosphorus concentration. These results are also supported by a study performed but Younis et al. (2007) in which those researchers observed that *Dahlia coccinea* produced more flowers when grown in media featuring maximum phosphorus levels. Adequate phosphorus nutrition enhances many aspects of plant development including flowering, fruiting, and root growth. Potassium deficiency was not observed in any of the potting media treatments used in this study. Flower diameter was increased in silt and spent mushroom compost due to the rich amount of potassium (840 ppm). These results are supported by the findings of Ahmed et al. (2004); their results showed that the size of flowers was significantly increased by the application of urea with a combination of potash and FYM in dahlia cultivars. The availability of plant nutrients in the growth media is associated with changes in pH. The results regarding the chemical properties of the media showed that all of the potting media had sufficient amounts of NPK but their response is associated with the pH of the media. Very low and very high pH values cause direct

damage to plant roots, but slightly less low or high pH can also decrease plant growth. In the present study, T_2 (sludge) had the highest pH and it demonstrated a negative effect on plant growth. This is because macronutrient and micronutrient availability may not be sufficient to support plant growth when the pH of the growing medium is high. As the soil pH increases, the solubility of many nutrients is reduced. As a result, these nutrients are precipitated as solid materials that plants cannot use (Altland, 2006). Studies with sewage sludge compost showed that the compost supplied potassium, phosphorus, and all essential trace elements to several potted species (Gouin, 1993). The use of compost materials in formulating potting media can result in substantial savings in fertilisers, but the salinity and high pH are pointed out as factors which may limit this use (Siminis & Manios, 1990).

Conclusion

The present study showed that agricultural and municipal wastes are good, cheap potting media components for the production of flowering plants. An economical and high-quality production of *Dahlia hortensis* 'Figaro' can be attained by using most suitable media. In this study, the results associated with plant growth parameters indicated that the maximum values for plant height, number of side shoots per plant, number of tubers per plant, flower diameter, and least days to flower emergence were observed in media containing coconut coir, whereas corm weight per plant was at a maximum when rice hull was added to silt. Chemical analyses of the potting media showed that all of the combinations tested had sufficient amounts of the nutrients essential for plant growth. The highest amount of nitrogen was observed in sewage sludge as compared to other media but its availability to the plant was restricted due to the higher pH of the growing medium. For this reason, plant growth in the sewage sludge based medium was found to be the lowest when compared with the other treatments. It can be concluded that coconut coir dust as potting soil is the most effective medium for plant growth as compared to other materials. With its higher pH and EC, sewage sludge produced the lowest results with regard to all of the plant growth parameters when 50% or more sewage sludge was added to the potting media. Thus it is suggested that coconut coir dust may be further exploited as a standard potting media and that the addition of 50% or more sewage sludge to potting media is not recommended for *Dahlia hortensis* 'Figaro'.

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