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Research Paper

The Effect of Peanut Shells as a Substitute for Peat in Potting Media on Growth and Nutrition of *Begonia rex*

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Abstract

Due to the environmental problems caused by the accumulation of significant amounts of waste from peanut cultivation, it seems necessary to provide a solution for the reuse of this organic waste. Therefore, this experiment was conducted to investigate the possibility of using compost of peanut shells in potting Begonia rex. The research was based on a randomized complete block design with five treatments, four pots per treatment, and three replications. The plants were grown in peat consisting perlite (2:1 v/v) and composts (25, 50, 75 and 100 v/v %) instead of peat in peat (P): perlite (Pe) (2:1 v/v) growth medium. The control consisted of P: Pe alone without peanut shells compost. The results showed that the application of peanut shells compost improved the growth factors of Begonia. Accordingly, the replacement of 25% of peanut shells compost had a better impact on plant growth by enhancing most growth factors including plant height (20.21 cm), number of leaves (13.13%), leaf fresh weight (48.88 g), leaf dry weight (2.01 g) and root fresh weight (2.37 g). However, 100% increase in peanut shells compost significantly reduced plant growth as compared to the control. It seems that in the treatment with 100% peanut shells compost, salinity increase (1.48%) was effective in reducing plant growth.

Keywords: Compost, Peat, Perlite, Physical properties, Soilless culture.

INTRODUCTION

The ideal planting bed should be able to keep the plant, water, and food and have the air supply to the roots. The appropriate substrate should provide the physical, chemical and biological requirements of the plant, be accessible, and be easy to work with (Meerow, 1997). Millions of tons of agricultural waste are produced in Iran, which can contribute supplying organic matter, but unfortunately most of it is burned or dumped, thereby polluting the environment. With the increased awareness of environmental hazards caused by organic waste and the need for sanitation or recycling, it is recommended to take advantage of composting biodegrades in order to reduce the use of non-renewable resources such as peat (Bugbee, 2002; Papafotiou *et al*., 2005). Because of their cellulose tissue, peanut shells need over a year to rot in natural conditions, but composting can reduce this time to three to four months. In the recent years, a waste management program has been considered through recycling in Iran due to the dumping of waste in nature or its burning. The reuse of organic waste is the most appropriate method for environmental management. Unfortunately, much of these wastes are dumped and lead the pollution of the environment (Azizi *et al*., 2008; Mohammadi Torkashvand *et al*., 2015).

Peat resources are limited in Iran, and most ornamental foliage plants are cultivated in soilless media among which peat is the basic medium, but the use of peat is questionable because of its environmental damage and its high costs for manufacturers of ornamental plants (Mahboub Khomami, 2015). So, researchers have been looking for high-quality and low-cost growth media to replace peat all over the world including Iran (Krumfolz *et al*., 2000). Some studies have shown that peat can be replaced by organic wastes such as municipal wastes, sewage sludge, livestock manure, paper, waste from pruning, fungus beds, and other organic waste after composting (Jayasinghe *et al*., 2010). The conversion of organic waste through biological methods and under the process of composting and vermicomposting has been studied by many scholars around the world (Mahboub Khomami, 2015; Bugbee, 2002; Papafotiou *et al*., 2005). They have specified that composting is an effective way to turn a fresh organic material into a product with a high potential for the use as a growth medium in ornamental plant production industry. Due to the increasing awareness of the environmental problems caused by the accumulation of waste, some researchers have recommended the use of waste compost instead of non-renewable resources of peat (Bugbee, 2002; Papafotiou *et al*., 2005). For this reason, the present experiment was designed to investigate the possibility of using peanut shells compost to replace peat in plant growth media. To this end, the possibility of using peanut shells compost as a growth medium was evaluated for *Begonia rex* as a test plant.

MATERIALS AND METHODS

Composting peanut shells

Peanut shells were collected from peanut-drying workshops in Astaneh, Guilan province, and dumped in a cubic meter (1 × 1 × 1) wooden boxes that had pores to provide aerobic conditions and microbial activity. Every 3 to 5 days, the temperature of the mass was controlled, the materials were aerated, the moisture was regulated, and the compost was prepared within 4 months. The compost was passed through a 20-mm sieve. The temperatures were recorded during four months and the prepared compost was applied as the growth medium. Some physicochemical characteristics of the peanut shells (nitrogen, phosphorus, potassium, organic carbon, C/N ratio, EC, and pH) were measured before and after composting (Table 3). *Begonia rex* was selected as the test plan. Begonia, a genus of flowering plants belonging to the family Begoniaceae, is one of the 10 largest angiosperm genera. Begonias are attractive perennial plants with soft and succulent stems and white, pink, red, orange or yellow flowers. The Begonia family is formed of five genera and 920 species, most of which belong to the genus *Begonia*. A complete randomized design was used with different levels of peanut shells compost.

Chemical analysis

The total nitrogen and the total organic carbon of the samples were measured by using a micro-Kjeldahl method (Singh and Pradhan, 1981) and Walkely and Black (1934)'s rapid titration method, respectively. pH and EC were determined on an extract of 1:5 ratio of compost to water by weight. Phosphorus and potassium were measured by the spectrophotometric and flame photometric methods, respectively. During the growth period, the pots were irrigated with distilled water. At the end of the experiment, plants were cut from the surface of the pot and the leaves were detached after five months and oven-dried at 75°C for 48 hours to determine their dry weight (Mahboub Khomami and Mammadov, 2014). The subsamples of the dry leaves were ground and then their dry ash was extracted with 2 M HCl from the furnace at 550ºC. K content was measured by a flame photometer and P by a spectrophotometer.

Physical analysis

The physical properties of the growing media were measured by Fonteno (1996)'s method and the bulk density, total porosity, container capacity, and air-filled porosity of the growth media were computed by the relevant equations (Table 1).

Table 1. The equations to find out the physical properties of the growth media.

Equation	Components of equation
Bd = (Wdsp-Wp /Vp)	Wdsp = Dry weight of substrates and the container
Pd = (Wdsp-Wp/ Vp- Vwd -(Wwsp-Wdsp))	Wp= Dry weight of the container
AFP = (Vwd×100/VP)	Vp= Volume of container
CC= ((Wwsp-Wp) ×100/VP)	Vwd = Volume of water drained
TP=AFP+CC	Wwsp= Substrates and container fresh weight

Abbreviations: Bd: Bulk density; Pd: Particle density; AFP: Air-filled porosity; CC: Container capacity; TP:Total porosity.

Plant experiment

The experiment was conducted in a fiberglass-covered greenhouse at the Ornamental Plants and Flower Research Station (37°01'44'' N. and 50°01'03'' E.), Lahijan, Iran to evaluate the impacts of composted peanut shells waste as an alternative to peat on the growth medium of the ornamental *Begonia rex* plant species. The average night/day temperature was 18±2/27±2°C with a relative humidity of 65-75% (Simon *et al*., 1976) and a medium light of between 75 to 150-foot candles. The rooted *Begonia rex* cuttings were transplanted in two-liter (about 5-cm diameters) plastic pots containing the growth medium mixes. Six treatments of the growth medium included control, peat consisting perlite (2:1 v/v), and peanut shells composts (25, 50, 75 and 100% v/v) instead of peat in P:Pe (2:1 v/v) growth medium. The compositions of the growth medium are presented in Table 2.

The applied peat was purchased from Kekkilä Group in Finland. After preparing the media, the rooted cuttings of *Begonia rex* were transferred to pots. For this aim, after preparing the beds, the roots of *Begonia rex* were first removed from the transplant pots and were completely washed. Then, one plant was cultivated in each pot with a new bed and it was then transferred to the greenhouse to pass the plant growth period. The pots were fed with 200 cm^3 solutions consist of OMEX 18-18-18 (N-P-K) every 10 days and were irrigated as needed. Plant height and leaf number, and leaf and root dry and fresh weights were measured at the end of the experiment.

Statistical analysis

The data were statistically analyzed by the SAS software (SAS Institute Inc., 2001) and their means were statistically compared by Tukey's multiple range tests.

Table 2. The composition of the growing media.

Treatment	Combination
Control	2 peat + 0 peanut shells composts + 1 perlite
25% compost	1.5 peat + 0.5 peanut shells composts + 1 perlite
50% compost	1 peat + 1 peanut shell composts + 1 perlite
75% compost	0.5 peat + 1.5 peanut shells composts + 1 perlite
100% compost	0 peat + 2 peanut shells composts + 1 perlite

Table 3. Some properties of peanut shells, composted peanut shells and peat used in the experiment.

Property	Peanut shells	Composted peanut shells	Peat
Total nitrogen (%)	0.87	2.76	0.63
Total phosphorus (mg/kg)	1190	1470	300
Total potassium (mg/kg)	18700	6700	300
Organic carbon (%)	30.0	27.1	55.7
C/N ratio	34.5	9.12	88.5
pH (1:5)	5.89	5.46	4.62
EC (dS/m)	1.38	4.30	0.32

RESULTS AND DISCUSSION

Chemical characteristics

Some chemical characteristics of the planting media are provided in Table 4. The use of peanut shells composts reduced the available phosphorus of growth media. A noticeable aspect was an increase in another nutrient in the growth media in proportion to the applied peanut shells compost. The C/N ratios in the peanut shells compost treatments were much lower than in the control due to the high organic carbon and low total nitrogen in peat compounds.

Growth media physical characteristics

Some physical characteristics of the planting media are provided in Table 5. The use of the peanut shells compost tends to decrease the bulk density of the growth media. The highest decrease was observed in 100% compost; consequently, the porosity of this medium was increased by 1.19% versus the control. Moisture content (container capacity) was increased when the peanut shells compost was added to the media (Table 5). Total porosity was increased from 78% to 93% when the level of the peat moss was increased from 0% to 50%. The salinity of the substrate was increased from 0.30 dS m^{-1} in the control to 1.35 dS m^{-1} in the 100% compost treatment. The acidity (pH) was increased in the proportion to the applied compost, so pH was increased by 4.5 units in the 100% compost treatment versus the control.

Leaf nutrient

The nitrogen concentration was increased in the 25% compost treatments (5.1%), but it was decreased in other treatments of compost, so they showed no significant difference from the control (4.1%).

Table 4. Some chemical properties of the growth media treatments.

Treatment	Total N (%)	Available P (mg/kg)	Available K (mg/kg)	Available Ca (mg/kg)	Available Mg (mg/kg)	Organic carbon (%)	C/N ratio
Control	0.90	770	1820	1900	5000	43	47.77
25% peanut shells compost	1.80	680	2990	3200	7900	33	18.33
50% peanut shells compost	1.90	550	3210	2500	7300	32	16.84
75% peanut shells compost	2.40	510	3580	2100	8300	35	14.58
100% peanut shells compost	2.70	440	4520	2500	9500	29	10.74

Table 5. Some physical properties of the growth media treatments.

Treatment	Bulk density (g/cm^3)	Air-fill porosity (%)	Container capacity (%)	Total porosity (%)	pH (1:5)	EC (dS/m)
Control	0.21	27.59	51.15	78.74	4.98	0.30
25% peanut shells compost	0.15	57.32	34.25	92.00	5.41	0.50
50% peanut shells compost	0.13	59.47	33.63	93.00	5.53	0.75
75% peanut shells compost	0.12	59.40	33.52	93.00	5.76	1.01
100% peanut shells compost	0.11	61.50	33.10	94.00	5.88	1.35
	0.19-0.70†	10-30†	45-65†	50-85†	5.3-6.5†	0.36-0.65*

†Range values recommended for the physical characteristics (Yeager, 1997; Abad *et al*., 2001)

*Whipker *et al.* (2000).

The results revealed that the highest leaf nitrogen was related to the 25% peanut shells compost treatment which significantly differed from 50, 75 and 100% treatments (Table 6). The 100% of the compost peanut shell had a high concentration of phosphorus (0.64%), showing a significant difference from the other treatments. The highest concentration of potassium was observed in the control (1.42%), which had no significant difference with the 75% peanut shell compost (1.37%). The highest magnesium (0.20%) was observed in the treatment of 75% peanut shells compost which differed significantly from 25, 50 and 100% treatments, but no treatment had a significant difference from the control (0.19%).

Table 6. The effect of peanut shells compost on leaf nutrient concentration.

	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
Control	4.1 b	0.49 c	1.14 b	1.42 a	0.19 a
25% peanut shells compost	5.1 a	0.39 c	1.19 b	1.20 cd	0.11 b
50% peanut shells compost	4.0 b	0.38 c	2.02 a	1.22 bc	0.11 b
75% peanut shells compost	3.3 cd	0.44 bc	2.03 a	1.37 ab	0.20 a
100% peanut shells compost	2.9 d	0.64 a	2.01 a	1.18d	0.10 b

*Figures with similar letter(s) in each column were not significant at the 5% probability level according to Tukey's test.

Plant growth factors

The highest number of leaves (11.66) was obtained from the substitution of peanut shells compost (25%) (Table 7) for peat, which had a significant difference ($P<0.05$) with other treatments. The lowest number of leaves was obtained from the replacement of 100% peanut shells compost (7.33) for peat, which had no significant difference with 75% peanut shells treatment (7.87). The highest height (21.1 cm) was obtained from the substitution of peanut shells compost (25%) (Table 7) for peat, which had no significant difference with control treatment (18.37 cm).

The highest leaf fresh weight (50.27 g) was obtained from the replacement of 25% peanut shells compost (Table 7) for peat, which showed a significant difference with the other treatments. There was no significant difference among 50%, 75% and 100% peanut shells compost treatments. The lowest leaf fresh weight (22.94 g) was obtained from the replacement of 100% peanut shells compost for peat, which had a significant difference with the control treatment and 25% peanut shells compost.

The highest leaf dry weight (1.98 g) was obtained from the replacement of 25% peanut shells compost (Table 7) for peat, which had a significant difference with the control and other peanut shells compost treatments. The highest root fresh weight (1.98 g) was related to 25% peanut shells compost, which differed significantly from the control (1.75 g) (Table 7). The highest root dry weight (0.15 g) was obtained from 25% peanut shells compost, which differed significantly from 50%, 75% and 100% peanut shells compost, but did not show a significant difference from the control (Table 7). The lowest root dry weight (0.09 g) was related to 100% peanut shells compost. The highest root length (27.33 cm) was obtained from 25% peanut shells compost, which differed significantly from the control, but showed insignificant differences from the other peanut shells compost treatments (Table 7).

Table 7. The effect of peanut shells compost on *Begonia rex* growth factors.

Treatment	Leaf number	Height (cm)	Root fresh weight(g)	Root dry weight (g)	Root fresh weight(g)	Root dry weight(g)	Root length (cm)
Control	10.33 b	18.37 b	45.38 b	1.90 b	1.75 b	0.14 ab	27.31 a
25% peanut shells compost	11.66 a	21.91 a	50.27 a	1.98 a	1.98 ab	0.15 a	27.33 a
50% peanut shells compost	9.41 b	21.25 a	25.04 c	1.20 c	1.19 c	0.12 bc	26.66 ab
75% peanut shells compost	7.87 c	20.54 ab	23.89 c	1.01 cd	0.96 cd	0.10 bc	26.63 ab
100% peanut shells compost	7.33 c	20.62 ab	22.94 c	0.97 d	0.61 d	0.09 d	21.83 c

*Figures with similar letter(s) in each column were not significant at the 5% probability level according to Tukey's test.

DISCUSSION

The results showed that increasing the amount of peanut shells compost instead of peat increased the total nitrogen content in growth media. The results showed that this may have been due to more nitrogen in the peanut shells compost than peat. Grigatti *et al*. (2007) reported that with the addition of composted manure to the soil in the pot growing media, nitrogen was more than peat. According to Nappi and Barberis (1993) in the growth media containing compost, nitrogen content was at a sufficient level for plant growth. The amount of phosphorus in the growth media was reduced as a result of increasing the replacement of peanut shells compost instead of peat. The highest amount of phosphorus was observed in the control and its lowest value was observed in 100% *Azolla* compost. According to the analysis, the amount of available phosphorus in peanut shells compost was higher than peat, but the available phosphorus was decreased in the growth media containing compost. Mohammadi Tarkashvand *et al.* (2015) stated that available phosphorus reduction in the compost could be due to microorganisms that converted mineral phosphorus into organic phosphorus, but we would suggest that this might be related to composting and leaching. Also, a decrease in phosphorus in growth media containing green waste compost and sewage sludge was reported by Grigatti *et al.* (2007) and Perez-Murcia *et al*. (2006). In these conditions, during the plant growth period, changes happened in the nutrient concentration, C/N ratio, and organic matter decomposition in the growth media. Logakanthi *et al*. (2006) reported that the C/N ratio of vegetable waste was reduced by 69% during composting, along with the consumption of 50% phosphorus by fungal species.

Peanut shells compost increases the potassium levels of growth media in proportion to the compost used as compared to the control, which corresponded with the results of Grigatti *et al.* (2007). The amount of potassium in peanut shells compost was 22 times more than in peat, leading to an increase in the potassium level of the medium.

It has been shown that because of higher nitrogen and lower carbon in peat compost, the ratio of C/N was reduced in the compost treatments (Jayasinghe *et al*., 2010).

Zucconi *et al*. (1981) stated that the C/N ratio of over 30 may cause problems for plant growth and according to Davidson *et al.* (1994), the C/N ratio of ideal compost to plant growth was less than 20. Accordingly, in peanut shells composting compartments, the C/N ratio was within the appropriate range for plant growth.

In terms of nutrient uptake, with the replacement of peanut shells compost for peat in the growth medium, only potassium concentration was increased in the plants, and the other nutrients did not show any increased rate of absorption by the plants in the other treatments compared to the control. As Ramezanzadeh *et al*. (2014) have shown, *Azolla* compost increases the concentration of potassium in plants.

According to Yeager *et al*. (1997), the ideal bulk density of the growth media is 0.19-0.70 g cm^{-3}. Accordingly, all treatments were within the ideal range. The porosity of the substrates was increased with the increase in the replacement of peanut shells compost for peat. The results showed that the total porosity and air filled porosity were increased, but the container capacity was decreased. Yeager (1997) proposed that the physical characters such as container capacity between 45% and 65% and air-filled porosity between 10% and 30% in all substrates is ideal for plant growth. The air-fill porosity needed for enough gas exchange should make up at least 15%, but ideally, it should be 20- 35% of the medium volume depending on the plants (Kasica, 1997). All composting treatments were outside the ideal range with respect to air-fill porosity, water holding capacity, and total porosity, but the control treatment was in the ideal range.

Peanut shells compost provides a higher buffer capacity in growth medium than what peat provides to growth medium. The pH of peanut shells compost-containing growth media was in the optimum range for the growth of ornamental foliage plants, so according to Abad *et al.* (2001), the appropriate pH for desirable growth was determined as to be 5.3–6.5. The appearance and size of plants are among the most desirable factors and the main criteria to determine the salinity tolerance of ornamental plants. According to Whipker *et al.* (2000), normal EC (1:5) within the root growth zone is in the range of 0.36-0.65 dS m^{-1}, and the EC of above 1.1 dS m^{-1} will damage the plant. Therefore, higher levels of compost with increasing salinity can be significantly harmful to plant growth. Some results have shown that the addition of 25-100% v/v green waste compost instead of peat to the growing media increases pH and EC of substrates (Grigatti *et al*., 2007).

The growth factors of *Begonia* include leaf number, height, leaf and root fresh weight, and root length, which were higher in the growth media containing 25% or 100% peanut shells compost instead of peat than in the control. These results are consistent with Ramezanzadeh *et al.* (2014) that stated that the application of compost in the growth medium increased plant height, shoot dry weight, and the number of English daisy. It seems that the effect of peanut shells compost on the growth of *Begonia rex* as a result of substitution for peat in the growth medium can be attributed to the presence of humic materials as Chen *et al.* (1989) claim that the effect of compost on *Ficus benjamina* growth may be similar to the role of growth regulators in plants. The significant reduction in the growth rate of *Begonia rex* in a 100% peanut shells compost could be related to the significant increase in total porosity and EC of the growth media.

In this experiment, in many cases, the concentration of nutrients in the plant did not match the concentration of nutrients in the substrate and growth factors. This can be due to the fact that nutrient concentration in plant organs depends on different factors, such as plant growth, ionic competition, and deposition, so it is sometimes impossible to use plant nutrient concentrations as a reliable parameter for assessing the plant growth. The impact of nutrient dilution resulting in additional yields can also give rise to confusion.

CONCLUSION

These experiments showed that peanut shells compost is suitable for replacing peat and can use up to 25% of it to replace peat and prepare a growth medium for potting plants. The increase in peanut shells compost content up to 100% is not recommended due to its undesirable physical properties. Therefore, the re-use of peanut shells as a growing medium can not only reduce peat consumption and minimize the accumulation of these wastes in the environment but it can also have economic benefits because they are more inexpensive than other common growth media.

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