

## **THE GROWTH OF CAMELLIA IN PEANUT SHELLES COMPOST MEDIA IN DIFFERENT CONCENTRATIONS OF POTASSIUM**

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**Abstract.** Agricultural wastes management is a step toward sustainable agriculture. Peanut shelles as remained wastes of cultivating peanut has considerable volume which its compost can be used as available sources of ornamental plants medium. A factorial experiment based on randomized completely blocks design was conducted to investigate the impact of peanut shelles compost as the growth medium of *Camellia* in different concentrations of potassium. Fifteen treatments, every treatment at three replicates and 45 plots were used for experiment. The rooted cuttings of *Camellia* were planted and periodic watering with Hoagland solution was performed two times per week. After five months, the plants growth indices and the concentration and uptake nutrients were measured. Results showed that peanut shelles compost increased growth indices than in the control. In the most growth indices, the plant indicated a better response to 40% (w/w) compost and finally 60%. The results are indicator of providing the needed potassium for plant by peanut shelles compost than in the control.

**Key words:** agricultural wastes, Hogland solution, plants, pot experiment

### **INTRODUCTION**

Iran is a talented country in producing flowers and ornamental plants due to the suitable diversity of weather and 40°C difference between the coldest and warmest region, energy and cheap forces at work, enough light (more than 250 days light and 120–150 thousand lux in year), cellulose wastes and consumption markets.

Today, most ornamental plants are cultivated in soilless media which peat is as basic medium [Atieyh et al. 2000], but the use of peat is doubtful due to ecological damages to environmental and economic advantageous. These factors caused those researchers think to beds with high quality and cheap instead of peat [Krumfolz et al. 2000]. Million tons of different agriculture wastes being produced annually across the country that can has role on preparing organic materials but unfortunately major part is burned or leaved

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somewhere and leads to environment pollution [Mohammadi Torkashvand 2010]. With increasing awareness of environmental dangerous of wastes and its sanitary landfill and decrease in the use of non-renewable sources like peat, further use of composted biosolids has been suggested in farming [Bugbee 2002, Papafotiou 2005]. Studies have shown that the peat can be replaced by organic wastes such as municipal wastes, sewage sludge, livestock manure, paper, waste of pruning and fungi beds and other organic waste after composting [Gayasinghe et al. 2010]. Application of manure, wood chips and paper wastes mixed with volcanic material in providing cultivation bed of Croton (*Codiaeum variegatum*) and Chrysanthemum showed that these materials can be used as planting bed [Cull 1981]. The bark of broad leaf and conifer trees, sewage sludge, sawdust, mushroom compost, municipal wastes compost are the materials that can be used as planting beds [Fred et al. 1997, Scharpenseel et al. 1987, Verdonck et al. 1992].

In greenhouses town of Guilan province, Iran, the medium used in the cultivation of camellia is mixture of different organic wastes such as peat, cocopeat, municipal wastes compost, tea wastes with sand and perlite that have a pH lower than 7.0. There is little literature on the impact of peat alternatives in the production of woody ornamental plants [Scagel 2003]. Larcher and Scariot [2009] suggested coconut fibers as a good partial peat substitute for potted camellia production. In Guilan province, Iran, abundant organic wastes are produced that one of the organic wastes is peanut shelles compost. The cultivation and production of peanut is dedicated in several populous countries in which the peanut is a major food crop. According to the World Food and Agriculture Organization, the most major peanut-producing countries in the world are India, China, United States, Indonesia and Myanmar. Peanut cultivation area in the world is about 22.2 million hectares that 16.3 million hectares in Asia, 7.39 million hectares in Africa, 0.7 million hectares is located in South and Central America [Maiti and Ebeling 2002, Murata 2003]. Cultivated area of peanut in Iran is about 3218 hectares which 2718 hectares is located in Guilan province. About 1980–3500 kg·ha pods is harvested and 89 327.6 tones pods is produced in Guilan. Between 35–40% of every kg yield of peanut is shelles wastes, therefore, it is estimated to produce about 3388–3873 tons peanut shelles wastes in Iran in every year [Agriculture Organization of Guilan province 2010]. Thus, there is high import of peanut in Iran. Alidoust et al. [2012] conducted a pot experiment to investigate the possibility using peanut shelles compost as appropriate bed in the cultivation of *Dracaena*. They reported that the potassium increased in cultivation bed proportional to the used peanut shelles compost, so potassium of 100% peanut shelles treatment increased 40 times rather than control (2:1 ratio of peat to perlite). Based on growers in greenhouses of Guilan province, camellia needs the high amount of potassium as same as nitrogen. Therefore, it has been decided that 1. To evaluate the possibility using this organic waste as a growth medium of *Camellia* and 2. To investigate impact of nutrient solution with different concentrations of potassium on plant growth and nutrient uptake especially K uptake.

## MATERIALS AND METHODS

A factorial experiment based on randomized completely blocks design was conducted to investigate the impact of peanut shelles compost as the growth medium of *Camellia* in different concentrations of potassium. The peanut shelles were supplied by peeling peanut factory which is located in Astane Ashrafie Township, Guilan, Iran, and then was transferred to research station. Peanut shelles were poured in the wooden boxes by 1 M<sup>3</sup> that had pores to supply aerobic conditions and activity of micro-organisms. Thus, recording temperature and aerating were done during four months and the prepared compost was used as the growth medium. Some physical and chemical characteristics (total nitrogen, phosphorus, potassium, organic carbon, C/N ratio, EC and pH in 1:5 extract peanut shelles to water) before and after being composted were measured (tab. 1). Table 1 shows some characteristics of the used compost. First factor was different ratio of peanut shelles compost include:

1. 50% perlite + 50% sand (v/v)
2. 20% peanut shelles compost + 40% perlite + 40% sand (v/v)
3. 40% peanut shelles compost + 30% perlite + 30% sand (v/v)
4. 60% peanut shelles compost + 20% perlite + 20% sand (v/v)
5. 100% peanut shelles compost

Table 1. Some properties of Composted peanut shelles and peat used in experiment

| Property             | Peanut shelles before composting | Composted peanut shelles |
|----------------------|----------------------------------|--------------------------|
| Total nitrogen (%)   | 0.87                             | 2.76                     |
| Total phosphorus (%) | 1.87                             | 0.67                     |
| Total potassium (%)  | 1.19                             | 1.48                     |
| Organic carbon (%)   | 30.0                             | 27.1                     |
| C/N ratio            | 34.5                             | 9.8                      |
| pH (1:5)             | 5.89                             | 5.06                     |
| EC (dS/m)            | 1.38                             | 4.30                     |

Some properties of the growth media are observed in table 2. The different concentration of potassium in nutrient solution was second factor include:

1. Nutrient solution without potassium
2. Nutrient solution with 3 mM potassium
3. Nutrient solution with 6 mM potassium

Fifteen treatments (tab. 3), every treatment at three replicates and 45 plots were used for experiment. The rooted cuttings of *Camellia* with the same size and height of 20 cm and the leaves number of 5–7, were prepared. The experiment duration was five months to appear the buds. Perlite with a diameter 1–2 mm (fine) was used and sands of the river have been washed to be free from any mud. Peanut shelles compost was prepared from Lahijan's Ornamental Flowers and Plants Research Station. In the beginning, FC (field capacity) of pots was measured to determine irrigation water requirement per pot in each time period, that this rate was 250 ml. Periodic watering with Hoagland solution was performed two times per week.

Table 2. The effect of treatments on some properties of the growth media

| Treatments            | Bulk density<br>(g·cm <sup>-3</sup> ) | Porosity<br>(%) | Total nitrogen<br>(%) | Available<br>phosphorus<br>(mg·kg) | Available<br>potassium<br>(mg·kg) | pH (1:5) | EC<br>(dS·m) |
|-----------------------|---------------------------------------|-----------------|-----------------------|------------------------------------|-----------------------------------|----------|--------------|
| Control <sup>1</sup>  | 0.62                                  | 77.0            | 0.05                  | 2.3                                | 10.0                              | 5.42     | 0.21         |
| 20% PSC <sup>2</sup>  | 0.53                                  | 82.0            | 0.6                   | 7.3                                | 212.3                             | 5.54     | 0.94         |
| 40% PSC <sup>3</sup>  | 0.51                                  | 84.0            | 1.6                   | 14.7                               | 635.6                             | 5.57     | 1.16         |
| 60% PSC <sup>4</sup>  | 0.36                                  | 87.0            | 2.2                   | 18.3                               | 1042.0                            | 5.97     | 2.26         |
| 100% PSC <sup>5</sup> | 0.22                                  | 92.0            | 2.84                  | 20.3                               | 1874.2                            | 6.18     | 2.47         |

<sup>1</sup> 50% perlite + 50% sand

<sup>2</sup> 20% peanut shelles compost + 40% perlite + 40% sand

<sup>3</sup> 40% peanut shelles compost + 30% perlite + 30% sand

<sup>4</sup> 60% peanut shelles compost + 20% perlite + 20% sand

<sup>5</sup> 100% peanut shelles compost

Table 3. The characteristics of applied treatments

| Symbol                    | Treatment   |
|---------------------------|---|
| Control × K <sub>0</sub>  | 50% perlite + 50% sand without K in nutrient solution             |
| Control × K <sub>3</sub>  | 50% perlite + 50% sand with 3 mM K in nutrient solution           |
| Control × K <sub>6</sub>  | 50% perlite + 50% sand with 6 mM K in nutrient solution           |
| 20% PSC × K <sub>0</sub>  | 20% PSC* + 40% perlite + 40% sand without K in nutrient solution  |
| 20% PSC × K <sub>3</sub>  | 20% PSC + 40% perlite + 40% sand with 3 mM K in nutrient solution |
| 20% PSC × K <sub>6</sub>  | 20% PSC + 40% perlite + 40% sand with 6 mM K in nutrient solution |
| 40% PSC × K <sub>0</sub>  | 40% PSC + 30% perlite + 30% sand without K in nutrient solution   |
| 40% PSC × K <sub>3</sub>  | 40% PSC + 30% perlite + 30% sand with 3 mM K in nutrient solution |
| 40% PSC × K <sub>6</sub>  | 40% PSC + 30% perlite + 30% sand with 6 mM K in nutrient solution |
| 60% PSC × K <sub>0</sub>  | 60% PSC + 20% perlite + 20% sand without K in nutrient solution   |
| 60% PSC × K <sub>3</sub>  | 60% PSC + 20% perlite + 20% sand with 3 mM K in nutrient solution |
| 60% PSC × K <sub>6</sub>  | 60% PSC + 20% perlite + 20% sand with 6 mM K in nutrient solution |
| 100% PSC × K <sub>0</sub> | 100% PSC without K in nutrient solution                           |
| 100% PSC × K <sub>3</sub> | 100% PSC with 3 mM K in nutrient solution                         |
| 100% PSC × K <sub>6</sub> | 100% PSC with 6 mM K in nutrient solution                         |

\*Peanut Shelles Compost

The pots were treated with the nutrient solution based on Hogland formula [Hogland 1950]. It is produced in two stages with a stock solution of each element maintained separately (tab. 4). The salts present in the Hogland formula include potassium phosphate, potassium nitrate, calcium nitrate and magnesium sulphate, which contain six microelements of phosphorus, potassium, nitrogen, calcium, sulphur and magnesium.

However, for the control or change in the concentration of one or multiple nutritional elements, the concentration of other elements within this formula would be also changed. Hence, trying to change the salt despite the controlled element concentrations of potassium would not make a difference in the concentrations of other elements. This is why the salts compounds differentiate in different concentrations of potassium [ $K_0$ ,  $K_3$  (3 mM) and  $K_6$  (6 mM)]. After studying the salt types, first of all one molar of their solution will be produced and stored as a stock solution, based on their chemical formulae and the molecular mass. Then an appropriate amount of each key solution will be mixed together to produce one liter of complete nutrition soluble solution.

Table 4. The salts containing the macro nutrition elements in Hogland nutrition solution

| Macronutrients           |                          |                          | Micronutrients        |
|--------------------------|--------------------------|--------------------------|-----------------------|
| $K_1$ (6 mM)             | $K_{0.5}$ (3 mM)         | $K_0$ (without K)        |                       |
| $KH_2PO_4$               | $KH_2PO_4$               | $Ca(NO_3)_2 \cdot 4H_2O$ | $H_3BO_3$             |
| $KNO_3$                  | $KNO_3$                  | $MgSO_4 \cdot 7H_2O$     | $MnCl_2 \cdot 4H_2O$  |
| $Ca(NO_3)_2 \cdot 4H_2O$ | $Ca(NO_3)_2 \cdot 4H_2O$ | $NH_4NO_3$               | $ZnSO_4 \cdot 7H_2O$  |
| $MgSO_4 \cdot 7H_2O$     | $MgSO_4 \cdot 7H_2O$     | $H_3PO_4$                | $CuSO_4 \cdot 5H_2O$  |
|                          | $H_3PO_4$                |                          | $H_2MoO_4 \cdot H_2O$ |
|                          | $NH_4NO_3$               |                          | $Fe_2(C_4H_4O_6)_3$   |

The second stage of producing nutrition soluble solution is to supply one liter of stock solution, which is made up of salt micro elements (tab. 4). But the best way is to avoid mixing the stock solution with any salt. In the end, one cubic centimeter of each of the micro element solutions was added to each one liter of macro element solutions. The end product with a mass of one liter is a complete nutrition solution.

After five months, the plants were harvested and the plant height, stem diameter, flower bud number, fresh and dry shoot and root weight were measured at every treatment. The sub samples of dry leaves (at 70°C for 48 h) were ground and then dry-ashed in a furnace at 550°C and then extracted with 2 M HCl. The concentrations of Ca, Mg, Fe, Mn and Zn were measured in the extracts by atomic absorption spectrophotometry, K by flame photometry, and P by spectrophotometry. Total kjeldahl nitrogen (TKN) of leaves and media and the total organic carbon (TOC) of the media were estimated by using a microkjeldahl method [Singh and Pradhan 1981] and Walkey and Blacks Rapid titration method [1934], respectively. The pH and EC of growth media were determined on a water extract from compost using compost to water ratio of 1:5 by weight. Thus, the phosphorus and potassium of media were determined by spectrophotometric and flame photometric methods, respectively.

The experiment was a completely randomized design in three replications and MSTATC software was used for variance analysis of data by Least Significant Difference (LSD) test.

## RESULTS AND DISCUSSION

**The effects of medium on the growth indices.** The effect of planting substrates on the growth indices is observed in table 5. The growth of *Camellia* in the treatments of 40 and 60% peanut shelles compost was more than control and 100% peanut shelles. The achieved results are accordance to Alidoust et al. [2012], Pool and Conover [1991] in *dracaena*, Abad et al. [2001], Mahboub Khomami and Padasht Dehkaei [2010] in *Ficus Benjamin*, Basantia et al. [2011] in marigold. Padasht Dehkaei [2004] survey the different effects of bark, tea wastes, municipal waste compost and rice hull on the growth of *Beaucarnea recurvata* and *Dracaena marginanta* and concluded that these compounds significantly increased the number of leaves, plant height and other growth parameters. Chen et al. [1989] found that the preference of compost substrates is due to the high level of nutrients and microbial population in the root rhizosphere lead to more growth. The growth of plant decreased significantly in 100% peanut shelles than in the control and other treatments of peanut shelles compost. It seems that the growth decreased due to the high percentage of pores, reducing of water retention capacity and increasing of salinity. A desirable bed must have a proper water holding capacity [Ronald and Dianne 2006]. Alidoust et al. [2012] attributed the decrease in growth of 100% peanut shelles than in other beds base on Atiyeh [2001] due to the severe decrease in bulk density to reduce the air conditioning and available water.

The more growth of roots in the 40 and 60% peanut shelles compost can have a major role on the effectively uptake of water and nutrients in the future. The parts of compost impacts can be due to humic materials. Chen et al [1989] also stated that the part of the effects of compost on growth of *Ficus Benjamin* could be due to a similar role in plant growth regulators. Accordingly, the root growth of the plant has increased in the presence of compost in the growth medium and improvement of bed physical conditions.

**The effects of potassium on the growth indices.** Based on table 6, the use of 3 mM potassium had the greatest effect on leaves number, fresh and dry weight of shoot and root of *Camellia*. Although K is not a constituent of any organic molecule or plant structure, it is involved in numerous biochemical and physiological processes and pivotal role to plant growth, yield, quality and stress [Cakmak 2005]. Potassium due to the rapid increase in leaf surface and transmission of combinations made from the leaves to the root is led to root growth [Salardini 2009]. Potassium is necessary for the synthesis and transport of nutrients and it is effective in elimination of some nutrients imbalance of soil and regulation of water uptake [Wang 2007].

Plant growth without potassium treatment indicated that peanut shelles compost plays a role in the providing of the needed potassium but it is not sufficient and the growth was increased with the addition of potassium to nutrient solution. Increasing of growth can be attributed to the potassium role in the cell growth and development and increase in photosynthesis. It is well known that potassium plays a key role in carbohydrate metabolism and photosynthesis [Marschner 1995]. Potassium is important for cell expansion and growth of the plants is the resulting concentrated potassium in cells and vacuoles [Marschner 1986]. Potassium specifically activates enzymes to produce large molecules such as protein and starch [Sulter 1985, Faquin 1994, Shabala 2003]. Egilla et al. [2005] stated that the sufficient consumption of potash fertilizer in *Hibiscus* when

Table 5. The Effect of growth media, K concentration in nutrient solution and interaction effect (K concentration  $\times$  growth medium) on the growth indices of Camellia

| Treatments  | Leaves number | Plant height (cm) | Bud number | Stem diameter (cm) | Fresh weight of root (g) | Dry weight of root (g) | Fresh weight of shoot (g) | Dry weight of shoot (g) |
|---|---------------|-------------------|------------|--------------------|--------------------------|------------------------|---------------------------|-------------------------|
| control   | 10.2b         | 18.3ab            | 2.2b       | 4.2b               | 21.9c                    | 5.3b                   | 21.3c                     | 6.0b                    |
| 20% PSC   | 11.0ab        | 17.8ab            | 2.3b       | 4.4b               | 25.3ab                   | 4.5b                   | 21.6bc                    | 6.4b                    |
| 40% PSC   | 13.1ab        | 20.4a             | 3.1a       | 5.3a               | 45.9a                    | 7.3a                   | 27.1a                     | 7.9a                    |
| 60% PSC   | 14.2a         | 21.4a             | 2.4b       | 4.4b               | 28.6b                    | 6.6a                   | 24.8ab                    | 7.4a                    |
| 100% PSC  | 6.0c          | 12.9b             | 1.6c       | 2.7c               | 8.6d                     | 4.7b                   | 13.4d                     | 3.2c                    |
| <b>K<sub>0</sub></b>                              | 8.6b          | 16.5b             | 2.3a       | 4.0a               | 22.7b                    | 3.7b                   | 18.9b                     | 5.1b                    |
| <b>K<sub>3</sub></b>                              | 13.8a         | 18.8a             | 2.2a       | 4.4a               | 33.0a                    | 5.2a                   | 24.3a                     | 7.1a                    |
| <b>K<sub>6</sub></b>                              | 10.3b         | 19.2a             | 2.3a       | 4.2a               | 22.6b                    | 4.6ab                  | 21.8a                     | 6.6a                    |
| <b>Control <math>\times</math> K<sub>0</sub></b>  | 9.3de         | 17.3bcd           | 2.2b-f     | 4.7b               | 32.0cde                  | 4.1cd                  | 22.1b                     | 6.2cd                   |
| <b>Control <math>\times</math> K<sub>3</sub></b>  | 11.3cd        | 19.3ab            | 2.6b-e     | 4.0bc              | 22.3ef                   | 5.5bc                  | 22.2b                     | 6.3cd                   |
| <b>Control <math>\times</math> K<sub>6</sub></b>  | 10.0d         | 18.3ab            | 1.6ef      | 3.8bc              | 11.5fgh                  | 1.3e                   | 19.6bc                    | 5.4de                   |
| <b>20% PSC <math>\times</math> K<sub>0</sub></b>  | 9.4de         | 15.4cd            | 1.9c-f     | 4.6b               | 17.3fgh                  | 3.8cd                  | 21.7bc                    | 5.9cde                  |
| <b>20% PSC <math>\times</math> K<sub>3</sub></b>  | 11.6cd        | 19.5ab            | 2.1b-f     | 4.8b               | 43.2b                    | 5.6bc                  | 30.9a                     | 9.1b                    |
| <b>20% PSC <math>\times</math> K<sub>6</sub></b>  | 12.0cd        | 18.4abc           | 3.0ab      | 3.9bc              | 15.4fgh                  | 4.1cd                  | 12.1d                     | 4.3fg                   |
| <b>40% PSC <math>\times</math> K<sub>0</sub></b>  | 10.6d         | 20.2ab            | 4.0a       | 4.6b               | 37.4bcd                  | 8.6a                   | 20.3bc                    | 5.45def                 |
| <b>40% PSC <math>\times</math> K<sub>3</sub></b>  | 16.6b         | 21.1ab            | 2.3b-f     | 5.8a               | 57.9a                    | 6.5b                   | 30.3a                     | 9.1b                    |
| <b>40% PSC <math>\times</math> K<sub>6</sub></b>  | 12.0cd        | 20.1ab            | 2.8bcd     | 5.6ab              | 42.5bc                   | 6.6b                   | 30.9a                     | 9.3b                    |
| <b>60% PSC <math>\times</math> K<sub>0</sub></b>  | 9.0de         | 19.5ab            | 2.0b-f     | 3.6c               | 18.6fg                   | 4.3cd                  | 19.5bc                    | 4.9ef                   |
| <b>60% PSC <math>\times</math> K<sub>3</sub></b>  | 21.3a         | 19.7ab            | 2.4b-f     | 4.4bc              | 31.3de                   | 6.4b                   | 22.1b                     | 6.8c                    |
| <b>60% PSC <math>\times</math> K<sub>6</sub></b>  | 12.4cd        | 25.1a             | 2.9bc      | 5.3ab              | 36.0bcd                  | 9.1a                   | 32.8a                     | 10.4a                   |
| <b>100% PSC <math>\times</math> K<sub>0</sub></b> | 4.6e          | 10.2e             | 1.7def     | 2.6cd              | 8.2bcd                   | 2.1e                   | 10.7d                     | 2.6h                    |
| <b>100% PSC <math>\times</math> K<sub>3</sub></b> | 8.0de         | 14.5cd            | 1.5f       | 3.1cd              | 10.3gh                   | 1.8e                   | 16.1cd                    | 3.8g                    |
| <b>100% PSC <math>\times</math> K<sub>6</sub></b> | 5.3e          | 14.1cd            | 1.4f       | 2.3e               | 7.4h                     | 1.7e                   | 13.4d                     | 3.3gh                   |

Table 6. The Effect of growth media, K concentration in nutrient solution and interaction effect (K concentration × growth medium) on the nutrient concentration of leaves

| Treatments                | Nitrogen (%) | Phosphorus (%) | Potassium (%) | Iron (mg·kg) | Zinc (mg·kg) | Manganese (mg·kg) |
|---------------------------|--------------|----------------|---------------|--------------|--------------|-------------------|
| control                   | 2.65ab       | 0.43b          | 2.41c         | 81.8a        | 7.16 b       | 16.1ab            |
| 20% PSC                   | 2.95a        | 0.43b          | 2.81bc        | 100.6a       | 10.4b        | 11.2b             |
| 40% PSC                   | 2.66ab       | 0.54a          | 3.75a         | 81.4a        | 7.70ab       | 14.0b             |
| 60% PSC                   | 2.84ab       | 0.41b          | 3.30ab        | 98.2a        | 9.42ab       | 11.5b             |
| 100% PSC                  | 2.38b        | 0.55a          | 2.29c         | 102.4a       | 9.61ab       | 19.8a             |
| K <sub>0</sub>            | 2.53b        | 0.48ab         | 2.23b         | 89.3a        | 8.33a        | 13.25a            |
| K <sub>3</sub>            | 3.1a         | 0.43b          | 3.19a         | 90.9a        | 8.76a        | 14.34a            |
| K <sub>6</sub>            | 2.51b        | 0.51a          | 3.33a         | 92.5a        | 9.40a        | 16.05a            |
| Control × K <sub>0</sub>  | 2.70abc      | 0.54bcd        | 1.73fg        | 49.30e       | 7.36a        | 15.27cde          |
| Control × K <sub>3</sub>  | 2.94ab       | 0.34i          | 1.65fg        | 73.86cde     | 7.76a        | 10.61e            |
| Control × K <sub>6</sub>  | 2.32abc      | 0.41fghi       | 3.85ab        | 92.26bcde    | 6.36a        | 22.43ab           |
| 20% PSC × K <sub>0</sub>  | 2.80abc      | 0.42efgh       | 2.51cde       | 98.30bcd     | 9.16a        | 8.36e             |
| 20% PSC × K <sub>3</sub>  | 3.27a        | 0.36hi         | 2.87cde       | 144.86a      | 11.43a       | 13.6de            |
| 20% PSC × K <sub>6</sub>  | 2.80abc      | 0.50bcde       | 3.06cd        | 57.73de      | 10.53a       | 11.5e             |
| 40% PSC × K <sub>0</sub>  | 2.48abc      | 0.49cdef       | 2.33def       | 88.30bcde    | 8.60a        | 10.16e            |
| 40% PSC × K <sub>3</sub>  | 3.01ab       | 0.45efg        | 4.38a         | 79.66cde     | 6.23a        | 20.84abc          |
| 40% PSC × K <sub>6</sub>  | 2.48abc      | 0.67a          | 4.56a         | 76.30cde     | 8.20a        | 11.03e            |
| 60% PSC × K <sub>0</sub>  | 2.80abc      | 0.37hi         | 3.15bc        | 102.13bcd    | 10.13a       | 13.18de           |
| 60% PSC × K <sub>3</sub>  | 2.94ab       | 0.38ghi        | 3.83ab        | 83.80bcde    | 10.46a       | 8.66e             |
| 60% PSC × K <sub>6</sub>  | 2.80abc      | 0.47def        | 2.92cde       | 108.60abc    | 7.50a        | 12.80de           |
| 100% PSC × K <sub>0</sub> | 1.86c        | 0.57bc         | 1.42g         | 108.13abc    | 6.40a        | 19.30bcd          |
| 100% PSC × K <sub>3</sub> | 3.11ab       | 0.58b          | 3.21bc        | 72.36cde     | 11.13a       | 26.48a            |
| 100% PSC × K <sub>6</sub> | 2.17bc       | 0.49cdef       | 2.24ef        | 126.43ab     | 11.20a       | 13.88de           |



Table 7. The Effect of growth media, K concentration in nutrient solution and interaction effect (K concentration  $\times$  growth medium) on the uptake of nutrients (mg·pot)

| Treatments                       | Nitrogen | Phosphorus | Potassium | Iron     | Zinc      | Manganese |
|----------------------------------|----------|------------|-----------|----------|-----------|-----------|
| control                          | 159.4a   | 25.9bc     | 139.8cd   | 0.42bc   | 0.037bc   | 0.088ab   |
| 20% PSC                          | 194.4a   | 26.8bc     | 180.9bc   | 0.71a    | 0.058a    | 0.068ab   |
| 40% PSC                          | 213.2a   | 43.7a      | 319.5a    | 0.63ab   | 0.054ab   | 0.11a     |
| 60% PSC                          | 209.6a   | 31.0b      | 239.6b    | 0.73a    | 0.062a    | 0.082ab   |
| 100% PSC                         | 79.4b    | 17.8c      | 77.7d     | 0.32c    | 0.026c    | 0.061b    |
| K <sub>0</sub>                   | 163.8b   | 23.7b      | 114.5b    | 0.42b    | 0.05b     | 0.03b     |
| K <sub>3</sub>                   | 184.0a   | 28.9ab     | 229.4a    | 0.66a    | 0.10a     | 0.05a     |
| K <sub>6</sub>                   | 165.7b   | 34.5a      | 230.4a    | 0.59ab   | 0.08ab    | 0.04ab    |
| Control $\times$ K <sub>0</sub>  | 167.3bcd | 33.68d     | 107.2de   | 0.30e    | 0.04bcdef | 0.09bcd   |
| Control $\times$ K <sub>3</sub>  | 185.6bcd | 21.56fg    | 103.9de   | 0.46cde  | 0.04bcde  | 0.06cde   |
| Control $\times$ K <sub>6</sub>  | 125.2cde | 22.50efg   | 208.2c    | 0.49bcde | 0.03ef    | 0.11b     |
| 20% PSC $\times$ K <sub>0</sub>  | 165.2bcd | 25.17ef    | 148.4d    | 0.57bcd  | 0.05bcde  | 0.04e     |
| 20% PSC $\times$ K <sub>3</sub>  | 297.5a   | 33.36d     | 261.7bc   | 1.31a    | 0.08a     | 0.12b     |
| 20% PSC $\times$ K <sub>6</sub>  | 120.3def | 21.78efg   | 132.4de   | 0.24e    | 0.04bcdef | 0.04e     |
| 40% PSC $\times$ K <sub>0</sub>  | 134.2cde | 26.64e     | 125.8de   | 0.47bcde | 0.04bcdef | 0.05e     |
| 40% PSC $\times$ K <sub>3</sub>  | 274.2a   | 41.55c     | 398.8a    | 0.72b    | 0.05bcde  | 0.18a     |
| 40% PSC $\times$ K <sub>6</sub>  | 231.2ab  | 62.93a     | 433.6a    | 0.70bc   | 0.07abc   | 0.09bc    |
| 60% PSC $\times$ K <sub>0</sub>  | 137.2cde | 18.13gh    | 154.3d    | 0.49bcde | 0.04bcde  | 0.06cde   |
| 60% PSC $\times$ K <sub>3</sub>  | 200.3bc  | 26.06ef    | 260.6bc   | 0.56bcd  | 0.06abcd  | 0.05de    |
| 60% PSC $\times$ K <sub>6</sub>  | 291.2a   | 48.88b     | 303.6b    | 1.12a    | 0.07ab    | 0.13b     |
| 100% PSC $\times$ K <sub>0</sub> | 48.36f   | 14.82h     | 37.00f    | 0.27e    | 0.01f     | 0.04e     |
| 100% PSC K <sub>3</sub>          | 118.3def | 22.16efg   | 121.98de  | 0.27e    | 0.03cdef  | 0.09bc    |
| 100% PSC K <sub>6</sub>          | 71.72ef  | 16.39h     | 74.14ef   | 0.41de   | 0.03def   | 0.04e     |

the water potential is low, lead to maintaining of pure photosynthesis and increase in net photosynthesis to transpiration ratio and finally lead to increase in dry weight.

Significant difference between the control treatment (without K) and 6 mM potassium treatment were not seen. It seems that in without potassium conditions, the bed containing peanut shelles compost plays a role in providing the required potassium and the growth had not been stopped, but the addition of 3 mM potassium and the better supply of potassium was led to increasing of plant growth. Using of full concentration of potassium in Hoagland solution (6 mM) lead to decrease in the growth. It seem that providing the potassium from both peanut shelles compost and nutrient solution caused to severe increase in K concentration around root environment and ionic competence was led to failure in uptake of other nutritional cations. Xu [2011] evaluated the impact of potassium in nutrient solution on *Houttuynia cordata* Thunb. Their results showed that 1.28 mM potassium was the optimum for *H. cordata* as highest values of dry weight, shoot height; root length and number were obtained at this concentration. The optimum potassium concentration resulted in the maximum net photosynthetic rate which could be associated with the highest chlorophyll content rather than limited stomatal conductance. The supply of surplus potassium negatively correlated with the biomass.

**Leaf nutrients concentration and nutrients uptake.** Table 6 shows the effects of different treatments on nutrients concentration in the leaf of Camellia. As regards, the nutrient concentration in the plants organ influenced by different factors like plant growth, ionic competence and deposition, sometimes it cannot use from elements concentration in plant as a reliable parameter for evaluation of plant growth. In this regard, the use of nutrient uptake by plants from the soil is a more reliable parameter. Since the uptake rate obtained from multiplying of nutrient concentration of plants and dry weight of plant, therefore, nutrient dilution effect disappears.

Table 7 show the effect of different treatments on nutrients uptake. The maximum uptake of nitrogen, phosphorus and potassium was observed on medium containing 40% compost and then 60% compost. Increasing of compost to 100% was led to significant decrease in uptake elements. Achieved results in agreement with those obtained by Alidoust et al. [2012] on *Dracaena* and Sharifi et al. [2010] on Marigold. The effect of planting bed on uptake of nutrients in this study shows that the microelements such as iron, manganese and zinc increased with increasing of compost until 40% and reached to the minimum level in the peanut shelles compost bed of 100%. This issue can be justified with improving of physical conditions and bed properties by compost. Castro et al [2009] reported increasing uptake of iron, copper and zinc in lettuce grown in the beds containing compost and they stated this issue is due to the high level of these elements in compost. Uptake of micronutrients in leaf of plant can be due to the relative increase of zinc and manganese in the bed with the higher compost. Zinc and manganese have high mobility to transport from root to the shoots, easily. In the present study, it was observed that 40% compost had the most effect on the amount of potassium uptake. It has been reported that vermicompost increases potassium uptake in the medical plants of Chamomile [Salehi et al. 2011]. The similar results were reported on the confirmation of the effect of vermicompost on the increasing of potassium uptake in the tomatoes that it is effective on the microbial activity improvement, the existence of plant growth regulator and increasing uptake of mineral elements such as potassium [Zaller 2007].

The results show that the usage of 3 mM potassium in the nutrient solution had the best results on the uptake of all nutrients, while the uptake of potassium decreased in the pots with zero concentration of potassium in the nutrient solution (potassium deficiency) and 100% concentration of potassium in the nutrient solution (potassium exorbitance). This issue can be due to better supplying of potassium in the planting bed and its availability for the plants which subsequently leads to better yield. The potassium intake of leaf was increased by increasing of potassium concentration. It can say that potassium uptake in plant is increased by adding of potassium to the growth medium.

**The interaction effect of medium and potassium on growth indices.** The results of table 5 shows that the greatest amount of plant growth in most indices achieved on the different beds on the concentration of 3 mM K. The results show that the growth in planting bed of 40 and 60% peanut shelles compost without potassium was similar or more than of the growth in control bed with consumption of 6 mM potassium in nutrient solution. This represents the providing of needed potassium of plant on the peanut shelles compost bed than in the control (without peanut shelles compost) even with the use of complete potassium in the nutrient solution that could support the growth of plant. Compost is led to better growth of root due to appropriate porosity to increase root surface in the soil and nutrients uptake for the growth of shoots. Also, peanut shelles compost rich in potassium can partially provide the needed potassium for plants and in other word, it leads to better quality of bed with air conditioning of the culture bed. Accordingly, growth and optimal uptake of nutrients through the roots is predictable.

In the 40 and 60% peanut shelles compost with 3 mM potassium in nutrient solution, the growth is increased. Increasing of concentration to 6 mM caused to slow growth. It seems that the combined effects of potassium in nutrient solution and the potassium of the peanut shelles compost is led to increase in potassium concentration that its competitive effect can be had a negative effect on the uptake of other nutrients. In the treatments of 40 and 60% compost (tab. 7) without potassium, the uptake of nitrogen, phosphorus, iron and zinc have not any difference with the uptake of these elements in the control bed with 6 mM potassium that this is due to increasing yield of plants and providing nutrients by peanut shelles compost.

## CONCLUSION

1. In general, the results showed that peanut shelles compost increased the growth indices of *Camellia* plant.

2. In the most growth indices, replacement 40–60% compost had the better effects on the growth of plant. Increasing of peanut shelles compost to 100% was led to decrease in growth and quality of plant.

3. The best result of plant growth was obtained by using 40–60% peanut shelles compost along with 3 mM potassium. The comparison between control with 6 mM K and 40 and 60% peanut shelles compost without K showed that mostly the growth indices of 40–60% compost either were more than the control or they have not significant difference than in the control.

4. The results are indicator of providing the needed potassium for plant by peanut shelles compost.

5. According to the desirable properties of peanut shelles compost and high porosity; it is suggested that this bed mixed with low pores beds and it can be used as an alternative imported beds.

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## WZROST KAMELII W PODŁOŻU Z KOMPOSTU Z ŁUPIN ORZECHÓW ZIEMNYCH O RÓŻNYM STĘŻENIU POTASU

**Streszczenie.** Zarządzanie odpadami rolniczymi jest krokiem w kierunku zrównoważonego rolnictwa. Łuski orzechów ziemnych jako pozostałość po uprawie orzechów mają znaczną objętość i w formie kompostu mogą być używane jako dostępne źródła podłoża dla roślin ozdobnych. Doświadczenie czynnikowe na podstawie całkowicie randomizowanych bloków przeprowadzono w celu zbadania wpływu kompostu z łusek orzechów ziemnych jako podłoża dla kamelii przy różnych stężeniach potasu. Doświadczenie objęło piętnaście zabiegów w trzech powtórzeniach oraz 45 poletek. Posadzone ukorzenione sadzonki kamelii podlewano dwa razy w tygodniu roztworem Hoaglanda. Po pięciu miesiącach dokonano pomiaru wskaźników wzrostu roślin, a także stężenia i poboru substancji odżywczych. Na podstawie wyników stwierdzono, że kompost z orzechów ziemnych zwiększa wskaźniki wzrostu w porównaniu z kontrolą. W odniesieniu do większości wskaźników wzrostu, rośliny wykazywały lepszą reakcję w przypadku 40% i ostatecznie 60% dodatku kompostu (% wag.). Wyniki wskazują na skuteczniejsze dostarczanie potasu potrzebnego do wzrostu roślin w przypadku kompostu z łusek orzechów ziemnych w porównaniu z kontrolą.

**Słowa kluczowe:** odpady rolnicze, roztwór Hoaglanda, rośliny ozdobne, doświadczenie doniczkowe

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