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*Research Paper*

# The Effect of Different Concentrations of Nitrogen and Potting Media Composition on the Growth and Quality of Poinsettia (*Euphorbia pulcherrima*) cv. 'Noel Red'

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Abstract

Poinsettia (*Euphorbia pulcherrima*) is one of the most important ornamental pot plants that form colored bracts in short days. The present research was carried out to evaluate the effect of different concentrations of nitrogen in nutrient solution (180, 230, 280, and 330 mg $L^{-1}$) and culture media composition (peat moss and perlite (2:1 v/v ratio) and cocopeat and perlite (2:1 v/v ratio)) on some morphological and physiological indices of poinsettia. The experiment was factorial based on a completely randomized design with eight treatments and three replications. Results showed that the nitrogen concentration of 230 mg $L^{-1}$ with cocopeat and perlite media increased plant height, canopy diameter, and nitrogen content of leaf tissue. The concentration of 230 mg $L^{-1}$ nitrogen also increased the fresh weight of stem and root more than other treatments whereas the highest stem dry weight resulted from the concentration of 280 mg $L^{-1}$ nitrogen and cocopeat and perlite media. The application of peat moss and perlite mixture with 330 mg $L^{-1}$ of nitrogen increased chlorophyll *a* and bract anthocyanin content. Generally, the results revealed that the application of 230 and 280 mg $L^{-1}$ nitrogen and a mixed cocopeat and perlite (2:1 v/v ratio) medium improved growth indices and quality properties of poinsettia.

**Keywords:** Anthocyanin, Nitrate, Peat moss, Poinsettia, Quality.

## INTRODUCTION

Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch) from the family Euphorbiaceae is indigenous to Mexico (Basyouni *et al*., 2015; Innes *et al*., 2018). This species is one of the most valuable pot plants of the floriculture industry that is grown for Christmas and is very popular in most parts of the world, especially in North America (Basyouni *et al*., 2015). The true flowers of poinsettia are called cyathium, which have no specific ornamental value. Before the appearance of cyathium, colorful bracts are developed with the origin of leaf to form the ornamental part of the plant (Musharraf Iraqi *et al*., 2014; Guo *et al*., 2018).

Plant nutrition is a very important issue in plant production management, which improves the quantity and quality of flowers and plants (Jones, 2012; Piyamart, 2017). Among the essential macronutrients, nitrogen is more important due to its significant effects on plant growth and development (Raviv and Lieth, 2008). Nitrogen is often a limiting factor in agriculture (van Bueren and Struik, 2017). Increasing nitrogen improves some morphological (e.g., height, canopy diameter, number and length of bract, dry weight) and physiological parameters (e.g., leaf chlorophyll content (SPAD values), the nitrogen content of leaf tissue), as well as the marketability of poinsettia (Basyouni *et al*., 2015). Chlorophyll index had a non-linear relationship with the status of nitrogen nutrition in a grass (Costa *et al*., 2015). Main environmental problems caused by nitrogen include pollution of water and soil resources, ozone depletion, and loss of biodiversity in the ecosystem (Waqar *et al*., 2014).

Generally, the method of plant growth and production is controlled by two groups of hereditary factors and environmental phenomena (mainly of culture medium) (Khoshkhoui, 2015; Hussain *et al*., 2017). Among various organic materials, peat moss is commonly used as a primary component of potting media to produce commercial plants. The long-term success of peat moss is certainly related to the physical, chemical, and biological properties of plant growth (Fascella, 2015). Cocopeat is produced by processing coconut fruit wastes (Raviv and Lieth, 2008; Fascella, 2015). The EC value of cocopeat ranges from 0.3 to 2.9 ds $m^{-1}$ (packet processing method). Cocopeat is often used individually or in combination with other neutral substances as an organic substrate for ornamental plants and vegetables, but they exhibit the same efficiency growth (Fascella, 2015; Ilahi and Ahmad, 2017). Perlite is aluminum silicates with a volcanic origin (Khalaj *et al*., 2014). Growth media enrichment with perlite improves the physical properties of media composition (Raviv and Lieth, 2008). Fascella (2015) reported that water and nutrient absorption was associated with the physical and chemical characteristics of media, and the development and performance of *Euphorbia×lomi* were similar in peat moss and cocopeat media. A combination of soil, cocopeat, and leaf mold increased the growth and quality parameters of rose plants (Chavada *et al*., 2017). The growing media have a great effect on plant growth and development. A proper selection of medium ingredients that leads to suitable porosity, good water holding capacity, and well drainage plays an important role in plant improvement and growth (Fazeli Kakhki *et al*., 2020). The chemical characteristics of growth media also affect irrigation demands and plant production programs (Majidi *et al*., 2019).

Due to the increasing development of greenhouse cultivation and demand for non-soil substrates, such as peat moss, and considering the high costs of peat moss, the present study was carried out to cast light on the feasibility of the replacement of high-cost peat moss with relatively inexpensive cocopeat medium. It also aimed to find out a suitable nitrogen concentration for the production of high-quality poinsettias in this culture medium.

## MATERIALS AND METHODS

### Plant materials and experimental design

This study was carried out in the greenhouse units of Urmia University as a factorial ex-

periment based on a completely randomized design with eight treatments. Factor I was assigned to four concentrations of nitrogen in nutrient solution (180, 230, 280, and 330 mg $L^{-1}$) and factor II was assigned to two types of growing media (cocopeat + perlite and peatmoss + perlite). There were three replications and three observations for each replication. Poinsettia 'Noel Red' plantlets with three to four leaves was provided from Selecta® Company and planted in 17 cm diameter pots containing two types of culture media, i.e., peat moss and perlite (2:1 v/v ratio) and cocopeat and perlite (2: 1 v/v ratio), in August, 2018. Novarbo peat moss and Sri Lanka cocopeat (pH 6.2-6.7 and EC ≤ 1.3, according to the package label) were used in the experiment. To supply the primary nutritional requirements of the transplanted poinsettias, 500 g of 12-14-24 NPK fertilizer (Fertiberia®) was added to 1000 L of culture media before planting as starter fertilizer, which was for the establishment period and before starting the use of the main nutrient solution. Average night/day temperature of the greenhouse was 18/25°C. The relative humidity was 70% and the light intensity was 450 to 500 µmol $s^{-1}$ $m^2$. To enhance vegetative growth and prevent premature flowering, the natural day length was reduced and the night breaking was interrupted. Hard pinching was done when the roots reached the inner wall of the pot. Fertilizer treatments were started two weeks after pinching in accordance with Tables 1a and 1b. Soft water with an EC level of below 10 µs $cm^{-1}$ was used for nutrient solution preparation and the final pH was adjusted to 6.0 to 6.2.

Table 1a. Fertilizer recipe* for the preparation of nutrient solutions with different nitrogen concentrations (values are in g per 1000 L of water).

| **Fertilizer** | **Nitrogen concentration** | | | |
|---|---|---|---|---|
| | **180 (mg $L^{-1}$)** | **230 (mg $L^{-1}$)** | **280 (mg $L^{-1}$)** | **330 (mg $L^{-1}$)** |
| $Ca(NO_3)_2.NH_4.10H_2O$ | 780 | 780 | 780 | 780 |
| $MgSO_4.7H_2O$ | 600 | 600 | 600 | 600 |
| $KH_2PO_4$ | 175 | 175 | 175 | 175 |
| $KNO_3$ | 0 | 384.5 | 550 | 550 |
| $NH_4NO_3$ | 165 | 165 | 255 | 392.5 |
| $K_2SO_4$ | 500 | 151 | 0 | 0 |
| Fe EDDHA chelate 6% | 15 | 15 | 15 | 15 |
| EC (ms/cm) | 2.5 | 2.7 | 2.8 | 3 |

*The above fertilizer recipe is a modified version of "Greneth Plants B.V. Office" fertilizer recipe for poinsettia growing (a commercial recipe).

Table 1b. Amount of micro elements used for preparing 1000 L of nutrient solution.

| **$H_3BO_3$(g)** | **$CuSO_4.5H_2O$(g)** | **$ZnSO_4.7H_2O$(g)** | **$MnCl_2.4H_2O$(g)** | **$(NH_4)_2MoO_4$(g)** |
|---|---|---|---|---|
| 2.86 | 0.08 | 0.22 | 1.81 | 0.4 |

*Based on modified Hoagland and Arnon (1950) micro-nutrients recipe.

Nutrient solutions were used based on the water requirement of the plants, and all pots were irrigated at the same time with an equal volume of nutrient solution per pot. Water drainage was about 15% at each turn. Measurements were taken after the full development of colored bracts.

**Measurement of traits**

**Plant height and canopy diameter**

Plant height (from pot surface to cyathium base) and canopy diameter were recorded using a ruler.

**Fresh and dry weight of stems and roots**

The fresh weight of stems and roots were measured using a digital scale (METTLER, PJ300) with a precision of 0.0001 g. The samples were put into a special paper pocket and were oven-dried at 72°C for 72 h. After they dried, the dry weight of the stems and roots were measured with the digital scale.

**Chlorophyll index**

Chlorophyll index was recorded using a SPAD meter (MINOLTA 502 Osaka, Japan).

**Chlorophyll and carotenoids content**

Chlorophyll was extracted by Lichtenthaler's (1987) method. For this, 0.1 g of leaf tissue was completely pounded in 5 ml of 100% acetone. The optical density (OD) of the extracted chlorophyll was measured at 663, 645, and 470 nm by a spectrophotometer. Chlorophyll and carotenoid contents were calculated by the following formulae:

$$\text{Chl. a} = (19.3 \times \text{OD } 663 - 0.86 \times \text{OD } 645) \quad (1)$$

$$\text{Chl. b} = (19.3 \times \text{OD } 645 - 3.6 \times \text{OD } 663) \quad (2)$$

$$\text{Chl. total} = \text{Chl. a} + \text{Chl. b} \quad (3)$$

$$\text{Car} = \frac{1000 \times \text{OD } 470 - 3.27 \times \text{Chl. a} - 104 \times \text{Chl. b}}{227} \quad (4)$$

**Anthocyanin**

Anthocyanin content was estimated by Wagner's (1979) method. So, 0.1 g of plant tissue was completely crashed in 10 ml of acidic methanol solution (including pure methanol and pure hydrochloric acid at a volumetric ratio of 1:99). Then, the extract was placed in darkness at 25°C for 24 h. It was then centrifuged at 4000 rpm for 10 min. Finally, its absorption was read at 550 nm with a spectrophotometer. The anthocyanin content was calculated by the following formula:

$$A = \varepsilon BC \quad (5)$$

In which A is the reading at 550 nm, ε denotes the extinction coefficient (equal to 33000 $cm^2\ mol^{-1}$), *B* represents cuvette width in cm, and *C* is anthocyanin concentration (μmol $g^{-1}$).

**Nitrogen content**

To determine the nitrogen content, leaf samples were collected and dried in an oven. The N content was determined by the Kjeldahl method (Ohayama *et al*., 1991). So, 0.3 to 0.5 g of the dried sample was powdered and mixed with 2.2 ml of an acidic mixture (100 ml of sulfuric acid and 6 g of salicylic acid). Then, 20 ml of the solution with 15 ml of sodium hydroxide (NaOH)

was poured into the balloon of a Kjeldahl machine. Then, 10 ml of boric acid, as well as three drops of nitrogen reagent, was poured into an Erlenmeyer flask and placed at the end of a distillation tube. For titration, 0.01 normal HCl solution was used. The nitrogen levels were calculated by the following formula:

$$\text{Nitrogen content of leaves} = \frac{(AV \times AN \times MMN \times TE) \times 100}{DSD \times WLP \times 1000} \quad (6)$$

in which AV is the acid volume consumed, AN is the acid normality, MMN is the molecular mass of the nitrogen, TE is the total volume of the extract, DSD is the digestion solution volume used in distillation, and WLP is the weight of leaf sample powder.

**Statistical analysis**

Data were analyzed using SAS 9.1 software package and means were compared by Duncan's test at $P<0.05$ and $P< 0.01$. The graphs were prepared in MS-Excel (2016) Software.

## RESULTS AND DISCUSSION

### Morphological traits

### Plant height and canopy diameter

The results of data analysis showed that the interactive effects of different nitrogen concentrations and culture media were significant on plant height ($P < 0.01$) (Table 2).

Table 2. Analysis of variance of the morphological traits of poinsettia stems and roots under different nitrogen concentrations and types of culture media.

| S.o.V | df | MS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plant height | Canopy diameter | Stem fresh weight | Stem dry weight | Root fresh weight | Root dry weight |
| Nitrogen (N) | 3 | 7.444$^{ns}$ | 12.180$^{ns}$ | 46.369* | 1.306$^{ns}$ | 65.563** | 1.399** |
| Culture media (C) | 1 | 4.166$^{ns}$ | 1.041$^{ns}$ | 3.377$^{ns}$ | 0.012$^{ns}$ | 85.658** | 1.582** |
| N×C | 3 | 28.5** | 12.902* | 3.727$^{ns}$ | 1.55* | 19.478$^{ns}$ | 0.205$^{ns}$ |
| Error | 16 | 3.708 | 3.791 | 12.544 | 0.418 | 6.574 | 0.145 |
| CV (%) | - | 6.678 | 5.938 | 15.226 | 13.102 | 12.155 | 13.611 |

*, ** and $^{ns}$: Significant at $P<0.05$, $P<0.01$ and insignificant, respectively.

Means comparison of data showed that the highest plant height (31.667 cm) resulted from 230 and 280 mg $L^{-1}$ nitrogen in cocopeat and perlite and peat moss and perlite culture media, respectively. The lowest plant height (25.667 cm) was obtained from the application of 330 mg $L^{-1}$ nitrogen and peat moss and perlite culture media (Fig. 1).

According to the analysis of variance, the effects of nitrogen and culture media were significant ($P<0.05$) on plant canopy diameter (Table 2). Fig. 2 shows that the application of 180 mg $L^{-1}$ nitrogen in the peat moss and perlite culture media led to the lowest canopy diameter (30.81 cm). The highest plant canopy diameter (32.66 cm) was observed at 280 mg $L^{-1}$ nitrogen and cocopeat and perlite culture media.

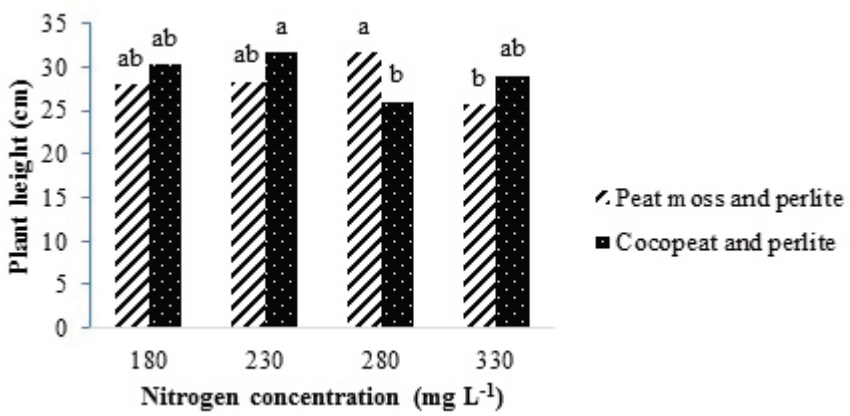


Fig. 1. The effects of different nitrogen concentrations and types of culture media on plant height of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.01) between the means based on Duncan's test.

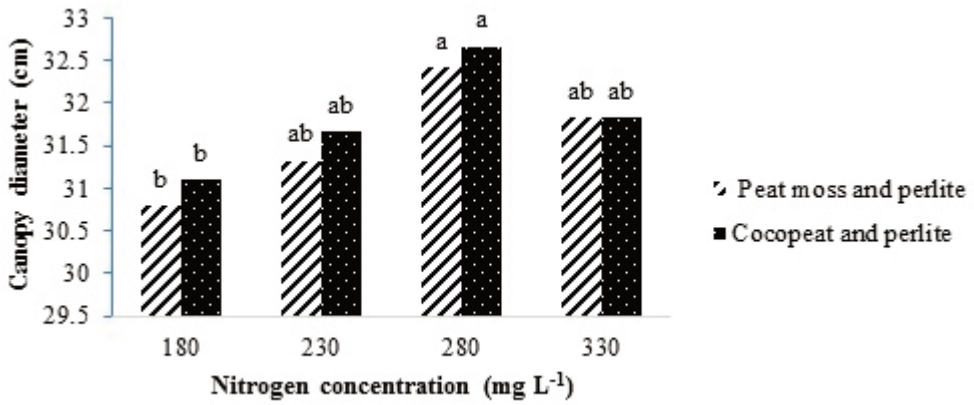


Fig. 2. The effect of different nitrogen concentrations and types of culture media on plant canopy diameter of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.05) between the means based on Duncan's test.

## Stem fresh and dry weight

The results of analysis of variance revealed that the main effect of nitrogen concentration was significant on stem fresh weight (Table 2). Means comparison showed that the highest stem fresh weight (27.401 g) was observed in 230 mg $L^{-1}$ nitrogen. The lowest amount of stem fresh weight (21.419 g) was obtained from 180 mg $L^{-1}$ nitrogen (Fig. 3).

Analysis of variance in Table 2 showed that stem dry weight was significantly influenced by the interaction of nitrogen concentration and culture media type (P<0.05). Fig. 4 shows that the highest stem dry weight (5.725 g) was at 280 mg $L^{-1}$ nitrogen concentration and cocopeat and perlite media. The lowest stem dry weight (4.194 g) was observed at 180 mg $L^{-1}$ nitrogen concentration and cocopeat and perlite culture media.

## Root fresh and dry weight

Analysis of variance showed that root fresh and dry weight were significantly influenced by nitrogen concentration and culture media type at P<0.01 (Table 2). Means comparison indicated that the highest root fresh weight (24.324 g) was obtained from the application of 230 mg $L^{-1}$ nitrogen.

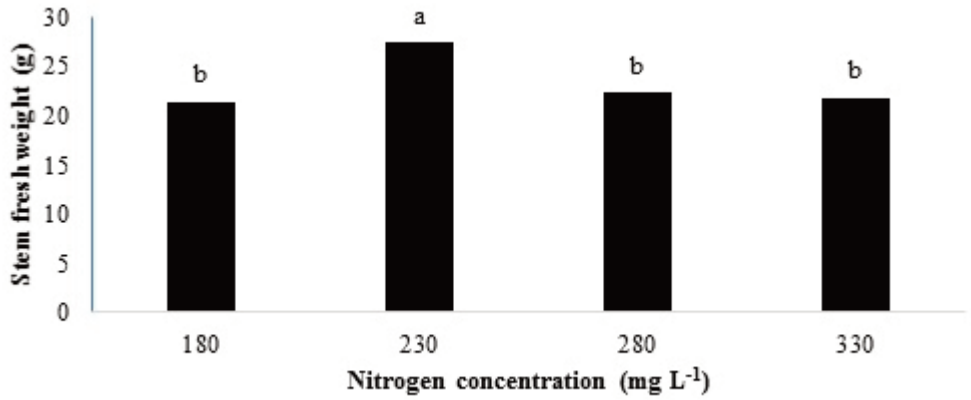


Fig. 3. The effect of different nitrogen concentrations on stem fresh weight of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.05) between the means based on Duncan's test.

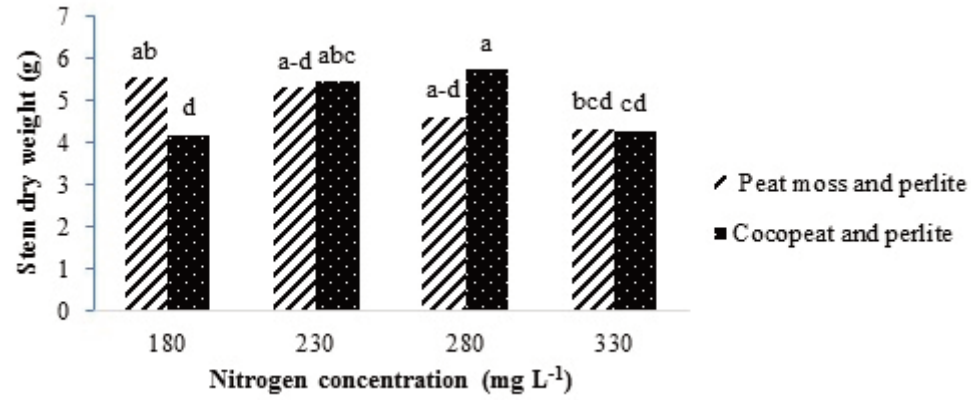


Fig. 4. The effect of different nitrogen concentrations and types of culture media on stem dry weight of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.05) between the means based on Duncan's test.

The lowest root fresh weight (17.193 g) was obtained from 330 mg $L^{-1}$ nitrogen (Fig. 5A). Fig. 5B shows that the highest and lowest root fresh weight (22.998 g and 19.205 g) were observed in cocopeat and perlite and peat moss and perlite, respectively.

Means comparison showed that with increasing nitrogen concentration, root dry weight was decreased. So, the highest root dry weight (3.303 g) was observed in 180 mg $L^{-1}$ nitrogen concentration, which had no significant difference with root dry weight at 230 and 280 mg $L^{-1}$ nitrogen concentrations. The lowest root dry weight (2.185 g) was obtained from the plants treated with 330 mg $L^{-1}$ nitrogen (Fig. 6A). Fig. 6B shows that the highest root dry weight (3.059 g) was obtained from the application of cocopeat and perlite culture media and the lowest amount (2.546 g) from peat moss and perlite media (Fig. 6B).

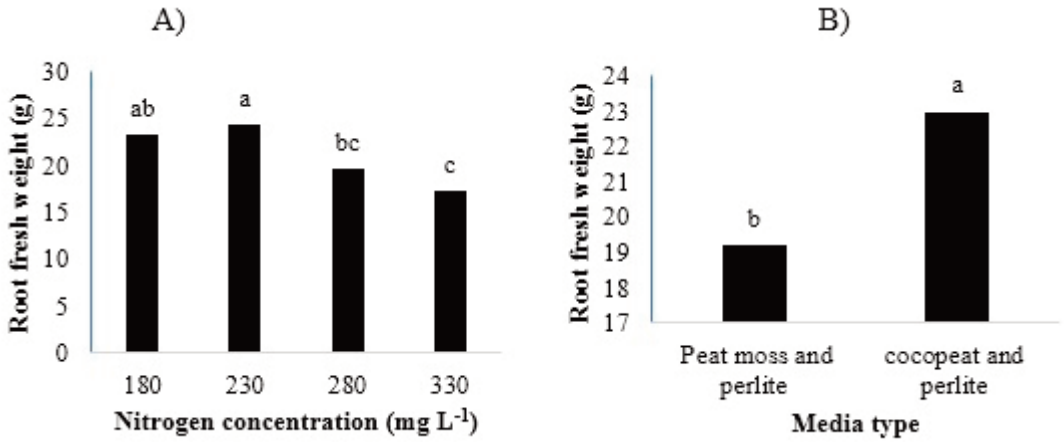


Fig. 5. The effect of different nitrogen concentrations (A) and culture media types (B) on root fresh weight of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.01) between the means based on Duncan's test.

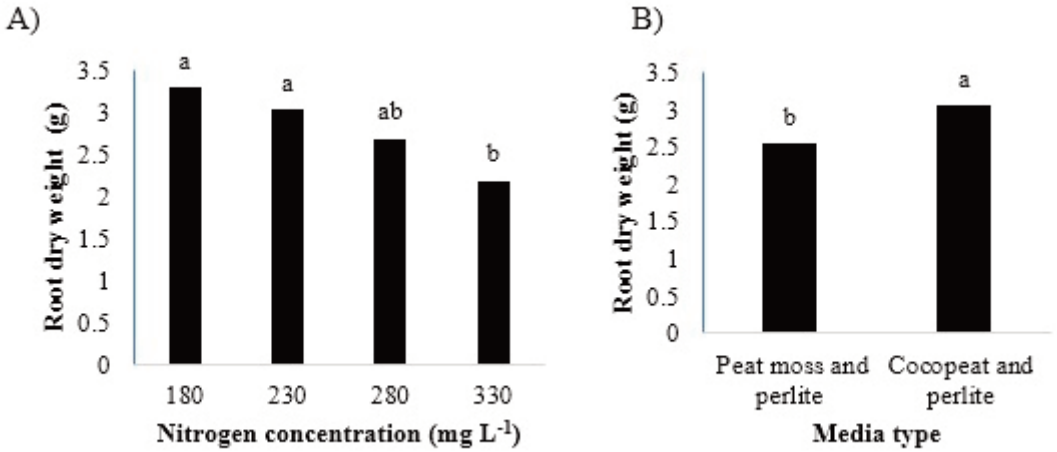


Fig. 6. The effect of different nitrogen concentrations (A) and culture media types (B) on root dry weight of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.01) between the means based on Duncan's test.

Nitrogen is a macronutrient that has very important and key roles in plant growth and development. Compared with other elements, nitrogen is required by plants in large amounts, so soils and growing media amended with additional nitrogen can increase yields (Barker and Pilbeam, 2015). Nitrogen deficiency (under critical concentrations) in plants increases growth inhibitors, reduces gibberellins (effective in root growth and alpha-amylase mRNA transcription), auxin (as a factor of apical dominance and root formation), and cytokinin (effective in stimulating nucleic acid production, cell division, longitudinal growth of leaves and stems), decreases meristematic activities, results in the production of short and dense internodes, decreases the number of lateral branches and canopy diameter of plant, and reduces root growth rate and stem and root fresh and dry weight (Hopkins, 1999; Jones, 2012). The ability of plants to absorb water and nutrients from culture media depends on their capacity to form a broad root system. Environmental conditions, such as insufficient aeration in peat moss and perlite and the deficiency or excessive use of macronutrients such as nitrogen in the culture medium can weaken root growth (Raviv and Lieth,

2008; Roosta *et al*., 2016). Decreased root growth rate reduces cytokinin synthesis and consequently its translocation to plant aerial organs (Raviv and Lieth, 2008). Improving the rhizosphere condition in cocopeat and perlite enhances root growth and activity and contributes to the better absorption of nutrients including nitrogen and phosphorus (Reddy and Ulaganathan, 2015), encourages overall plant growth and stem elongation, and increases plant canopy diameter. Higher leaf, stem, and root fresh and dry weights were also observed in these conditions (Dole and Wilkins, 2004).

Nitrogen regulates plant metabolism and development by regulating the concentration of endogenous hormones such as auxin and cytokinins (Xu *et al*., 2015). The growth and elongation of root cells are consistent with acid-growth theory. By stimulating proton pump, low pH, while is a prerequisite for the activation of hydrolyzing enzymes involved in the division of cell wall bonds and cell development in the apoplast, $H^+$ substitution with $Ca^{2+}$ weakens the cell wall and ultimately elongates cell division and growth of plant organs (Mengel *et al*., 2001; Raviv and Lieth, 2008). An important factor in the effect of auxin is its concentration in plant tissue. The sensitivity of different plant tissues to the concentration of auxins varies. Stem tissues are more tolerant to auxin than other tissues. While root tissues are more sensitive than other plant organs, in any given tissue, as long as auxin concentration is lower than its maximum tolerance, the hormone has a stimulating effect on its physiological activities, but when concentration is too high, it has an inhibiting effect and results in inhibiting the proton pump and reducing root growth, cytokinin levels, and elemental adsorption (N, P, and Mg), and decreasing aerial growth (Raviv and Lieth, 2008; Khoshkhouy, 2015). The effect of gibberellin on stem elongation of the poinsettia, geranium (*Pelargonium*), and fuchsia) *Fuchsia×hybrida* L.) plants has been reported in several studies (Dole and Wilkins, 2004). The effects of increasing nitrogen uptake on the height of poinsettia (Basyouni *et al*., 2015) and tomato (Fandi *et al*., 2010) are in agreement with the results of this study.

Since the activity of nutrient carriers is changeable depending on nutrient concentrations in the root medium (Hopkins, 1999), it seems that the HAT (high-affinity transport) mechanism is activated in plants under nitrogen deficiency or low nitrogen concentration conditions in the root environment and increases this element absorption rate. On the other hand, excessive concentrations of nitrogen in the root medium reduce nitrogen uptake through the activation of the LAT (low-affinity transport) mechanism (Tabatabaei, 2015), resulting in the decreased growth hormones, which consequently decreases plant height, canopy diameter, and root development. With lowering nitrogen concentrations, plant tissue, stems, and branches became thinner and usually made a closed-angle with the main stem (Kamalizadeh and Shiravand, 2013), which may be another possible reason for the decrease in plant canopy diameter at a concentration of 280 mg $L^{-1}$ in this research.

Due to the high cation exchange capacity of peat moss (Dole and Wilkins, 2004), the application of high concentrations of nitrogen is likely to increase EC level. Low aeration of peat moss and perlite along with high EC levels probably cause a stressful condition and increase abscisic acid content, and subsequently result in stomatal closure and the reduction of transpiration rate. So, the mass flow of some nutritional elements, such as nitrogen and magnesium, is probable (Barker and Pilbeam, 2015).

Root respiration depends on some factors, such as oxygen level, moisture status, and temperature of culture media. Reduced gas exchange capacity and respiration rate in peat moss and perlite media resulted in increasing internal cell acidity and altering conductivity and movement of water through roots. Finally, the low permeability of the roots to water decreased root fresh weight (Taiz and Zeiger, 2002). Chavada *et al*. (2017) report that the positive effects of cocopeat containing substrates on growth parameters in rose due to the increased nutrient uptake is in line with the results of the present study.

Compared with peat moss, cocopeat culture media probably provided more nitrogen accessibility to roots in time due to lower cation exchange capacity (Mengel *et al*., 2001; Pardossi *et al*., 2011) and may affect growth traits in this study.

## Physiological traits

### Chlorophyll index

Analysis of the variance showed that the main effects of nitrogen concentrations and culture media were significant on chlorophyll index (Table 3).

Means comparison showed that the highest amount of chlorophyll index (50.805) was obtained from 180 mg $L^{-1}$ nitrogen and the lowest (48.121) from 280 mg $L^{-1}$ nitrogen concentration (Fig. 7A). Fig. 7B depicts that the highest amount of chlorophyll index (51.430) was obtained from peat moss and perlite and the lowest (47.821) from cocopeat and perlite media.

Table 3. Analysis of variance of some physiological traits of poinsettia under different nitrogen concentrations and culture media.

| S.o.V | df | MS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | SPAD | Chl. a | Chl. B | Total Chl. | Carotenoid | AC | N |
| Nitrogen (N) | 3 | 10.936$^{*}$ | 0.280$^{ns}$ | 0.082$^{ns}$ | 0.411$^{ns}$ | 0.01$^{ns}$ | 3.223$^{*}$ | 0.064$^{**}$ |
| Culture media (C) | 1 | 78.124$^{**}$ | 0.485$^{*}$ | 0.1$^{ns}$ | 0.144$^{ns}$ | 0.186$^{**}$ | 4.737$^{*}$ | 0.066$^{**}$ |
| N×C | 3 | 0.875$^{ns}$ | 0.461$^{*}$ | 0.127$^{ns}$ | 0.380$^{ns}$ | 0.202$^{**}$ | 5.873$^{**}$ | 0.047$^{*}$ |
| Error | 16 | 2.876 | 0.120 | 0.051 | 0.157 | 0.014 | 0.690 | 0.011 |
| CV (%) | - | 3.417 | 12.841 | 27.852 | 11.303 | 24.896 | 14.122 | 3.128 |

*, ** and $^{ns}$: Significant at P < 0.05, P < 0.01 and insignificant, respectively. AC: Anthocyanin.

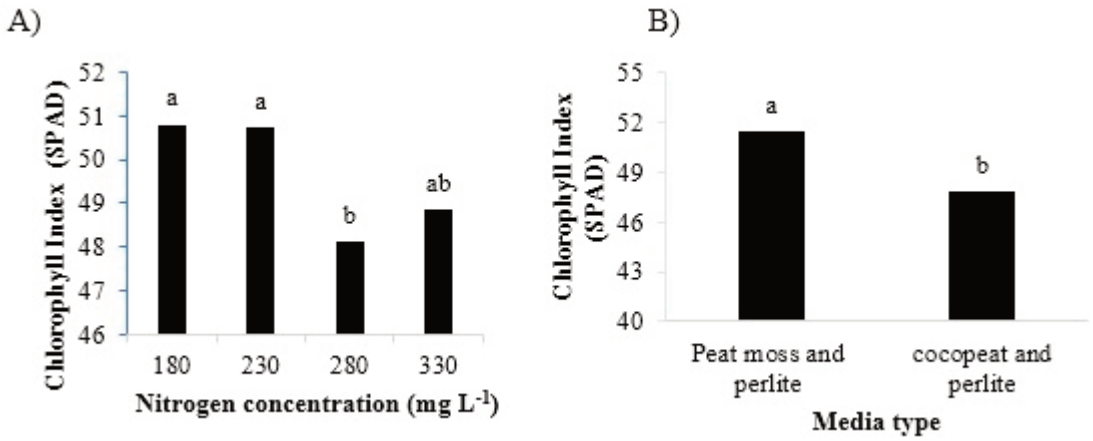


Fig.7. The effect of different nitrogen concentrations (A) and culture media (B) on chlorophyll index of poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.05 A and P<0.01 B) between the means based on Duncan's test.

**Chlorophyll a, b, and total**

According to the analysis of variance, chlorophyll *a* was significantly ($P < 0.05$) influenced by different concentrations of nitrogen and culture media (Table 3). Analysis of variance revealed that neither chlorophyll *b* nor total chlorophyll was affected by nitrogen concentrations and culture media (Table 3). Means comparison showed that the highest amount of chlorophyll *a* (3.054 mg $g^{-1}$ FW) was observed in poinsettia treated with 330 mg $L^{-1}$ nitrogen concentration in peat moss and perlite media. The lowest amount of chlorophyll *a* (1.944 mg $g^{-1}$ FW) was obtained from the application of 180 mg $L^{-1}$ nitrogen and cocopeat and perlite media (Fig. 8).

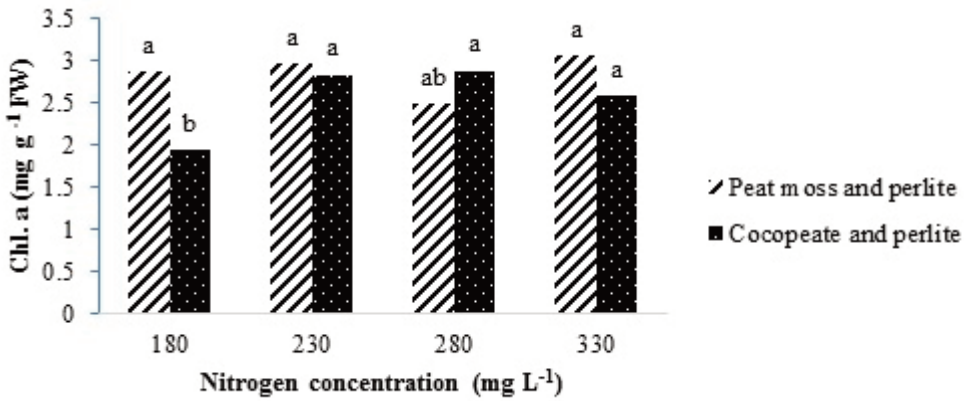


Fig. 8. The effect of different nitrogen concentrations and culture media on chlorophyll *a* in poinsettia 'Noel Red'. Non-similar letters indicate a significant difference ($P<0.05$) between the means based on Duncan's test.

Since oxygen is normally supplied by diffusion through the air in culture media, roots appear to have a lower respiration rate under low aeration in peat moss and perlite. Decreased respiratory rate results in increased internal cell acidity and abscisic acid content (Taiz and Zeiger, 2002). Due to the high sensitivity of poinsettia to ethylene (Dole and Wilkins, 2004), internal abscisic acid can reduce the activity of chlorophyllase II by inhibiting ethylene production (Taiz and Zeiger, 2002) and reducing metabolism activities, so delaying the breakdown process of chlorophyll molecules can be attributed to higher chlorophyll content (Khoshkhouy, 2015) in peat moss and perlite culture media. Peat moss and perlite substrate may also have an inhibitory effect on ACC oxidase activity and ethylene production in plant tissue by increasing cation exchange capacity and calcium uptake, which increases the chlorophyll content in this substrate (Torre *et al*., 1999).

Increasing chlorophyll content in cocopeat and perlite media can be associated with the improved conditions of rhizosphere aeration, good respiration, and sufficient energy to absorb nutrients such as nitrogen and magnesium that are involved in chlorophyll molecule structure and are essential for chlorophyll formation (Fascella, 2015). Excessive nitrogen in the nutrient solution is likely to reduce chlorophyll content by the accumulation of non-chlorophyll compounds (Barker and Pilbeam, 2015). On the other hand, low concentrations of nitrogen can reduce chlorophyll content in the long run. Our results support Argyropoulou *et al*.'s (2015) reports on the effect of nitrogen on chlorophyll content in basil (*Ocimum basilicum* L.) according to which chlorophyll content was affected by nitrogen concentration in nutritional solution. The results of Costa *et al*.'s (2015) research on nitrogen in grass showed that chlorophyll index had a nonlinear relationship with nitrogen nutrition status, which is in line with the results of the present study.

**Leaf carotenoid and bract anthocyanin**

Analysis of variance showed that carotenoid content was significantly influenced by the interaction of different nitrogen concentrations and culture media at P<0.01 (Table 3). Means comparison indicated that the highest amount of carotenoid (0.721 mg $g^{-1}$ FW) was observed at 330 mg $L^{-1}$ nitrogen concentration and cocopeat and perlite media. The lowest carotenoid content (0.205 mg $g^{-1}$ FW) was obtained from the application of 180 mg $L^{-1}$ nitrogen in cocopeat and perlite media (Fig. 9).

Anthocyanin content was significantly affected by different nitrogen concentrations and culture media (P<0.05) and their interaction (P<0.01) (Table 3). According to means comparison, the highest amount of anthocyanin (8.343 mg $g^{-1}$ FW) was detected in the plants treated with 330 mg $L^{-1}$ nitrogen and the lowest (4.494 mg $g^{-1}$ FW) in those treated with 180 mg $L^{-1}$ nitrogen in peat moss and perlite media (Fig. 10).

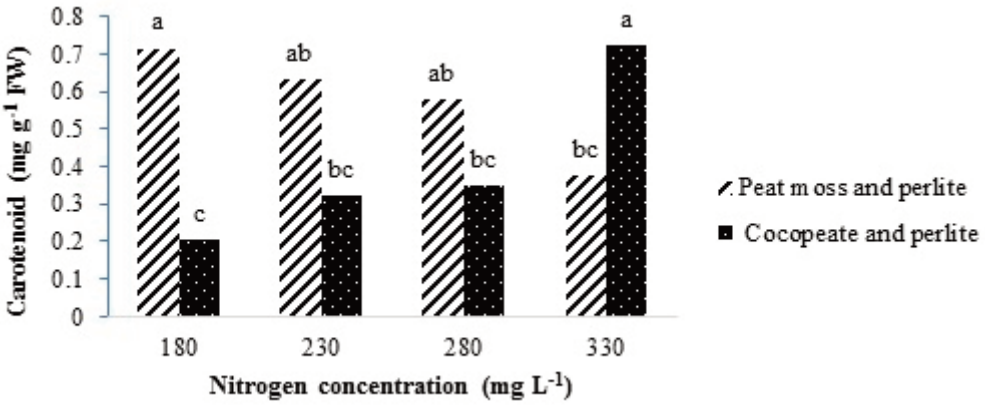


Fig. 9. The effect of different nitrogen concentrations and culture media on carotenoid content in poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.01) between the means based on Duncan's test.

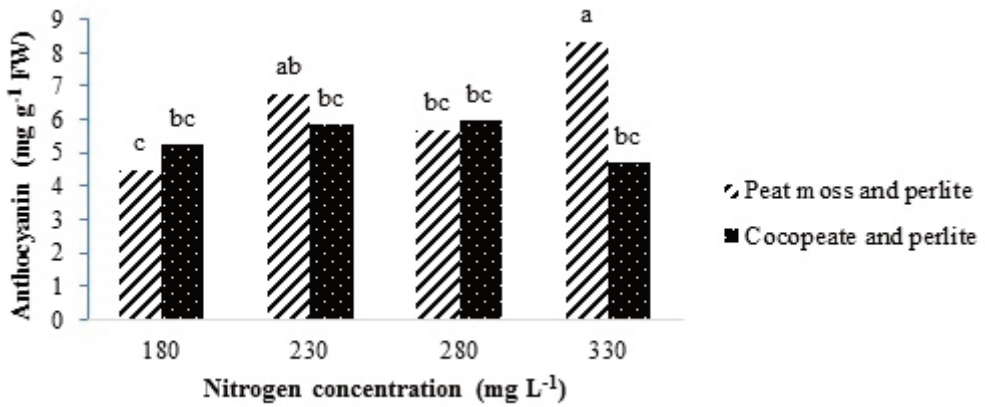


Fig 10. The effect of different nitrogen concentrations and culture media on anthocyanin in poinsettia 'Noel Red'. Non-similar letters indicate a significant difference (P<0.01) between the means based on Duncan's test.

In plants, anthocyanin production is influenced by internal and external factors such as the accumulation of sugars and carbohydrates, nutrient stress (especially nitrogen and phosphorus), plant hormones, water stress, low temperature, and light intensity (Tanaka *et al*., 2005). Increasing nitrogen concentration at nutrient solutions in the present study probably decreased the osmotic potential in the rhizosphere area and led to a decrease in transpiration, nitrogen uptake, photosynthesis, and the consumption of photosynthetic products (Taiz and Zeiger, 2002) in the growing leaves. In low nitrogen uptake or nitrogen deficiency conditions, carbohydrates cannot be used to produce amino acids or other nitrogenous compounds. Carbohydrates that are not used in nitrogen metabolism may be used in producing anthocyanin, which causes the accumulation of anthocyanin and the appearance of purple color in the leaves, petiole, and stems in some nitrogen-deficient plants (Taiz and Zeiger, 2002). This may be a reason for the increase in anthocyanin content of bracts at low concentrations of nitrogen in plant tissue. Peat moss and perlite culture media may have an increasing effect on the synthesis of phenols and anthocyanin due to its high cation exchange capacity and more absorption of some elements such as calcium (though influencing the genes of anthocyanin and phenylalanine ammonia-lyase synthesis pathway). The amount of available nitrogen in culture media may be limited by a number of environmental factors affecting nitrogen fixation, such as moisture status, pH, oxygen, and temperature (Khoshkhouy, 2015). Respiratory inhibitors and reduced aeration in the rhizosphere area of peat moss and perlite (Taiz and Zeiger, 2002) may be a possible reason for increasing carbohydrate accumulation and anthocyanin in bracts in this study.

**Leaf nitrogen**

The results in Table 3 show that the uptake of N element was significantly affected by different nitrogen concentrations ($P<0.01$), types of culture media, and their interaction ($P<0.05$). Means comparison revealed that the highest amount of nitrogen content (3.67 %) was observed in 230 mg $L^{-1}$ concentration of nitrogen and cocopeat and perlite media. The lowest nitrogen content (3.28 %) was obtained from the application of 330 mg $L^{-1}$ nitrogen concentration and peat moss and perlite media (Fig. 11).

Nutrient carrier activity is closely correlated with the concentration of elements in the root zone (Raviv and Lieth, 2008; Reddy and Ulaganathan, 2015). Nitrogen transporters are controlled by proteins and small RNAs in response to internal and external levels of nitrogen, carbon status,

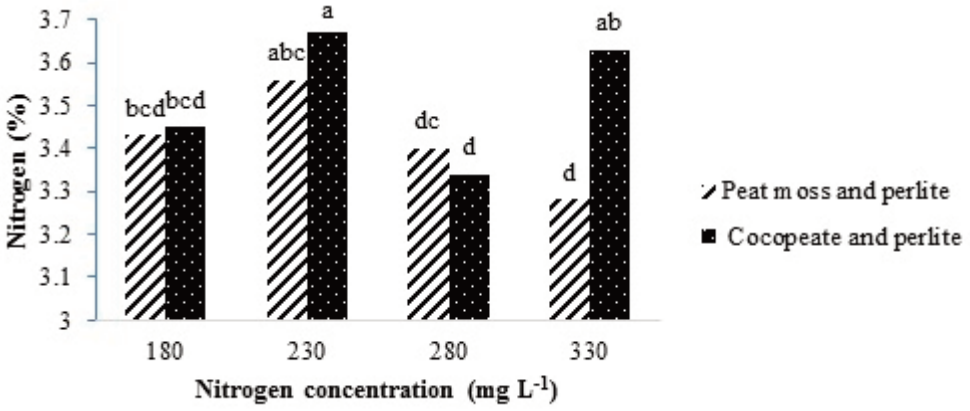


Fig.11. The effect of different nitrogen concentrations and culture media on nitrogen content in poinsettia 'Noel Red'. Non-similar letters indicate a significant difference ($P<0.05$) between the means based on Duncan's test.

and plant hormones. NLP$_7$protein, which is highly expressed at lateral roots, plays a role in the expression of genes involved in the activation of nitrogen uptake and the control of stomatal opening. Decreased expression or mutation in this type of protein leads to impaired nitrogen uptake and integration. Excessive nitrogen has a damaging effect on lateral root development due to the effects of phytohormones, such as abscisic acid, auxins, and ethylene (Reddy and Ulaganathan, 2015(. So, decreased levels of root contact with nutrients may be a reason for decreasing nitrogen uptake when higher concentrations of nitrogen are supplied. Peat moss and perlite, under oxygen-deficient conditions, may result in impairing nutrient uptake, such as nitrogen, due to the reduced ATP levels and proton pump activity (Mengel *et al*., 2001).

## CONCLUSION

Plant nutrition management is one of the most important aspects of ornamental plant production that influences plant quality. Suitable culture media should have some chemical and physical characteristics, such as high cation exchange capacity, good aeration, and water retention, accessibility, and low cost. Based on the results of the present study, 230 and 280 mg $L^{-1}$ nitrogen improved the plant height, canopy diameter, plant weight, and consequently the quality of poinsettia. Also, cocopeat increased nutrient uptake due to better root aeration, therey improving the growth characteristics of poinsettia. The comparison of poinsettia growth and development in peat moss and cocopeat-based media showed that the quality of poinsettia plants grown in low-cost cocopeat not only was competitive with those grown in high-cost peat moss, but there was also some other advantages with cocopeat.

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