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Effects of graded nitrogen levels on the growth and quality of *Cordyline fruticosa* L. *variety* 'Purple Compacta' in Batticaloa district of Sri Lanka

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Abstract

Cordyline is a popular foliage plant with high demand in the export markets as cut decorative foliage. Nitrogen has significant effects on vegetative growth and quality of foliage plants. A shade house (50%) experiment was conducted to determine the effects of graded nitrogen levels on vegetative growth and quality of cordyline (Cordyline fruticosa var. 'purple compacta') plants in the Crop Farm, Eastern University, Sri Lanka. The experiment was arranged in a completely randomized design with twenty replications. Five treatments were defined viz. 0.5(T1), 1.0 (T2), 1.5 (T3), 2.0 (T4) and 2.5 (T5) g nitrogen/plant/month (g/p/m). Recommended agronomic practices were followed uniformly for all treatments. Parameters viz. plant height, leaf area and plant biomass were measured at monthly interval and quality of cuttings was assessed at 3 months after transplanting. Analysis of Variance was performed to determine significant difference among treatments ($p < 0.05$). Results revealed that plants belong to T1 (nitrogen level 0.5g/p/m) showed significantly ($p < 0.05$) better performance in the measured growth parameters viz. plant height, leaf area and plant biomass while the lowest performance was observed in T5 at 3 MAT. In quality assessment, plants grown at T1 received significantly highest scores. It could be concluded that, nitrogen level of 0.5g/p/m (T1) is the suitable amount of nitrogen as growth and quality of plants was higher.

Keywords: *Biomass partitioning, Foliage plant, Leaf area, Plant biomass*

Introduction

Cordyline (*Cordyline fruticosa* var. 'purple compacta') is a popular foliage plant that belongs to family Asparagaceae. Cordyline is a popular pot plant (Kobayashi *et al.,* 2007). It is an evergreen foliage plant grown in houses or outdoors (Weerahewa and Somaratne, 2011). It has high demand in the export markets as cut decorative foliage (Weerahewa and Somaratne, 2011). The agro climatic diversity in Sri Lanka is very much beneficial and offers scope for the production of foliar ornamentals and cut flowers. However, commercial floriculture nurseries are mainly found in the central uplands and the lowlands in western and north-western regions (Weerakkody, 2004). Batticaloa is a prominent agricultural district in the central part of the Eastern province of Sri Lanka (Anon, 2004). Climatic requirements of cordyline are compatible to the prevailing climatic conditions in Batticaloa district and therefore this crop can be selected as a foreign income earner to this area. Popularity of cordyline is attributed to vigorous vegetative growth and leaf colour (quality of foliage) (Anderson, 1976). The major nutrient required for optimum growth of a plant is nitrogen. Nitrogen is essential for both leaf colour and variegation and the basic quality parameters in foliage plants (Jimenez and Lao, 2005). Nitrogen fertilizer rate and time of application also affect plant growth and development (Alley *et al.*, 1996). Therefore application of proper nitrogen level is important in nurseries where *C. fruticosa* plants are grown. Optimum shade level for the cultivation

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of cordyline (*Cordyline fruticosa* var. 'purple compacta') in Batticaloa district is 50% (Krishnakanth *et al*., 2017). However, optimum amount of nitrogen for cordyline (*Cordyline fruticosa* var. 'purple compacta') has not been recommended for Batticaloa district of Sri Lanka.

Hence objectives of this experiment were to evaluate the effects of graded nitrogen levels on vegetative growth and quality of cordyline (*Cordyline fruticosa* var. 'purple compacta') and to identify the optimum nitrogen level for the cultivation of cordyline (*Cordyline fruticosa* var. 'purple compacta') at 50% shade level in the Batticaloa district.

Materials and methods

A shade house experiment was conducted from July to November 2017 at the Crop Farm, Eastern University, Vantharumoolai, Batticaloa, located in the low country dry zone of Sri Lanka. Experiment was arranged in a completely randomized design (CRD). Graded levels of nitrogen were defined as treatments viz. 0.5 (T1- Control), 1.0 (T2), 1.5 (T3), 2.0 (T4) and 2.5 (T5) g of Nitrogen/Plant/Month. Each treatment contained 20 replications. An experimental unit consisted of one plant. Split application of nitrogen was practiced. Urea was used as a nitrogen source in this experiment. Plants were arranged at the spacing of 15cm × 15cm. Uniform sized (20cm), rooted and one month old, soft wood cuttings of cordyline (*Cordyline fruticosa* var. 'purple compacta') were used as planting material, propagated in Crop Farm, Eastern University, Batticaloa and treated with fungicide (Captan®) before propagation. Cuttings were planted into polybags (diameter and height of the bags were 4 and 6 inches respectively) filled with potting media containing compost and top soil in a ratio of 1: 1 (volume basis). Nitrogen fertilizer application was done according to a treatment structure. Potassium and Phosphorous was applied at the recommended and fixed rates (1.0g/plant/month and 0.5g/plant/month respectively) (Department of Agriculture, 2002).

All the crop management practices were followed uniformly for all treatments based on the recommendations of Department of National Botanic Gardens, Sri Lanka.

Plants were destructively sampled monthly in all treatments during the experiment. Plant height (cm), leaf area per plant (Portable leaf area meter, LICOR- 3000C, Lincolin, USA) (cm^2) and Total plant biomass (dry weight basis, g) were taken as measurements. Analysis of Variance was carried out using Statistical Analysis System (SAS) to determine significant differences among treatments ($p<0.05$). Treatment means were compared using Tukey's test at the 0.05 probability level. Scores obtained from the quality evaluation of plants were analysed through Mood's Median test at the 0.05 probability level.

Results and discussion

1. Plant height (cm)

Influence of different nitrogen levels on plant height was first apparent at one month after transplanting and this difference among treatments persisted throughout the experimental period.

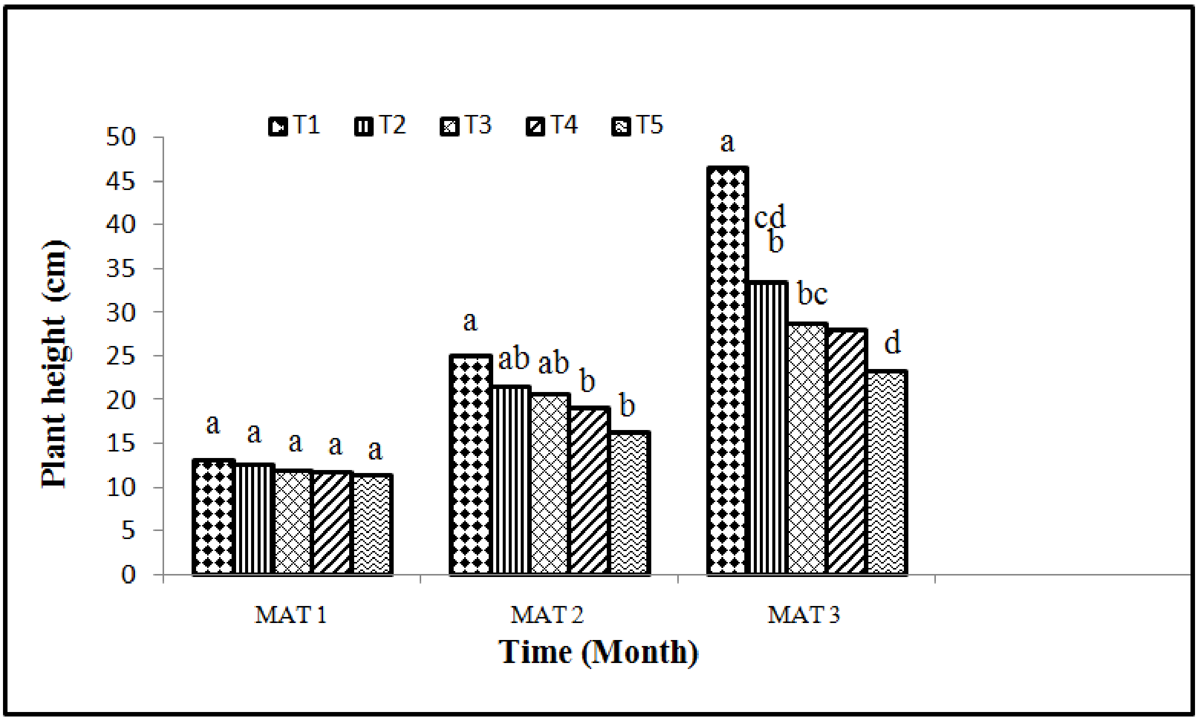

Fig.1. Effect of graded nitrogen levels on plant height of cordyline (*Cordyline fruticosa* var. 'purple compacta') at 1, 2 and 3 months after transplanting (MAT). Bars on the graph with the same letter are not significantly different according to the Tukey's test at 5% level of probability. (n=3).

Cordyline plants grown at nitrogen level 0.5 g/plant/month (g/p/m) showed maximum plant height (46.6cm) while lowest plant height (23.2cm) was recorded in T5 at 3 MAT. It was observed that, plant height of cordyline decreased with increasing level of nitrogen in this experiment.

Plants produced highest plant height at nitrogen level 0.5 g/p/m at 3 MAT. Nitrogen is the main component of chlorophyll and photosynthetic enzymes. Optimum concentration of nitrogen fertilizer can enhance nitrogen uptake. This increase has a positive effect on the chlorophyll concentration and photosynthetic rate. This would have caused an increased vegetative growth in plants.

Nitrogen is also a constituent of the proteins, nucleic acids and nucleotides that are essential to the metabolic function of a plant (Salisbury and Ross, 1992).

Chen *et al.* (2013) revealed that nitrogen increases the number and length of the internodes which results in progressive increase in plant height. These could be the reasons for highest plant height observed in 0.5g/p/m nitrogen level (T1) at 3 MAT.

Plants produced lowest plant height at nitrogen level 2.5 g/p/m at 3 MAT. At higher levels, nitrogen can be toxic and suppress plant height of cordyline plants. Further higher concentration of nitrogen could cause hormonal imbalance in plants which in turn suppress plant growth. Haynes *et al.* (1986) reported that excessive nitrogen reduced plant height by suppressing growth and development. Britto and Kronzucker (2002) also opined that nitrogen toxicity causes growth suppression in plants. These could be the reasons for the lowest plant height observed at 2.5g/p/m nitrogen level (T5) at 3 MAT.

2. Leaf area per plant (cm²)

It was found that there were significant ($p<0.05$) differences in the leaf area of cordyline plants under different nitrogen levels at 1,2 and 3 months after transplanting (MAT).

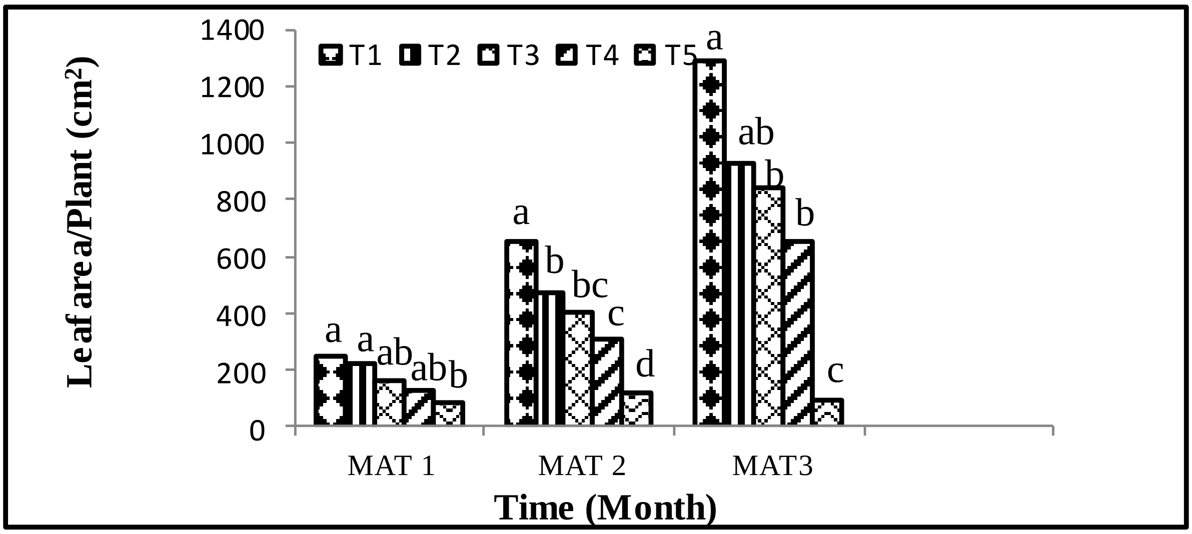

Fig.2. Effect of graded nitrogen levels on leaf area per plant of cordyline (*Cordyline fruticosa* var. 'purple compacta') at 1, 2 and 3 months after transplanting (MAT). Bars on the graph with the same letter are not significantly different according to the Tukey's test at 5% level of probability. (n=3).

Cordyline plants grown at nitrogen level 0.5g/plant/month (g/p/m) produced significantly ($p<0.05$) highest LA (1288.5cm²) among all the treatments, while lowest LA (95.5cm²) was recorded in T5 at 3 MAT. Plants belong to nitrogen level 0.5 g/p/m would have received optimum amount of nitrogen. Therefore they developed maximum LA than plants grown at other nitrogen levels in this experiment. Chapman and Barreto (1997) pointed out that nitrogen has a positive effect on the leaf expansion and total number of leaves. Leaf area is important for maximizing plant photosynthetic capacity as well (Wolk *et al*., 1983). Squire *et al*. (1987) stated that the main effect of nitrogen fertilizer was to increase the rate of leaf expansion leading to increasd interception of solar radiation by the canopy.

Boroujerdnia and Ansari (2007) pointed out that the application of nitrogen fertilizer stimulates vegetative growth by increasing number of leaves and leaf area. These might be the reasons for the highest LA observed at 0.5g/p/m nitrogen level (T1) at 3 MAT.

The plants grown at nitrogen level 2.5 g/p/m produced lowest LA at 3 MAT. Plants grown at this nitrogen level received sub optimum amount of nitrogen for their growth. High levels of nitrogen may have reduced the rate of leaf formation and development in cordyline. This may be due to the inhibitory effect of nitrogen at higher concentration. Ramachandra (1982) reported that in China aster (*Callistephus chinensis* L.) leaf area increased with increasing level of nitrogen up to 120kg/ha and reduced at the higher nitrogen levels. Duble (1996) also stated that leaf area of turf grasses is reduced by excess nitrogen in soil. Lowest LA was observed in 2.5g/p/m nitrogen level (T5) at 3 MAT due to these reasons.

It was found that LA of cordyline plants decreased with increasing level of nitrogen in this experiment. Zhang *et al*. (1993) stated that higher levels of $NO3^-$ inhibit root growth and leads to a decrease in plant growth. Under nitrogen deficiency, plants exhibit stunted growth and small leaves while excess nitrogen is also detrimental for plant growth (Wolf, 1999). Thus higher levels of nitrogen might be toxic for cordyline plants and it could have led to a reduction in leaf area.

3. Plant biomass (g)

It was found that there were significant ($p<0.05$) differences in the plant biomass of cordyline plants under different nitrogen levels at 1,2 and 3 months after transplanting (MAT).

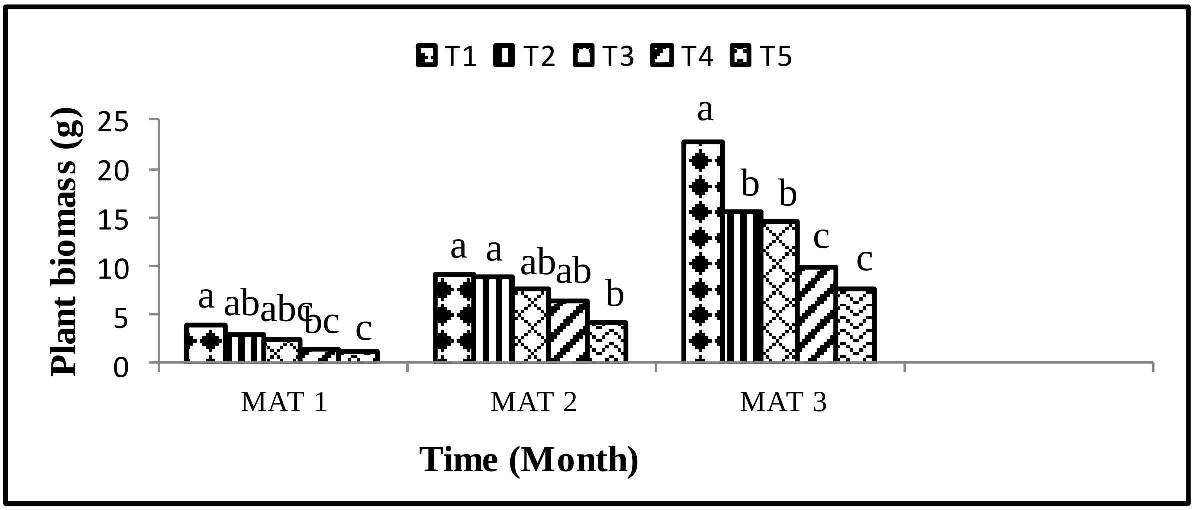

Fig. 3. Effect of graded nitrogen levels on plant biomass of cordyline (*C.fruticosa* var. 'purple compacta') at 1, 2 and 3 months after transplanting. Bars on the graph with the same letter are not significantly different according to the Tukey's test at 5% level of probability. (n=3).

Cordyline plants grown at nitrogen level 0.5g/plant/month (g/p/m) produced significantly ($p<0.05$) highest biomass (22.7g) among all the treatments, while the lowest biomass (7.6g) was recorded in T5 at 3 MAT. Cordyline plants grown at 0.5g/p/m nitrogen level produced highest biomass at 3 MAT; since plants grown at this nitrogen level would have received optimum level of nitrogen supply.

Optimum rate and time of N application can enhance yield productivity and nutrient use efficiencies (Fernandez *et al*., 2009; Nielsen, 2013). Therefore their growth rate and carbon assimilation were at highest level.

Leaf area of the plants was also higher at this nitrogen level. Increased leaf area can contribute for enhanced photosynthesis and subsequently plant biomass. Squire *et al*. (1987) stated that the main effect of nitrogen fertilizer was to increase the rate of leaf expansion leading to increased interception of solar radiation by the canopy and subsequently plant biomass. These might be the reasons for highest biomass produced by plants at nitrogen level 0.5 g/p/m at 3 MAT.

Cordyline plants grown in T5 produced significantly ($p<0.05$) lowest biomass than other treatments at 3 MAT. Nitrogen is an important component of amino acids, which are building blocks of hormones. Excess availability of nitrogen would have interfered with the carbon assimilation of plants. Also excess nitrogen reduces leaf growth, photosynthesis and total number of leaves per plant. This might be the reason for lowest biomass produced by the plants grown at this nitrogen level (2.5g/p/m).

It was noticed that biomass of cordyline plants decreased with increasing level of nitrogen in this experiment. Rincon *et al*. (1998) reported that increasing nitrogen up to 100 kg ha^{-1} increased the yield of lettuce, while the application of 150 and 200 kg ha^{-1} caused a decrease in the biomass. Niyokuri *et al*. (2013) also opined that in Zucchini (*Cucurbita pepo* cv.Diamant L.), maximum fresh edible yield was recorded for 120 kg Nha^{-1} while plants subjected to 80 and 160 kg Nha^{-1} produced significantly lower yield compared to the control.

The higher vegetative biomass results can be attributed to the role of nitrogen in creating the plant fresh and dry matter as well as many energy rich compounds which regulates photosynthesis and plant production (Wu *et al*., 1998).

According to Wei *et al*. (2009) excess nitrogen application causes osmotic stress, which can cause oxidative damage injuring to many important cellular components, such as lipids, protein, DNA and RNA leading to reduced growth and eventual yield of plants. These could be reasons for reduction in biomass of cordyline (*Cordyline fruticosa* var. 'purple compacta') with increasing level of nitrogen in this experiment.

4. Quality Evaluation of experimental plants

Quality of plants was significantly (Mood's Median test, p= 0.00) influenced by different nitrogen levels (Table 1) and was significantly (p=0.00) higher at 0.5g/plant/month (g/p/m) nitrogen level compared with other treatments at 3 months after transplanting (MAT).

Table 1. Quality evaluation of cordyline (*Cordyline fruticosa* var. 'purple compacta') at 3 months after transplanting.

Nitrogen level (g/plant/month)	Median
0.5	85.0
1.0	78.5
1.5	74.0
2.0	64.0
2.5	51.5
P value	**0.00**

Cordyline (*Cordyline fruticosa* var. 'purple compacta') has high demand in the export markets as a cut decorative foliage (Weerahewa and Somaratne, 2011). Noordegraaf (1992) stated that colour of leaves, leaf expansion, shoot elongation, numbers of leaves in a cutting are the main quality parameters of foliage plants. Morphology of leaves adds value to its quality in the export market (Gunadasa and Dissanayake, 2012). Nitrogen level greatly influences quality and appearance of foliage (Anon, 2015). Muchow (1998) opined that nitrogen fertilizer affects leaf area development and leaf area maintenance. Nitrogen application rate and fertilizer N source affect quality of plants (Zhang *et al.,* 1993). Therefore application of appropriate nitrogen level is necessary in nurseries where cordyline plants are being grown to obtain quality cuttings for export markets.

In quality evaluation, cordyline (*Cordyline fruticosa* var. 'purple compacta') plants grown at 0.5g/p/m nitrogen level (T1) obtained significantly highest score while significantly lowest score was received in T5 at 3 MAT.

Cordyline plants grown in T1 had virtuous confirmation and superior overall appearance than other treatments. They also showed fresh appearance, normal sized and shaped leaves, without indication of senescence, chlorosis and necrosis as well as insect pest damages and produced upright strong stems. This may be due to plants grown at this nitrogen level receiving optimum amount of nitrogen.Thus producing plants with improved quality and high commercial value suitable for the export market. Optimum nitrogen is essential for both, leaf colour and variegation that are considered basic quality parameters in foliage plants (Jimenez and Lao, 2005). These could be the reasons for highest score obtained by the plants belong to T1 (nitrogen level 0.5g/p/m)

Cordyline plants received lowest score at nitrogen level 2.5 g/p/m than other treatments at 3 MAT. Plants grown at this nitrogen level showed a relatively high amount of chlorotic and necrotic appearance. Plants also showed highest mechanical damages due to lack of configuration. Long-term exposure to excessive nitrogen fertilization generally results in more foliar chlorosis, stressful reaction, and eventually fatal damage leading to less quality products (Aerts, 1989). Herms (2002) stated that excessively fertilized plants may have increased susceptibility to diseases and insect attacks and excessive fertilization is a factor that contributes to outbreaks of many insect species.

These might be the reasons for lowest score obtained by the plants treated with T5 (nitrogen level 2.5g/p/m).

It was also noticed that the quality of cordyline plants decreased with increasing level of nitrogen in this experiment. It was found that higher N application causes a reduction in N use efficiency in corn (Ma and Biswas, 2016). Further nitrogen might be toxic for cordyline plants at higher levels and it could reduce the growth and quality of plants. Decreased quality of cordyline (*Cordyline fruticosa* var. 'purple compacta') with increasing level of nitrogen in this experiment was attained due to these reasons.

Conclusions

Cordyline plants grown at 0.5 g/plant/month (g/p/m) nitrogen level showed better performance among the other nitrogen levels tested here (1.0, 1.5, 2.0 and 2.5 g/plant/month) in growth parameters viz. plant height, leaf area per plant, plant biomass and leaf nitrogen content though lowest performance was recorded in T5 based on the regression graphs.

Further plants grown at 0.5 g/p/m nitrogen level received better score in quality assessment among the other treatments tested here. Vegetative growth and quality of cordyline plants (*Cordyline fruticosa* var. 'purple compacta') decreased with increasing level of nitrogen in this study. Thus, it could be concluded that 0.5g/p/m nitrogen level applied in split doses at monthly interval is optimum for growing cordyline (*Cordyline fruticosa* var. 'purple compacta') when compare to other nitrogen levels tested at 50% shade level in the Batticaloa district of Sri Lanka. A commercial scale evaluation is needed to recommend these findings to floricultural industries.

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