

SCIENTIFIC ARTICLE

Combined effects of NPK fertilizer with foliar application of benzyladenine or gibberellic acid on *Dracaena marginata* 'Bicolor' grown in different potting media

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Abstract

A pot experiments was carried out to evaluate the influence of growing media and combined treatments of NPK with either benzyladenine or gibberellic acid on growth, chemical constituents and anatomical structure of *Dracaena marginata* 'Bicolor'. The plants were grown in two growing media; peat-moss, peat-moss+ sand (1:1, v v⁻¹), received monthly NPK fertilizers (2 and 4 g pot⁻¹) combined with either of benzyl adenine (BA) at 100 and 150 ppm or gibberellic acid (GA₃) at 150 and 250 ppm, while the control plants received no treatments. As general, the results indicated that, peat- moss was superior to peat-moss+ sand medium on increasing most of vegetative growth parameters in terms of plant height, number of leaves/plant, leaf area, root length, as well as fresh and dry weights of leaves, stems and roots/plant, besides some macro elements represented in N, P, K, Ca and Mg% in both leaves and stems. While plants grown in peat-moss+ sand possessed significantly higher contents of total chlorophylls, total carbohydrates, Cu, Fe, Mn, Zn and B than those grown in peat- moss alone. Plants received combined NPK with either BA or GA₃ resulted in significant increases in most of morphological and chemicals content over the control plants and it was outstanding that, GA₃ was more effective than BA when they were combined with NPK. It can be concluded that for the highest quality, quantity growth and economic production of *Dracaena marginata* 'Bicolor', the plants could be grown in a medium of peat-moss and supplied monthly with NPK fertilizer at 2 g plant⁻¹ along with foliar sprayed with 250 ppm GA₃.

Keywords: foliage plant, hormones, mineral nutrition, peat moss, sand.

Resumo

Efeito combinado do fertilizante NPK com a aplicação foliar de benziladenina ou ácido giberélico em *Dracaena marginata* 'Bicolor' cultivada em diferentes substratos

Um experimento em vaso foi realizado para avaliar a influência do substrato e dos tratamentos combinados de NPK com benziladenina ou ácido giberélico no crescimento, constituintes químicos e estrutura anatômica de *Dracaena marginata* 'Bicolor'. As plantas foram cultivadas em dois meios de cultivo; turfa-musgo, turfa-musgo + areia (1:1, v v⁻¹), recebeu fertilizantes NPK mensais (2 e 4 g vaso⁻¹) combinados com benziladenina (BA) a 100 e 150 ppm ou ácido giberélico (GA₃) a 150 e 250 ppm, enquanto as plantas controle não receberam tratamentos. De modo geral, os resultados indicaram que turfa-musgo foi superior a turfa-musgo + areia média no aumento da maioria dos parâmetros de crescimento vegetativo em termos de altura da planta, número de folhas/planta, área foliar, comprimento da raiz, bem como fresco e seco pesos de folhas e caules e raízes/planta, além de alguns macroelementos representados em % de N, P, K, Ca e Mg nas folhas e caules. Enquanto as plantas cultivadas em turfa + areia possuíam conteúdos significativamente maiores de clorofilas totais, carboidratos totais, Cu, Fe, Mn, Zn e B do que aquelas cultivadas apenas em turfa. As plantas que receberam NPK combinado com BA ou GA₃ resultaram em aumentos significativos na maioria do conteúdo morfológico e químico sobre as plantas de controle e foi notável que GA₃ foi mais eficaz do que BA quando combinados com NPK. Pode-se concluir que para a mais alta qualidade, crescimento em quantidade e produção econômica de *Dracaena marginata* 'Bicolor', as plantas poderiam ser cultivadas em meio de turfa e abastecidas mensalmente com fertilizante NPK a 2 g planta⁻¹ junto com pulverização foliar de GA₃ a 250 ppm.

Palavras-chave: folhagem, hormônios, nutrição mineral, turfa, areia.

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Introduction

The genus *Dracaena* comprising about 40 species belongs to the family Ruscaceae, only six species are cultivated and used as foliage plants including *D. deremensis*, *D. fragrans*, *D. reflex*, *D. sanderiana*, *D. marginata* and *D. surculosa*. *Dracaena marginata* known as Madagascar dragon is evergreen ornamental shrub or small tree. It is growing to 3-5 m tall with a spread of 0.9-1.2 m. The leaves are slender, sword-shaped, slightly flexible having pleasant appearance (Huxley, 1992; Odenwald and Turner, 2006).

Growing media plays a vital role in plant growth and development of indoor potted plants. The physical and chemical properties of used media are the dominant factors affecting plant growth; hence these properties influence availability of nutrients and water for the plant growth and penetration of its roots in the soil. Peat moss is the most widely organic substrate used for the preparation of growing media for the potted ornamental plants. However, it is very expensive so that its replacement with cheaper available substrates is necessary (Shahid et al., 2017). Sand is generally the least expensive of inorganic amendments added to growing media for achieving and maintaining a structural system of macro pores that improve aeration and drainage. It was found that peat-moss alone increased the growth of different indoor plants (Mousa et al., 2015; Younis et al., 2016; Badran et al., 2017), while other studies demonstrated that peat + sand (2:1) medium increased the growth and chemical composition parameters of *Celosia argentea* (Abd el Gayed and Attia, 2018).

Fertilizers are essential for production of healthy potted ornamental plants. The NPK fertilization has a positive effect on the various biochemical processes that occur within the plant giving normal plant growth and development. Different NPK fertilization treatments have favorably influenced on growth of several foliage plants (El-Naggar and Ahmad, 2016; Abou Dahab et al., 2017; El-Sayed and Ismail, 2017; Mohamed, 2018).

Concerning Cytokinins are a large group of plant hormones which play a pivotal role as active molecules in many physiological processes of plant growth and development. Benzyl adenine (BA) had been newly used to maintain or increase the quality of different ornamental plants (Askari-Khorasgani and Mortazaeinezhad 2016; Matak et al., 2017). Moreover, its ability to increase number of chloroplasts, chlorophyll synthesis, bud differentiation and branching had been reported (Kochhar and Sukhbir, 2020). It was reported that its application induced vegetative growth, photosynthesis rate, soluble sugars,

indoles, soluble phenols and the contents of N, P and K in organs of croton plants (Ibrahim et al., 2010). The leaf area and fresh weight of leaves and stems had been recorded (Fuadi et al., 2014).

Gibberellins (GAs) can influence different biological processes and plant growth, i.e. from vegetative growth to flowering, and also stimulate aspects of flower development. In addition, gibberellins effect on other developmental responses such as dormancy, sex expression, leaf and fruit senescence, root and fruit growth and development of seeds in the fruit (Plackett and Wilson, 2016; Satish and Manju, 2018). The beneficial effect of GA₃ on different indoor plants had been reported by prior research who concluded that GA₃ induced flowering (Huang et al., 2015; Gad et al., 2016) promoted plant height, leaf area, number of leaves, stem diameter, fresh and dry weights, relative growth rate as well as increased the contents of total chlorophylls, total carbohydrates, and macronutrients (Mazher et al., 2014; Hananfy et al., 2019).

Furthermore, previous studies had been conducted in order to evaluate the interactive effect of BA with GA₃ (Henschke et al., 2015; Gabrel et al., 2018; Sardoei, 2018), NPK fertilizer with BA (Ngapui et al., 2018), NPK with GA₃ (El-Sayed et al., 2016) and NPK with potting media (Badran et al., 2017; Mohamed, 2018). However, there is lack of researches about the influence of potting media and NPK along with BA or GA₃ as growth regulators on the indoor plants and their anatomical structure.

Therefore, the main object of present study was to determine the effect of different growing media and combined NPK with either BA or GA₃ and their interaction effects on the growth, chemical constituents and anatomical structure of *Dracaena marginata* 'bicolor' plants.

Material and Methods

The experiment was carried out in the glasshouse at the nursery of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons of 2018 and 2019.

Seedlings of *Dracaena marginata* 'Bicolor' plants were obtained from the Ornamental Department, Agriculture Research Centre A.R.C, Ministry of Agriculture, Giza, Egypt. Uniform seedlings (20-25 height cm and having 10-15 leaves/ seedlings) were planted individually On 20th March 2018 and 2019, in 30 cm plastic pots filled media containing peat-moss or peat-moss+ sand (1:1: v v⁻¹) media. The chemical analysis of growing media was done at Soil, Water and Environment Research Institute, Agriculture Research Centre A.R.C according to (Jackson 1973), the results are presented in Table 1.

Table 1. The properties and constituents of growing media used for growing *Dracaena marginata* during 2018 and 2019 seasons.

Growing media	Organic matter [%]	EC [dS/m]	pH	WHC [%]	Macro nutrients [%]					Micro nutrients [ppm]			
					N	P	K	Mg	Ca	Fe	Mn	Zn	Cu
Peat moss	92	0.57	5.74	61.5	1.34	0.24	0.76	0.23	1.02	427	127	45.44	8.73
Peat +sand (1:1)	42.63	0.97	6.97	45.7	1.11	0.11	0.53	0.41	1.83	456	114	40.04	5.66

WHC: Water holding capacity

Starting from 20th April till 20th October, for both seasons, the plants grown in different soil media received monthly different treatments. A combination of NPK was added to soil in forms of (NPK, 20:20:20) at the rate of 2 and 4 g pot⁻¹ with foliar spray of either benzyladenine (BA) at the concentrations of (100, 150 ppm) or gibberellic acid (GA₃) at the concentrations of (150, 250 ppm) until dropping point. The control plants were sprayed only with tap water without fertilization.

The experimental design was factorial 2x9 in randomized complete block design with 18 treatments. The first factor is 2 growing media, peat-moss and peat-moss + sand (1:1 v/v). The second factor is 9 treatments of combined NPK with either BA or GA₃ concentrations including control (T1), 2 g NPK + BA at 100 ppm (T2), 2 g NPK + BA at 150 ppm (T3), 4 g NPK + BA at 100 ppm (T4), 4 g NPK + BA at 150 ppm (T5), 2 g NPK + GA₃ at 150 ppm (T6), 2 g NPK + GA₃ at 250 ppm (T7), 4 g NPK + GA₃ 150 ppm (T8), 4 NPK + GA₃ at 250 ppm (T9). Each treatment consisting of 6 pots arranged in 3 blocks (replicates), each replicate including 36 plants (2 plants from each treatment).

On 20th November for both seasons, the experiment was terminated and the vegetative growth traits were registered, including: plant height (cm), number of leaves/plant, stem diameter (mm), leaf area (cm²), root length (cm), fresh and dry weights of leaves, stems and roots/plant. The chemical constituents were determined including: total chlorophylls (SPAD) in fresh leaf samples (Netto et al., 2005), total carbohydrates (%) in dried leaves and stems samples (Dubois et al., 1956). Another dried leaves and stems samples were digested for nutrients determination. The concentration of N (Horneck and Miller, 1998), P (Jackson, 1973), K (Horneck and Hanson, 1998), Ca and Mg (Estefan et al., 2013) and the contents of Cu, Fe, Mn and Zn (Chapman and Pratt 1961), beside B (Gupta, 1998) were determined.

Anatomical studies

At the end of vegetative growth, specimens of the leaves were taken and tissue specimens dissected to the size of the sample, and transferred to FAA solution at room

temperature for 20 hours. After fixation, they were washed in 50% ethanol then dehydration was completed by transferring the sample to 100% butyl alcohol (changes, for one day each). Dehydrated sample were immersed into a 1:1 solution of 100% ethanol: xylene for 1 hour, then transferred into xylene for storage until infiltration with molten Paraplast in a 55-60°C oven. The tissues were placed into wax 58 °C and placed into embedding molds in 7x7x5 mm disposable base molds (SLEE MAINS type MPS/P, Germany). The wax blocks containing the embedded tissue were sectioned using a rotary microtome (Leica RM 2125) with heavy duty high profile disposable microtome blades. (Ellis, 1976; Aiken et al., 1984). Images were acquired with a camera Leica ICC50 HD digital camera attached to a Leica motorized light microscope system. Averages of readings from 4 slides / treatment were calculated.

All previous data were subjected to analysis of variance (ANOVA). The effects of growing media (G), combined treatments of NPK with either BA or GA₃ concentrations (T), and their interactions was analyzed by two-ways randomized block ANOVA. The Least Significant Difference (L.S.D.) test at the 5% level was used to compare the means values of different parameters (Steel and Torrie, 1997).

Results and Discussion

Vegetative growth parameters

Effect of growing media

The results of the two growing seasons (Tables 2- 4) showed that, in most cases, the plants grown in peat-moss had significantly higher values for most vegetative growth parameters of *Dracaena marginata* 'Bicolor' as compared with that grown in peat moss + sand. The only exception to this general trend was recorded with stem diameter which recorded higher increment with plants grown in peat moss + sand than those grown in peat moss alone. The results of superior peat moss alone as a growing medium in boosting the vegetative traits are in harmony with those reported on indoor plants by previous studies (Mousa et al., 2015; Younis et al., 2016; Badran et al., 2017).

Table 2. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on plant height, number of leaves, stem diameter, leaf area and root length of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season														
	Growing media (G)														
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	Plant height [cm]			Number of leaves /plant			Stem diameter [mm]			Leaf area[cm ²]			Root length [cm]		
T1 (Control)	43.39 e-gA	39.41gA	41.40	39.33 iA	39.10 iA	39.22	1.08	1.21	1.15 a	53.53 gA	50.67 gA	52.10	52.13 hA	43.86 iB	48.00
T2	50.87 b-dA	43.49 e-gB	47.18	48.80 d-gA	49.20 d-fA	49.00	1.16	1.21	1.19 a	75.45efA	68.42 fA	71.94	60.70 d-fA	57.13 fgA	58.92
T3	54.71 abA	51.25 b-dA	52.98	51.13 cdA	53.06 bcA	52.10	1.22	1.27	1.25a	82.45deA	74.23 fB	78.34	59.70 efA	61.46 d-fA	60.58
T4	49.62 d-gA	42.49 fgA	46.06	45.67 hA	46.06 ghA	45.87	1.21	1.30	1.26 a	70.47fA	71.53 fA	71.00	69.63 abA	65.43 b-dA	67.53
T5	50.01 b-eA	47.09 c-fA	48.55	47.17 f-hA	49.73 d-fA	48.45	1.28	1.44	1.36 a	73.82fA	75.33 fA	74.58	66.33 bcA	58.60 efB	62.47
T6	53.89 bcA	51.28 b-dA	52.59	48.43 d-hA	49.93 d-fA	49.18	1.32	1.43	1.38 a	93.61bcA	87.20 cdA	90.41	63.20 c-eA	61.93 c-fA	62.57
T7	60.62 aA	50.78 b-dB	55.70	57.10 aA	53.97 bB	55.54	1.30	1.50	1.40 a	106.01aA	95.87 bB	100.94	72.16 aA	69.36 abA	70.76
T8	48.83 b-fA	51.60 b-dA	50.22	53.40 bcA	43.60 e-hB	48.50	1.46	1.54	1.50 a	90.31bcA	90.23 bcA	90.27	68.53 abA	53.86 ghB	61.20
T9	48.56 b-fA	48.95 b-fA	48.76	50.30 deA	49.20 d-fA	49.75	1.32	1.51	1.42 a	94.14bcA	94.64 bcA	94.39	69.43 abA	52.46 hB	60.95
Mean (G)	51.17	47.37	----	49.04	48.21	----	1.26 B	1.38 A	----	82.20	78.68	----	64.65	58.23	----
L.S.D. (0.05)²															
G	Sig.			N.S			Sig.			Sig.			Sig.		
T	4.31			1.84			1.62			5.02			3.03		
G X T	6.09			2.60			2.29			7.09			4.28		
	2 nd season														
T1 (Control)	44.99 jA	40.69 kB	42.84	41.20 iA	39.37 iA	40.29	1.11	1.19	1.15 a	58.59iB	54.12 iB	56.36	49.80 jA	41.76 kB	45.78
T2	47.63 ijB	52.68 d-fA	50.16	51.86 d-fA	46.67 hB	49.27	1.09	1.16	1.13 a	81.75ghA	75.24 hA	78.50	62.63 fgA	54.86 iB	58.75
T3	55.28 ceA	53.98 dfA	54.63	54.87 a-cA	52.40 c-fB	53.64	1.19	1.29	1.24 a	90.65efA	85.81fgA	88.23	65.66 deA	62.86 fgA	64.26
T4	48.68 hiA	46.65 ijA	47.67	51.33 efA	45.37 fgB	48.35	1.24	1.52	1.38 a	82.05ghA	77.14 hA	79.60	70.93 abA	63.83 e-gB	67.38
T5	51.33 f-hA	49.28 g-iA	50.31	54.03 b-dA	52.36 c-fA	53.20	1.31	1.87	1.59 a	82.07ghA	75.73 hA	78.90	68.93 bcA	55.30 iB	62.12
T6	58.04 a-cA	56.02 b-dA	57.03	56.83 aB	54.13 b-dA	55.48	1.37	1.46	1.42 a	98.86 b-dA	97.10 c-eA	97.98	66.60 cdA	58.66 hB	62.63
T7	60.54 aA	58.83 abA	59.69	56.83 aA	56.73 aA	56.78	1.45	1.34	1.40 a	107.08aA	100.17a-cA	103.63	72.60 aA	65.13 d-fB	68.87
T8	53.55 d-fA	52.61 d-fA	53.08	55.67 abA	52.43 c-fB	54.05	1.42	1.89	1.66 a	91.67d-fA	90.93d-fA	91.30	69.33 bA	58.20 hB	63.77
T9	53.07 d-fA	52.37 e-gA	52.72	53.56 b-eA	48.60 ghB	51.08	1.45	1.38	1.42 a	106.40 abA	97.22c-eB	101.81	70.90 abA	61.86 gB	66.38
Mean (G)	52.57	51.46	----	52.91	49.78	----	1.29 A	1.46 B	----	88.79	83.72	----	66.38	58.05	----
L.S.D. (0.05)²															
G	N.S			Sig.			Sig.			Sig.			Sig.		
T	2.13			1.56			2.73			5.15			1.66		
G X T	3.01			2.21			3.87			7.28			2.35		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5= 4 g NPK + BA (150 ppm), T6= 2 g NPK + GA₃ (150 ppm), T7= 2 g NPK + GA₃ (250 ppm), T8= 4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm), ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

Table 3. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on fresh and dry weights of leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season											
	Growing media (G)											
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	F.W of leaves			D.W of leaves			F.W of stems			D.W of stems		
T1 (Control)	41.94 fA	39.46 fA	40.70	9.42 eA	9.91eA	9.67	34.75 ijA	31.88 jA	33.32	12.28 c-eA	9.88 eB	11.08
T2	51.41 deA	51.39 deA	51.40	12.02 deA	14.33 a-dA	13.18	37.67 f-iA	37.35g-iA	37.51	14.44 bcA	12.56cdA	13.50
T3	56.82 c-eA	52.79c-eA	54.81	15.69 a-cA	14.98a-dA	15.34	50.43 abA	46.01 cdB	48.22	15.64 abA	13.49 b-dA	14.57
T4	52.56 c-eA	50.14 eA	51.35	15.09 a-dA	11.15 c-eB	13.12	38.81 hiA	32.20 jB	35.51	12.76 cdA	12.63 cdA	12.70
T5	60.15 b-dA	50.14 eB	55.15	17.47 aA	13.15 abB	15.31	40.83 efA	38.48 f-hA	39.66	13.82 b-dA	12.63 cdA	13.23
T6	51.94 c-eA	59.40 b-eA	55.67	12.62 c-eB	16.37 b-dA	14.50	47.42 bcA	40.83 efB	44.13	14.58 bcA	13.80 b-dA	14.19
T7	72.08 aA	54.66 c-eB	63.37	17.69 aA	15.97a-cA	16.83	52.50 aA	50.16 abA	51.33	17.38 aA	14.84 bcB	16.11
T8	56.38 abA	52.58 c-eA	54.48	16.61abA	10.32 c-eB	13.47	40.22 e-gA	38.46 f-hA	39.34	13.81 b-dA	13.08 b-dA	13.45
T9	60.47 bcA	56.24 c-eA	58.36	15.95a-cA	15.32a-dA	15.64	43.40 deA	36.09 hiB	39.75	13.38 b-dA	12.78 cdA	13.08
Mean (G)	55.97	51.87	----	14.73	13.50	----	42.89	39.05	----	14.23	12.85	----
L.S.D. (0.05)²												
G	N.S			N.S			Sig.			Sig.		
T	5.35			2.13			2.10			1.57		
G X T	7.57			3.02			2.96			2.23		
	2 nd season											
T1 (Control)	43.82 hA	43.70 hA	43.76	10.91 gA	11.65 fgA	11.28	38.96 f-hA	31.80 iB	35.38	13.84 a-dA	11.12dA	12.48
T2	51.20 gA	52.45 fgA	51.83	13.92 d-fA	14.86 c-eA	14.39	35.45 hB	42.25 d-gA	38.85	14.31 a-dA	15.51abA	14.91
T3	58.33 b-fA	60.33 b-eA	59.33	16.67 b-dA	16.95 bcA	16.81	52.19 abA	46.71 cB	49.45	16.24 abA	13.79 a-dA	15.02
T4	56.13c-gA	46.49 hB	51.31	16.39 b-eA	14.01 c-eA	15.20	42.90 c-fA	33.68 ghB	38.29	15.34 abA	13.97 a-dA	14.66
T5	59.56b-fA	52.05 d-gB	55.81	16.15 b-eA	17.14 bcA	16.65	45.06 cdA	40.91 e-gB	42.99	15.00 a-cA	14.49 a-cA	14.75
T6	54.40e-gA	60.47 b-eA	57.44	16.85 b-dA	14.73 c-eA	15.79	46.42 cB	50.63 bA	48.53	14.99 a-cA	14.91 a-cA	14.95
T7	69.35 aA	65.39 abA	67.37	20.32 aA	18.38 abA	19.35	54.99 aA	44.78 c-eB	49.89	17.60 aA	14.64 a-cA	16.12
T8	60.76a-cA	50.63 d-gB	55.70	16.35 b-dA	14.75 c-eA	15.55	42.60 c-gA	44.17 c-fA	43.39	13.65 b-dA	15.41 abA	14.53
T9	62.50 b-dA	59.24 b-fA	60.87	18.73 abA	13.51 e-gB	16.12	44.66 c-eA	43.88 c-eA	44.27	15.28 abA	13.97b-dA	14.63
Mean (G)	57.34	54.53	----	16.25	15.11	----	44.80	42.09	----	15.14	14.20	----
L.S.D. (0.05)[*]												
G	N.S			N.S			N.S			N.S		
T	4.39			1.81			2.52			2.04		
G X T	6.21			2.56			3.56			2.88		

^{*}T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8=4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm), ² G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

Table 4. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on fresh and dry weights of roots of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season					
	Growing media (G)					
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	F.W of roots			D.W of roots		
T1 (Control)	39.18 jA	32.90 kB	36.04	14.32 d-gA	11.94 gA	13.13
T2	48.96 e-gA	43.00 iB	45.98	14.20 d-gA	15.70 c-fA	14.95
T3	50.65 c-eA	44.49 hiB	47.57	18.32 bcA	14.53 d-gA	16.43
T4	50.12 c-eA	40.98 jB	45.55	19.06 abA	17.32 b-dA	18.19
T5	46.69 ghA	44.70 hiA	45.70	14.08 d-gB	19.01 abA	16.55
T6	51.62 c-eA	47.08 f-hB	49.35	16.06 b-eA	14.29 d-gA	15.18
T7	58.76 aA	54.73 abB	56.75	21.55 aA	17.28 b-dB	19.42
T8	52.67 cdA	45.52 hiB	49.10	16.27 b-eA	13.97 e-gA	15.12
T9	53.42 bcA	44.30 hiB	48.86	16.23 b-eA	13.93 e-fA	15.08
Mean (G)	50.23	44.19	----	16.68	15.33	----
L.S.D. (0.05)²						
G	Sig.			N.S		
T	2.01			1.97		
G X T	2.84			2.78		
	2 nd season					
T1 (Control)	32.61 kA	31.72 kA	32.17	11.29 gA	10.40 gA	10.85
T2	50.23 fgA	46.44 hiB	48.34	15.46 efA	17.60 b-fA	16.53
T3	52.48 deA	45.99 hiB	49.24	16.87 c-fA	15.76 d-fA	16.32
T4	55.16 cA	40.32 hB	47.74	17.80 b-fA	20.14 a-cA	18.97
T5	54.27 cA	42.72 jB	48.50	19.55 a-cA	20.46 a-cA	20.01
T6	55.55 cA	48.38 ghB	51.97	19.46 a-dA	18.94 a-eA	19.20
T7	61.80 aA	51.32 efB	56.56	21.97 aA	20.97 abA	21.47
T8	53.53 c-cA	46.52 hiB	50.03	19.55 a-cA	18.19 b-fA	18.87
T9	58.80 bA	46.77 hB	52.79	21.67 abA	14.92 fB	18.30
Mean (G)	52.71	44.46	----	18.18	17.49	----
L.S.D. (0.05)[*]						
G	Sig.			Sig.		
T	1.51			2.28		
G X T	2.13			3.22		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8=4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm), ² G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

The favorable effect of peat- moss medium on enhancing vegetative growth may be attributed to its properties such as low pH and EC values in addition to its high water-holding capacity as indicated in (Table 1), this may be associated with water supply in sufficient quantities for turgidity and various positive metabolism including cells enlargement which in turn lead to stimulation of stem elongation (Fascella, 2015; Badran et al., 2017).

Effect of NPK with plant growth regulators treatments

Data in Tables (2-4) indicated that, the combined treatment of NPK with either BA or GA₃ concentrations resulted in significant increases in most of the vegetative growth parameters in terms of plant height, number of leaves/plant, leaf area, root length, fresh and dry weights of leaves, stems and roots as compared to the untreated plants. In spite of this, it was notable that, the only parameter which insignificantly affected by integrated NPK rates with BA or GA₃ was stem diameter as compared to each other and control plants. Also, it was detected that, GA₃ was more effective than BA when they were combined with NPK at the same rates. These results are in agreement with the finding of the previous study on croton plants (Ibrahim et al., 2010) who reported that GA₃ treatments were more effective than BA on increasing plant height, leaf area, fresh and dry weights of stems, leaves and roots of croton plants.

Concerning the application NPK combined with the same concentrations of plant growth regulators (BA or GA₃), it was found that the lowest rate of NPK was more effective than the highest one; this may be due to plant sensitivity against salt toxicity resulting from excessive fertilization rates. In both seasons, the highest values for most vegetative parameters were obtained from the plants treated with the combination of NPK at 2 g pot⁻¹ with GA₃ at 250 ppm, while the lowest values were resulted from the control plants. Similar increases in the vegetative growth parameters due to application of NPK in combination with GA₃ had been authenticated by previous research (El-Sayed et al., 2016). Also, increases in growth parameters of *Dendrobium densiflorum* plants as a result of combined NPK with BA have been reported by prior study (Ngapui et al., 2018).

The above-mentioned results showed the important role of N, P and K as well as BA and GA₃ in the different physiological processes within the plant, which in turn affect the plant growth. Nitrogen is an important macro-element in organic molecules in plants including proteins, nucleic acids, purines, pyrimidines, co-enzymes (vitamins), and production of chlorophyll. Phosphorus is a component

of sugar phosphates, nucleic acids, nucleotides, co-enzymes, phospholipids, however potassium is essential in activation of enzymes and co-enzymes, proteins formation, photosynthesis, sugar transport, the uptake of other nutrients and their movement within the plant. The stimulated effect of BA may be due to its role in increasing cell division and enlargement, branches formation and overcoming the apical dominance leading to increase plant growth. The favorable effect of GA₃ on the plant growth may be attributed to its effect on stimulating the expression of enzymes involved in cell wall loosening and genes controlling cell division and also stimulating microtubule rearrangements associated with cell expansion (Satish and Manju, 2018). It was stated that the increase of plant growth by BA mainly associated with higher net assimilation rates and increased N content per unit leaf area (Di Benedetto and Galmarini, 2015), while increasing plant growth due to GA₃ may be attributed to its influence on increasing photosynthesis rate through increasing leaf surface (Lima et al., 2014). Moreover, increasing plant growth as a result of combined growth hormones with nutrient may be owing to physiological role of hormones and nutrient in synthesis of the plant phytochemicals through the action of various enzymes activity and protein synthesis (Tandel et al., 2018).

Effect of the interaction between growing media and NPK combined with plant growth regulators treatments

Data presented in Tables (2-4) revealed that generally, the plants grown in peat- moss or peat-moss + sand and received different NPK combined with BA and GA₃ treatments were significantly higher than those of the control plants. In both seasons, in most cases, the highest values recorded for most of the vegetative characteristics were obtained from plants grown in peat moss medium and received of 2 g NPK + GA₃ at 250 ppm as compared with the control which giving lowest values.

Chemical constituents

Total chlorophylls and total carbohydrates contents

From the data Table (5) it's possibly discerned that, in both seasons, total chlorophyll in the leaves and total carbohydrates in the leaves and stems of *Dracaena marginata* 'Bicolor' were significantly higher in the plants grown in peat-moss+ sand medium than those grown in peat-moss alone. These findings are in accordance with the results obtained by previous studies which showed that a mixture peat-moss with sand increased chlorophyll content (EL-Quasni et al., 2014; Abd el Gayed and Attia, 2018).

Table 5: Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on total chlorophylls, total carbohydrates in leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season								
	Growing media (G)								
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	Total chlorophylls (SPAD) in leaves			Total carbohydrates (%) in leaves			Total carbohydrates (%) in stems		
T1 (Control)	54.50 iB	63.10 ghA	58.80	35.11 LA	33.18 mB	34.15	29.25 hA	27.93 hA	28.59
T2	60.33 hB	64.30 gA	62.32	37.97jkA	36.91 lA	37.44	33.27 gA	31.21 gB	32.24
T3	72.43 b-dB	75.96 abA	74.20	39.35ijA	38.25 jkA	38.80	36.11 efA	32.19 gB	34.15
T4	68.10 efB	73.00 b-dA	70.55	37.21kB	40.21hiA	38.71	35.12 fB	36.52 d-fA	35.82
T5	67.10 efA	69.53 deA	68.32	41.65ghB	44.60 eA	43.13	37.29 c-eB	38.22 cA	37.75
T6	64.53 efB	68.13 efA	66.33	40.95 hiB	42.85 fgA	41.90	35.25 fA	36.55 d-fA	35.90
T7	69.40 deB	78.10 aA	73.75	39.96 hiB	43.96 efA	41.96	37.76 cdB	39.86 bA	38.81
T8	70.76 c-eB	74.40 bcA	72.58	48.37cA	46.31 dB	47.34	39.88 bA	40.18 bA	40.03
T9	72.00 cdB	71.73 c-eA	71.87	55.82 bB	58.61 aA	57.22	40.21 bB	43.11 aA	41.66
Mean (G)	66.57	70.92	----	41.82	42.76	----	36.02	36.20	----
L.S.D. (0.05)²									
G	Sig.			Sig.			Sig.		
T	2.40			1.14			0.99		
G X T	3.39			1.61			1.40		
2 nd season									
T1 (Control)	59.30 hA	62.93 ghA	61.12	32.16 lmA	31.63 k-mA	31.90	26.40 lB	29.11 kA	27.76
T2	65.43 fgA	65.90 e-gA	65.67	34.87jkA	34.52 jkA	34.70	31.52 jB	34.17 hiA	32.85
T3	70.40 b-eB	78.06 aA	74.23	33.21 klB	39.75 fA	36.48	33.44 hiA	32.74 ijA	33.09
T4	70.66 b-dA	73.93 abA	72.30	36.17 ijA	37.11 hiA	36.64	36.31 deA	32.91 iB	34.61
T5	71.46 b-dA	72.40 b-dA	71.93	37.54 g-iB	39.56 fA	38.55	34.49 f-hA	33.82 g-iA	34.16
T6	67.73 d-fA	71.90 b-dA	69.82	41.77 deA	39.27 fgB	40.52	37.90 bcA	34.59 f-hB	36.25
T7	70.93 b-dB	78.30 aA	74.62	42.94 dA	38.42 f-hB	40.68	37.11 cdA	36.96 cdA	37.04
T8	68.86 c-fB	74.96 abA	71.91	40.28 efB	46.86 cA	43.57	35.23 e-gB	38.59 bA	36.91
T9	72.53 b-dA	73.13 bcA	72.83	48.88 bB	53.57 aA	51.23	35.39 efB	39.95 aA	37.67
Mean (G)	68.59	72.39	----	38.65	40.08	----	34.20	34.76	----
L.S.D. (0.05)³									
G	Sig.			Sig.			Sig.		
T	2.99			1.27			0.93		
G X T	4.23			1.79			1.32		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8=4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm), ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

The data in the data Table (5) also showed that application of the combined NPK with either BA or GA₃ significantly increased total chlorophyll content in the leaves and total carbohydrates in leaves and stems as compared to the untreated plants. Similar results on increasing the contents of chlorophylls or carbohydrates due to application the combined NPK with GA₃ were reported by previous study (El-Sayed et al., 2016; Ghata, 2016). Earlier studies (Tandel et al., 2018) reported increase in carbohydrates content due to combined urea with BA.

In both seasons, the lowest values of total chlorophyll content were obtained from plants grown in peat-moss medium without additional treatments, while the highest values were obtained from the plants grown in peat-moss + sand and received 2 g NPK + GA₃ at 250 ppm. In both seasons, the highest values of total carbohydrates were recorded in the plants grown in peat moss + sand and received 4 g NPK + GA₃ at 250 ppm, whereas the lowest values were determined in the plants grown in peat-moss + sand without treatments.

Nutrients content:

Macro elements

The chemical analysis of the leaves and stems (Tables 6 and 7) demonstrated that, generally, the uptake and accumulation of macro elements represented in N, P, K, Ca and Mg% were significantly higher in peat moss-grown plants than those grown in peat-moss + sand. However, in the first season there were no significant differences between the two tested growing media concerning the values of P and Mg% in stems and K% in the leaves.

The obtained results of increased N, P or K% in plants grown in peat moss alone compared to other media are similar to those found by prior research (Mousa et al., 2015). The obtained results of increased the accumulation of macro elements in peat moss-grown plants could be explained on the basis of high content of organic matter in peat moss maybe increase the activity of the beneficial microorganisms that play vital role in soil aeration and availability of the elements in rhizosphere to be absorbed

by the plant roots. Moreover, its proper pH and EC values, high water-holding capacity may be had favorable effect in availability of nutrients and its accumulation in plant organs (Abdul-Hafeez et al., 2015; Pascual et al., 2018).

As for the effect of NPK in combination with BA and GA₃, the data in Tables (6 and 7) pointed out that, application of the combined treatments resulted in significant increases in N, P, K, Ca and Mg% in the leaves and stems compared to the control plants. However, in the first season plants treated with the combined treatments of 2 g NPK + BA at 100 or 150 ppm (T1 and T2) had insignificantly higher values of P% in the stems than the control plants. The data also showed that, in most cases, the values of macro nutrients were increased steadily with increasing application rate of NPK and BA or GA₃ concentration compared the control plants. Furthermore, the combined NPK with GA₃ appeared to be more effective than combined with BA at the high concentration (250 ppm). These results of increased N, P or K% as a result of accompanied NPK with GA₃ treatments are in agreement with those obtained by prior research (El-Sayed et al., 2016; Ghata, 2016), while increased N, P or K% due to the combined NPK with BA treatments are in harmony with prior study (Barman and Naik, 2017).

Regarding the interaction effect, data in Tables (6 and 7) showed that, plants grown in peat moss only or peat moss + sand and received different combined treatments of NPK with either BA or GA₃ resulted in significant increment of mineral nutrients percentage than those resulted from control plants. The data also revealed that, under both growing media GA₃ was more effective than BA when combined with NPK at the same rate.

Micro elements

The data in in Tables (8 and 9) showed that in most cases, the values of micro elements represented in Cu, Fe, Mn, Zn and B in the leaves and stems of plants grown in peat-moss + sand were higher than those of the plants grown in peat-moss alone. In the first season the accumulation of Zn and B in stems was the only exceptions which showed different trend, as peat moss grown plants produced significantly higher values than peat moss + sand medium.

Table 6. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on N, P and K% in leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season																	
	Growing media (G)																	
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	N [%] in leaves			N [%] in stems			P [%] in leaves			P [%] in stems			K [%] in leaves			K [%] in stems		
T1 (Control)	1.54 cA	1.56 cA	1.55	0.97iA	1.02iA	1.00	0.22gA	0.24fgA	0.23	0.18	0.20	0.19 a	2.02 gB	2.11hA	2.07	1.98 iA	2.00iA	1.99
T2	1.77 bcA	1.69 bcA	1.73	1.47ghA	1.45 hA	1.46	0.29 c-fA	0.27 e-gA	0.28	0.20	0.21	0.21a	2.27fA	2.22 hA	2.25	2.07hA	2.09ghA	2.08
T3	1.83 a-cA	1.78b cA	1.81	1.53efA	1.49f-hA	1.51	0.28 d-fA	0.29 c-fA	0.29b	0.22	0.23	0.23 a	2.43dA	2.39 dFA	2.41	2.10 ghA	2.13fgA	2.12
T4	1.92 a-cA	1.87a-cA	1.90	1.57deA	1.53 efA	1.55	0.30 b-fA	0.29 c-fA	0.30b	0.24	0.24	0.24d	2.49cA	2.42dfB	2.46	2.17 d-fA	2.15 egA	2.16
T5	2.17 a-cA	2.23a-cA	2.20	1.63 bcA	1.61 cdA	1.62	0.33b-dA	0.31b-eAA	0.32	0.25	0.26	0.26 c	2.51cA	2.49cA	2.50	2.26 bA	2.24 bcA	2.25
T6	2.21 a-cB	2.33a-cA	2.27	1.52 e-gA	1.48f-hA	1.50	0.30 b-fA	0.32 b-eA	0.31	0.27	0.26	0.27 b	2.31fB	2.37eA	2.34	2.13fgA	2.11ghA	2.12
T7	2.42 a-cA	2.37a-cA	2.40	1.61 cdA	1.57deA	1.59	0.32b-eA	0.30 b-fA	0.31	0.28	0.27	0.28 a	2.54 cA	2.49cA	2.52	2.19 c-eA	2.17d-fA	2.18
T8	2.57 a-cA	2.52a-cA	2.55	1.64 bcA	1.60cdA	1.62	0.36bA	0.30 b-fB	0.33	0.29	0.26	0.28 a	2.79 bA	2.80bA	2.80	2.25bA	2.22 b-dA	2.24
T9	2.87 aA	2.70abB	2.79	1.74 aA	1.67bA	1.71	0.39 aA	0.33b-dB	0.36	0.30	0.26	0.28 a	3.21aA	3.19 aA	3.20	2.39aA	2.34 aA	2.37
Mean (G)	2.14	2.12	----	1.52	1.49	----	0.31	0.29	----	0.25 A	0.24 B	----	2.51	2.50	----	2.17	2.16	----
L.S.D. (0.05)²																		
G	Sig.			Sig.			Sig.			N.S			N.S			Sig.		
T	0.07			0.06			0.02			0.05			0.04			0.04		
G X T	0.10			0.08			0.03			0.06			0.06			0.07		
2 nd season																		
T1 (Control)	1.45 iA	1.48 iA	1.47	1.07 hA	1.09 hA	1.08	0.25 iB	0.29 hiA	0.27	0.20	0.22	0.21 h	1.57jA	1.59 jA	1.58	1.96hB	2.13gA	2.05
T2	1.79 ghA	1.66 hA	1.73	1.59 d-fB	1.39gA	1.49	0.37d-gA	0.35fgA	0.36	0.23	0.25	0.24g	1.70iA	1.58j B	1.64	2.25deA	2.30cA	2.28
T3	1.78 ghA	1.77 ghA	1.78	1.49f gA	1.52fA	1.51	0.37d-gA	0.36 f-gA	0.37	0.27	0.25	0.26 f	1.80hA	1.78 hA	1.79	2.31cB	2.45bA	2.38
T4	1.69 hB	2.02 fA	1.86	1.65 dB	1.78cA	1.72	0.41c-eA	0.33ghB	0.37	0.32	0.29	0.31 d	1.94gA	1.76 hB	1.85	2.52aA	2.11gB	2.32
T5	2.11 efA	1.94 fgB	2.03	1.66 dB	1.89bA	1.78	0.44 bcA	0.33ghB	0.39	0.32	0.34	0.33 b	2.16 dA	2.00 efB	2.08	2.51aB	2.26c-eA	2.39
T6	2.27deA	2.28 deA	2.28	1.58 d-fA	1.51fA	1.55	0.41c-eA	0.35 fgB	0.38	0.31	0.27	0.29e	1.95fgA	1.77 hB	1.86	2.10cB	2.19fA	2.15
T7	2.52 bcA	1.99 fB	2.26	1.79 cA	1.53 efB	1.66	0.39 c-fA	0.32 ghB	0.36	0.35	0.28	0.32c	1.96gA	2.04 eA	2.00	2.21efB	2.26 c-eA	2.24
T8	2.39 cdB	2.62 bA	2.51	1.59 d-fA	1.68 dA	1.64	0.43bcA	0.42 b-dA	0.43	0.36	0.30	0.33b	2.10cA	2.11 cdA	2.11	2.27c-dA	2.24d-fA	2.26
T9	2.97 aA	2.62 bB	2.80	1.99 aA	1.63 de	1.81	0.51 aA	0.47abB	0.49	0.39	0.33	0.36 a	2.44 aA	2.31bB	2.38	2.54aA	2.41bB	2.48
Mean (G)	2.11	2.04	----	1.60	1.56 B	----	0.40	0.36	----	0.31A	0.28B	----	1.96	1.88	----	2.30	2.26	----
L.S.D. (0.05)²																		
G	Sig.			Sig.			Sig.			Sig.			Sig.			Sig.		
T	0.11			0.08			0.03			0.01			0.06			0.03		
G X T	0.16			0.11			0.04			0.16			0.09			0.05		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 gNPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8=4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm) ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

Table 7. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on Ca and Mg% in leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season											
	Growing media (G)											
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	Ca [%] in leaves			Ca [%] in stems			Mg [%] in leaves			Mg [%] in stems		
T1 (Control)	1.49 hA	1.50hA	1.50	1.30jA	1.33h-jA	1.32	0.25 ijA	0.23 jA	0.24	0.21gA	0.20gA	0.21
T2	2.13fA	1.93 gB	2.03	1.43 fA	1.35 g-iB	1.39	0.27h-jA	0.25 ijA	0.26	0.24efA	0.26d-fA	0.25
T3	2.19efA	2.16 fA	2.18	1.36 g-iA	1.38 f-gA	1.37	0.29hiA	0.27h-jA	0.28	0.27d-fA	0.24 efA	0.26
T4	2.25 deA	2.21efA	2.23	1.31ijB	1.40 fgA	1.36	0.32f-hA	0.30 g-iA	0.31	0.26d-fA	0.25efA	0.26
T5	2.30b-dA	2.32 b-dA	2.31	1.38 f-gA	1.41 fgA	1.40	0.35e-gA	0.35e-gA	0.35	0.28c-eA	0.27d-fA	0.28
T6	2.29 cdA	2.31 b-dA	2.30	2.11 dA	2.00 eB	2.06	0.38 c-eA	0.37d-fA	0.38	0.31b-dA	0.33bcA	0.32
T7	2.31 b-dA	2.33 b-dA	2.32	2.19 cA	2.14 cdB	2.17	0.40 c-eA	0.41bcA	0.41	0.33bcA	0.35abA	0.34
T8	2.38 bA	2.35 bcA	2.37	2.31 abA	2.29 bA	2.30	0.46abA	0.43bcA	0.45	0.36abA	0.36abA	0.36
T9	2.49 aA	2.51aA	2.50	2.36aA	2.33abA	2.35	0.51aA	0.49 bA	0.50	0.39aA	0.37aA	0.38
Mean (G)	2.20	2.18	----	1.75	1.74	----	0.36	0.34	----	0.29	0.29	----
L.S.D. (0.05)²												
G	Sig.			Sig.			Sig.			N.S		
T	0.05			0.03			0.04			0.04		
G X T	0.07			0.04			0.06			0.05		
2 nd season												
T1 (Control)	1.42jB	1.46j A	1.44	1.38 ijA	1.31 kB	1.35	0.27hA	0.21iB	0.24	0.23 efA	0.21gA	0.22
T2	2.10 f-hA	1.86 iB	1.98	1.47ghA	1.30 kB	1.39	0.30 hA	0.28hA	0.29	0.26 d-fA	0.22fB	0.24
T3	2.01 g-iA	1.96 hiB	1.99	1.41iA	1.39iA	1.40	0.33f-hA	0.29 hA	0.31	0.25efA	0.23efA	0.24
T4	2.11f-hB	2.15e-gA	2.13	1.49 gA	1.33 jkB	1.41	0.37e-gA	0.30hB	0.34	0.29 c-eA	0.26d-fA	0.28
T5	2.40 bcA	2.19d-fB	2.30	1.42 hiA	1.32 kB	1.37	0.40 deA	0.33f-hB	0.37	0.33bcA	0.26d-fB	0.30
T6	2.31c-eA	2.18 d-fA	2.25	2.05fA	2.04 fA	2.05	0.44 cAd	0.32f-hB	0.38	0.33bcA	0.33bcA	0.33
T7	2.33cdA	2.20 d-fA	2.27	2.11eA	2.15 eA	2.13	0.42c-eA	0.38efB	0.40	0.36abA	0.35abA	0.36
T8	2.20 d-fA	2.33cdA	2.27	2.28 cA	2.22 dB	2.25	0.47 bcA	0.45cdA	0.46	0.38bA	0.35abB	0.37
T9	2.95aA	2.54bB	2.75	2.49 aA	2.40 bB	2.45	0.59 aA	0.55 bA	0.57	0.44aA	0.44aA	0.44
Mean (G)	2.20	2.10	----	1.79	1.72	----	0.40	0.35	----	0.32	0.29	----
L.S.D. (0.05)[*]												
G	Sig.			Sig.			Sig.			Sig.		
T	0.11			0.03			0.05			0.02		
G X T	0.15			0.05			0.06			0.05		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8= 4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm) ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

Table 8. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on Cu, Fe and Mn (ppm) in leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season																	
	Growing media (G)																	
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	Cu (ppm) in leaves			Cu (ppm) in stems			Fe (ppm) in leaves			Fe (ppm) in stems			Mn (ppm) in leaves			Mn (ppm) in stems		
T1 (Control)	4.87jA	4.81jA	4.84	3.22gA	3.18gA	3.20	68.29rA	65.23sB	66.76	50.13qB	52.10pA	51.12	53.28oA	50.89pB	52.09	48.99iB	51.11hA	50.05
T2	5.75h-jA	5.25igA	5.50	3.55gA	3.49gA	3.52	86.86oA	81.74pB	84.30	52.21oB	55.27nA	53.74	66.91mA	63.79nB	65.35	59.22fA	55.27gB	57.25
T3	5.89hiA	6.39ghA	6.14	3.78gA	4.28fA	4.03	98.71mA	95.37nB	97.04	60.12iA	57.19mB	58.66	69.11iA	66.48mB	67.80	56.13gB	59.10fA	57.62
T4	7.33gA	7.21gA	7.27	4.28fB	5.63eA	4.96	114.52iB	117.11kA	115.82	59.95kB	62.05jA	61.00	80.36hB	87.96gA	84.16	64.16eA	65.19eA	64.68
T5	8.97fA	9.43fA	9.20	6.13dA	6.09dA	6.11	122.71jA	120.13iB	121.42	63.22iB	68.43hA	65.83	88.12fB	90.32dA	89.22	70.12dA	71.22dA	70.67
T6	10.95eB	13.91cA	12.43	7.59cdB	9.47bA	8.53	133.63hB	136.29gA	134.96	80.34gB	84.71fA	82.53	71.42kB	78.42iA	74.92	72.11dA	71.61dA	71.86
T7	10.61eB	12.81dA	11.71	8.02cdA	8.75 cdA	8.39	151.82fB	155.32eA	153.57	85.02eA	84.69eA	84.86	75.33jB	82.19gA	78.76	70.49dA	69.94eA	70.22
T8	14.29cA	14.10cA	14.20	8.15bcA	9.95bA	9.05	167.33dB	170.11cA	168.72	93.10dB	95.00cA	94.05	89.96eB	97.82bA	93.89	75.52cA	74.33cB	74.93
T9	20.45 aA	18.14 bB	19.30	11.11aA	10.01abA	10.56	180.54 bB	189.04 aA	184.79	96.37bB	98.35aA	97.36	94.85cB	100.1aA	97.49	79.13bB	81.07aA	80.10
Mean (G)	9.90	10.23	----	6.20	6.76	----	124.93	125.59	----	71.16	73.09	----	76.59	79.78	----	66.21	66.54	----
L.S.D. (0.05)²																		
G	Sig.			Sig.			Sig.			Sig.			Sig.			Sig.		
T	0.64			0.70			0.58			0.48			0.71			0.87		
G X T	0.91			0.99			0.82			0.68			1.01			1.23		
	2 nd season																	
T1 (Control)	4.46hA	4.44hA	4.45	2.89gA	2.73gA	2.81	74.11pA	73.29qA	73.70	61.67jA	49.92oB	55.80	57.74iA	48.47mB	53.11	44.22kA	43.68iA	43.95
T2	5.42gA	5.53gA	5.48	3.15fA	3.45fA	3.30	86.00oB	100.91mA	93.46	58.03iA	51.19nB	54.61	68.98iA	66.39kB	67.69	54.82jA	54.19jA	54.51
T3	5.54gB	6.45fA	6.00	3.65fA	3.77fA	3.71	102.82 iA	97.32nB	100.07	65.53hA	52.61lB	59.07	75.95hA	67.16jB	71.56	54.38jB	58.51hA	56.45
T4	6.54fA	6.61fA	6.58	3.94fA	4.55eA	4.25	137.98iA	120.12kB	129.05	64.15iA	59.36kB	61.76	82.99fB	87.40dA	85.20	56.28iB	70.10dA	63.19
T5	9.63dA	8.98eA	9.31	6.62dA	4.39eB	5.51	133.38jB	138.08hA	135.73	65.52hB	73.64fA	69.58	91.79cA	85.21eB	88.50	68.08fA	69.93eB	69.01
T6	9.36dA	12.88bB	11.12	6.29d	9.21abA	7.75	139.73fA	131.55gB	135.64	66.68gB	73.53fA	70.11	75.18hA	73.98A	74.58	74.34cA	64.21gB	69.28
T7	11.61cA	12.20bA	11.91	7.54cB	8.61bA	8.08	153.35eA	153.78eA	153.57	83.32dB	89.99bA	86.66	76.09gA	75.54hA	75.82	73.43cA	68.77fB	71.10
T8	13.74bA	11.75cB	12.75	6.35dB	8.97bA	7.66	165.67dB	193.13bA	179.40	77.27eB	89.15cA	83.21	93.87cB	115.2bA	104.53	64.93gB	77.43bA	71.18
T9	15.29aA	15.32aA	15.31	9.44aA	8.31bB	8.88	186.43cB	207.74aA	197.09	82.28dB	95.47aA	88.88	92.79cB	117.8 aA	105.30	73.58cB	83.83aA	78.71
Mean (G)	9.07	9.35	----	5.54	6.00	----	131.05	135.10	----	69.38	70.54	----	79.49	81.90	----	62.67	65.63	----
L.S.D. (0.05)²																		
G	Sig.			Sig.			Sig.			Sig.			Sig.			Sig.		
T	0.56			0.61			0.71			0.36			0.93			0.97		
G X T	0.79			0.86			1.00			0.51			1.31			1.37		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8=4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm) ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

Table 9. Effect of growing media, combined NPK with foliar application of plant growth regulators treatments and the interactions between the two factors on Zn and B (ppm) in leaves and stems of *Dracaena marginata* during the 2018 and 2019 seasons.

Treatments (T) ¹	1 st season											
	Growing media (G)											
	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)	Peat	Peat+ sand	Mean (T)
	Zn (ppm) in leaves			Zn (ppm) in stems			B (ppm) in leaves			B (ppm) in stems		
T1 (Control)	41.27qB	43.63nA	42.45	20.39sB	23.14qA	21.77	19.05sB	20.27qA	19.66	18.87pA	18.02qB	18.45
T2	42.52pB	49.12mA	45.82	35.12nA	28.34pB	31.73	22.91pB	24.62oA	23.77	21.36nA	20.16oB	20.76
T3	44.93nB	53.13jA	49.03	37.33mA	33.27oB	35.30	25.39nB	28.13mA	26.76	24.10lA	22.10mB	23.10
T4	48.7 lB	58.37kA	53.57	40.11kA	39.42lB	39.77	29.47lB	31.41kA	30.44	26.90jA	24.41kB	25.655
T5	53.11jB	61.19iA	57.15	45.81iA	43.88jB	44.85	32.49jB	35.61iA	34.05	30.01hA	27.20iB	28.605
T6	61.53hB	67.55gA	64.54	49.13hB	52.43gA	50.78	37.86hB	39.52gA	38.69	33.17fA	29.07B	31.12
T7	69.18fB	73.39eA	71.29	54.26fB	56.36eA	55.31	41.93fB	44.21eA	43.07	36.08dA	31.14gB	33.61
T8	78.21dB	80.63cA	79.42	59.20dB	60.32cA	59.76	44.13dB	47.19cA	45.66	39.03bA	34.27eB	36.65
T9	89.60bB	91.47aA	90.54	66.10aA	63.29bB	64.70	48.29bB	49.11aA	48.70	41.23aA	38.10cB	39.67
Mean (G)	58.79	64.28	----	45.27	44.49	----	33.50	35.56	----	30.08	27.16	----
L.S.D. (0.05)²												
G	Sig.			Sig.			Sig.			Sig.		
T	0.83			0.38			0.04			0.14		
G X T	1.17			0.54			0.05			0.20		
	2 nd season											
T1 (Control)	40.20pB	43.93oA	42.07	24.17oB	25.88nA	25.03	19.86qB	25.56oA	22.71	23.3oA	20.45qB	21.88
T2	50.85nB	56.02kA	53.44	45.03kA	36.81mB	40.92	24.90pB	27.05nA	25.98	24.05nA	21.45pB	22.75
T3	58.61iB	57.26jA	57.94	49.12iA	41.07 lB	45.10	27.90mB	32.33jA	30.12	25.91mB	26.11lA	26.01
T4	58.93fB	59.81gA	59.37	54.95gA	44.80kB	49.88	34.27iA	30.79lB	32.53	31.65kB	32.12jA	31.89
T5	54.61lA	52.43mB	53.52	53.08hA	49.68iB	51.38	30.10lB	35.97hA	33.04	34.10hB	36.27eA	35.19
T6	66.30cA	59.30hB	62.80	47.30jB	57.62eA	52.46	35.49gB	41.17fA	38.33	34.57gA	33.93iB	34.25
T7	63.74dA	62.16eB	62.95	56.17fB	59.96dA	58.07	42.35fB	46.05dA	44.20	35.10fB	36.48dA	35.79
T8	56.88kB	69.86bA	63.37	61.48cB	62.67bA	62.08	44.58eB	47.67cA	46.13	41.97dB	44.32bA	43.15
T9	56.24kB	75.69aA	65.97	61.97cB	78.41aA	70.19	51.37bB	53.63aA	52.50	43.55cB	46.41aA	44.98
Mean (G)	56.26	59.61	----	50.36	50.77	----	34.54	37.80	----	32.69	33.06	----
L.S.D. (0.05)²												
G	Sig.			Sig.			Sig.			Sig.		
T	0.86			0.55			0.15			0.11		
G X T	1.21			0.78			0.11			0.16		

¹T1= Control, T2=2 g NPK + BA (100 ppm), T3=2 g NPK + BA (150 ppm), T4= 4 g NPK + BA (100 ppm), T5=4 g NPK + BA (150 ppm), T6=2 g NPK + GA₃ (150 ppm), T7=2 g NPK + GA₃ (250 ppm), T8= 4 g NPK + GA₃ (150 ppm), T9= 4 g NPK + GA₃ (250 ppm) ²G= Growing media, T= Treatments, G X T= Growing media X Treatments, different lower case letters in the columns and upper case letters in the rows for each variable indicate a significant difference at 5% level of significance by LSD test.

In this respect previous finding (Abdul-Hafeez et al., 2015) indicated that peat-grown plants were inferior to those grown in clay or rice straw in Fe, Cu and Mn contents in leaves of *Gardenia jasminoides*.

The data in Tables (8 and 9) also cleared that the uptake and accumulation of Cu, Fe, Mn, Zn and B contents in the leaves and stems were markedly affected by the treatments of combined NPK with both BA and GA₃, as compared to the control plants. In both seasons, in most cases plants treated with any of the combined treatments had significantly higher values than the values obtained from untreated control plants. Also the data indicated that, GA₃ was more effective than BA when combined with NPK at the same rates.

Concerning the interaction effects, the data in Tables (8 and 9) revealed that plants received any treatments of

combined NPK with either BA or GA₃ had significantly higher values of micro elements than those obtained from control plants. Overall, in both seasons the lowest values were obtained from plants grown in medium containing peat-moss only or peat-moss+ sand and received no treatments. While, the highest values were recorded with plants grown in medium of peat- moss+ sand and received combined treatments of 4 g NPK + GA₃ at 250 ppm.

Leaf anatomy

As shown in Fig.1 (a, b, and c) the leaves of *Dracaena marginata* are compound and composed of two little thicker upper and lower epidermis cells. They are covered with thick layer of cuticle particularly existing in the upper epidermis, meanwhile stomata were concentrated on the lower epidermis.

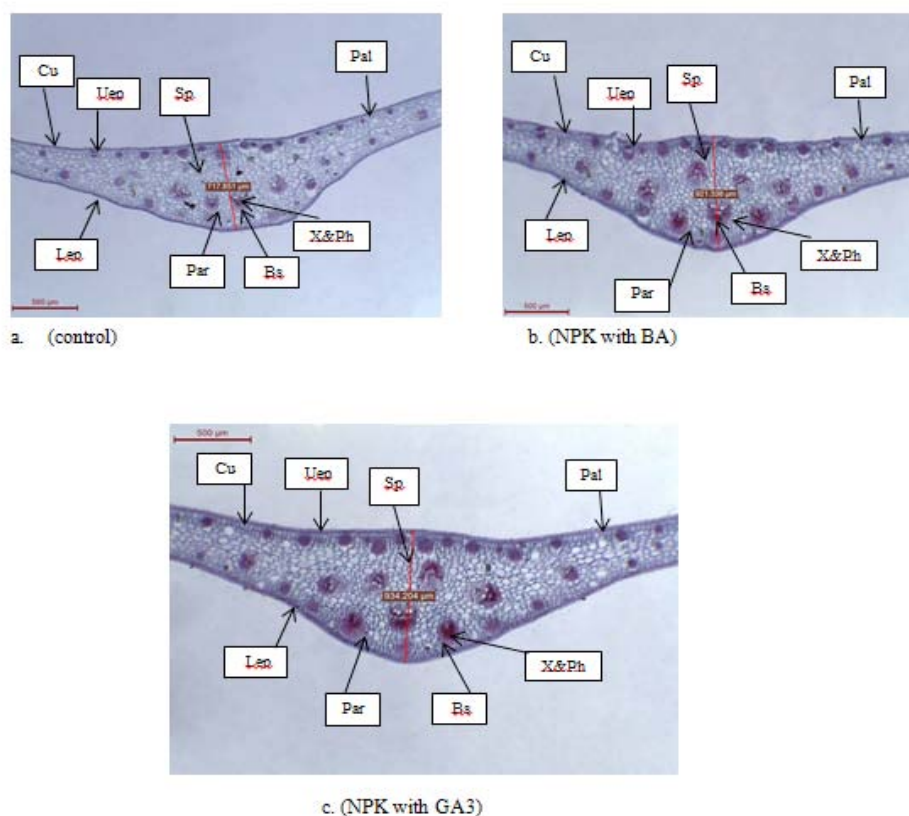


Figure 1. Cu: cuticle, Uep: upper epidermis, Sp: spongy parenchyma, Pal: palisade tissue, Lep: lower epidermis, Par: parenchyma, Bs: bundle sheath, X&Ph: xylem and phloem.

Cross section in the leaves revealed that, the epidermis tissue cells (both upper and lower) of the control (Fig. a) were consisting of similar shape and size barrel, compactly arranged tiny cells and then become thicker and larger than control as shown in (Fig. b) as a result of the combined NPK with BA treatments. The application of NPK combined with GA₃ treatments resulted in the maximum size of the epidermis cells (Fig. c). Regarding the mesophyll tissue that consists of palisade and spongy parenchyma cells, in which the palisade lies just inner to the upper

epidermis, and composed of elongated cells organized in two layers. The palisade cells region was compact and filled with chloroplasts which arranged along their radial walls, whereas the parenchyma cells tissue were present above and below the large vascular bundles. The spongy parenchyma cells region are loosely arranged, filled with chloroplasts and present below the palisade and extends up to the lower epidermis. It was remarkable that, the thickness of mesophyll tissue, which is specialized in photosynthetic and contains chloroplasts in palisade cells were visible and

clear. The size of the spongy parenchyma tissue, air spaces of that treated with combined NPK with GA₃ became the largest as compared to both of combined NPK with BA treatments and control. Furthermore, vascular bundles of combined NPK with GA₃ treatment were larger and greater as shown in (Fig. c) as compared with the other treatments including control. These results are representing evidence of chlorophyll concentration, which was higher for the combined NPK with GA₃ treatment and that reflected the increased total carbohydrates percentage with the same previous treatment compared to control. This might be attributed to the increase in the chlorophylls synthesis and photosynthesis rate. The previous data are in conformity with the results obtained by (Ullah et al., 2017).

Conclusions

On the basis of earlier stated data, for the best vegetative growth and economic production of *Dracaena marginata* 'Bicolor', the plants advised to grow in a medium of peat-moss and supplied monthly with NPK fertilizer (20:20:20) at the rate of 2 g plant⁻¹ along with foliar sprayed of GA₃ at the concentration 250 ppm.

Author Contribution

HAA: Responsible for implantation of the experiment according to established treatments, data collection, and data evaluation, arrangement of experimental data, statistical analysis, manuscript writing and corrections. ABE: Implantation of the experiment according to established treatments, data collection, statistical analysis, manuscript writing and corrections. MMA: Assistance in data collection, chemical analysis, statistical analysis, assistance in the preparation of manuscript.

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