American-Eurasian J. Agric. & Environ. Sci., 2 (6): 711-719, 2007
ISSN 1818-6769

Stimulatory Effect of NPK Fertilizer and Benzyladenine on Growth and Chemical Constituents of *Codiaeum variegatum* L. Plant

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Abstract: Two pot experiments were conducted during two successive seasons (2005 and 2006) at National Research Centre, Dokki, Cairo, Egypt (Research and Production Station, Nubaria). The aim of this work is to study the stimulatory effect of NPK fertilizer rates (4 and 8 g pot^{-1}), benzyladenine at 20 and 40 ppm L^{-1} and their combinations on the growth and chemical constituents of *Codiaeum variegatum* L. plants. The results indicated that foliar application of benzyladenine, NPK fertilizer or their combinations influenced the vegetative growth of croton plants (plant height, leaves and branches number, root length, diameter of stem, leaf area, fresh and dry weights of leaves, branches and roots), especially when plants were sprayed with BA (20 ppm L^{-1}) combined with NPK (4 g pot^{-1}). The same tendency was observed regarding chlorophyll a, b, carotenoids content, total carbohydrates percentage as well as the percentages of N, P and K.

Key words: Benzyladenine · *Codiaeum variegatum* L. · growth · NPK · total carbohydrates · chlorophyll

INTRODUCTION

Croton (*Codiaeum variegatum* L.) c.v. Pictum var. "Gold Star", Family Euphorbiaceae, is a tropical woody shrub native to South Sea Island and the Malay Peninsula. It is one of the beautiful indoor and outdoor plants.

Most studies concerning the effect of bioregulator (BA) and/or NPK fertilizer have been conducted, while only a few studies have examined the combined effect of both BA and NPK simultaneously.

Fertilizers are sources of plant nutrients that can be added to soil to supply its natural fertility. They are intended to supply plant needs directly rather than indirectly through modification of such properties as soil pH and structure. There is usually a dramatic improvement in both quantity and quality of plant growth when appropriate fertilizers are added. The change from an agrarian society and a subsistence type of agriculture to a modern mechanized society is accompanied by a marked increase in the use of fertilizers [1].

In this respect, Reem [2] mentioned that increasing plant growth of croton plant could be obtained though application of NPK at rate of 2 and 4 g pot^{-1}. Zaghloul *et al.* [3] on *Philodendron domesticum* L., Atta-Alla *et al.* [4] on *Cordyline terminalis* cv. Atoom concluded that application of Kristalon (2 g L^{-1}) produced the longest plants, the tallest root, increased the number of leaves as well as the fresh and dry weights of stems and roots.

Profitable responses to NPK fertilization are mentioned by Poole and Conover [5] on *Nephrolepis exaltata*. Also, El-Kiey and El-Bana [6] on *Philodendron burguedy*, Zaghloul *et al.* [3] on *Philodendron domesticum* L. and Hanafy [7] on rosella plants, they concluded that the Chl a, b, carotenoids as well as NPK content in plants often increased by adding kristalon as fertilizers.

Cytokinins are important plant hormones that regulate various processes of plant growth and development including cell division and differentiation, enhancement of leaf expansion and nutrient mobilization [8, 9]. The response of plants to cytokinins have been also discussed in more papers where Eraki [10] on *Hibiscus sabdariffa* L. plants mentioned that application of BA significantly increased plant height, number of branches, fresh weight of herb/plant as well as fresh and dry weights of leaves than the control. Hassanein [11] on *Pelargonium graveolens*, El-Sayed *et al.* [12] on *Polianthus tuberosa*, Menesi *et al.* [13] on *Calendula*

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officinalis and Mazrou *et al.* [14] on sweet basil, they found that foliar application of BA increased fresh and dry weights of different organs, active constituents production of these plants and increased total carbohydrates content on comparison to the untreated plants.

The aim of the present study is to investigate the stimulatory effect of NPK fertilizer and benzyladenine and their combination on growth and chemical constituents of *Codiaeum variegatum* L. plants.

MATERIALS AND METHODS

Pot experiment was carried out during the two successive seasons of (2005-2006) at National Research Centre (Research and Production Station, Nubaria).

Rooted terminal cutting of Croton (*Codiaeum variegatum* L.) cv. Pictum var. "Gold Star". (15-20 cm height) which 4-5 leaves were transplanted on 17th March in both seasons, as two cuttings in plastic pots 30 cm in diameter that were filled with media containing peat and sand (1:1) by volume. The experiments in both seasons included treatments in which the combination of two levels of NPK in the form of Kristalon (19:19:19) at levels of (4 and 8 g pot^{-1}) and two concentrations of Benzyladenine (BA) 20 and 40 ppm in addition to the control. The fertilizers were added every two weeks through the period of experiments which expanded to six months. Application of BA (20 and 40 ppm) was carried out twice as foliar sprays. The first was applied one month after transplanting and the second was done after one month from the first, while controls were sprayed with tap water. Treatments were distributed in a complete randomized design with six replicates for each treatment.

Through the two successive seasons, a representative plant sample was taken from the six replicates for each treatment and the growth parameters included plant height (cm), number of leaves, number of branches, root length (cm), leaf area (cm^2), fresh and dry weights of leaves, branches and roots (g/plant). For chemical analysis, fresh leaves (g/plant) were sampled every two months to determine chlorophyll a, b and carotenoids according to Saric *et al.* [15], another sample of dried leaves (70°) was used to determine total carbohydrate percentage using methods described by Dubois *et al.* [16]. Nitrogen percentage was determined by Markhan [17]. Phosphorus determination was carried out according to King [18]. Potassium was determined using atomic absorption spectrophotometer. All previous data were subjected to statistical analysis according to a procedure outlined by Snedecor and Cochran [19].

Treatment means were compared by L.S.D. at 5% test and combined analysis of the two seasons were calculated according to the method of Steel and Torrie [20].

RESULTS AND DISCUSSION

Effect on growth:

Effect of NPK fertilizer: Data in Table 1 show that Kristalon fertilizer greatly increased growth of croton plants compared with the control treatment. The lower level (4 g pot^{-1}) significantly increased plant height, number of leaves, number of branches, root length, diameter of stem and leaf area by about (29.4, 62.1, 58.3, 39.7, 46.2 and 44.3%, respectively) compared with control plants, the relatively highest increments were recorded when Kristalon was applied at the level of 4 g pot^{-1} and the lowest increments were relative to the highest level (8 g pot^{-1}).

These results may be due to the salt toxicity from excessive fertilizer application, they may be accounted for by the slightly reduced growth and nutrient uptake at the 8 g pot^{-1} rate, as compared with 6 g pot^{-1} rate on *Dracaena draco* [21]. Burghardt and Ellering [22] on *Ficus elestica* "Decora", Shedeed *et al.* [23] on the same plants and Poole and Conover [5] on *Dieffenbachia maculata* and *Codiaeum variegatum* applied different rates of NPK, they found that plants grew well, formed good root system and plant height was increased.

It is evident also in Table 1 that Kristalon fertilizers caused significant increments in both fresh and dry weights of croton plants over the control plants. The relative percentage of increments of fresh weight in leaves, branches and roots over the control plants reached (94.0, 71.2 and 101.3%) and (78.9, 50.8 and 66.0%) as well as in the dry weight of these parameters, they reached to (40.7, 73.1 and 98.5%) and (30.9, 45.7 and 64.2%) due to the low level (4 g pot^{-1}) and high level (8 g pot^{-1}), respectively. Abou Dahab [24] on *Chlorophytum comosum* stated that NPK at 1:1:1 and 1:2:1 were the most effective treatments for increasing the plant height and offsets number, whereas NPK at 2:1:2 gave the highest number of leaves and increased foliage fresh and dry weights. The experiments of Chase [25] and Chase and Poole [26] on *Codiaeum variegatum* cv. "Gold Star" reported that the best plant quality was obtained by using Osmocote (19:6:12) fertilizer. Also, Badawy *et al.* [27] found that the lowest fertilization rate (2.5 g/NPK pot) resulted in the best growth on *Chamaedorea elegans*. These improvements might be due to that the plant can't

Table 1: Effect of NPK fertilizers (Kristalon) on growth characters of *Codiaeum variegatum* L. plants (Mean data of the two seasons)

							Fresh weight (g)			Dry weight (g)		
Treatments	Plant height (cm)	No. of leaves	No. of branches	Root length (cm)	Diameter of stem (cm)	Leaf area (cm^2)	Leaves	Branches	Roots	Leaves	Branches	Roots
Control	68.3	277	10.8	29.2	1.19	4369	123.7	60.2	30.3	25.5	21.2	13.7
NPK (4 g pot^{-1})	88.4	449	17.1	40.8	1.74	6304	240.0	103.1	61.0	35.9	36.7	27.2
NPK (8 g pot^{-1})	83.1	391	15.1	36.8	1.38	5707	221.4	90.8	50.3	33.4	30.9	22.5
LSD at 5%	2.20	22.35	0.7	2.0	0.02	401	12.60	6.06	1.9	1.41	2.21	0.8

Table 2: Effect of benzyladenine on growth characters of *Codiaeum variegatum* L. plants. (Mean data of the two seasons)

							Fresh weight (g)			Dry weight (g)		
Treatments	Plant height (cm)	No. of leaves	No. of branches	Root length (cm)	Diameter of stem (cm)	Leaf area (cm^2)	Leaves	Branches	Roots	Leaves	Branches	Roots
Control	75.1	310	13.1	32.3	1.24	5024	163.3	75.9	38.7	28.1	26.3	17.2
BA 20 ppm	84.7	428	15.9	39.0	1.56	5989	221.2	95.5	53.8	34.6	33.5	24.2
BA 40 ppm	80.1	380	19.9	35.5	1.51	5368	200.6	82.8	49.1	32.1	29.0	21.9
LSD at 5%	2.20	22.35	0.7	2.0	0.02	401	12.60	6.06	1.9	1.41	2.21	0.8

carry out its life processes if it lacks nitrogen to form these vital constituents. Growing plants must have nitrogen to form new cells and the rate of growth then becomes very nearly proportional to the rate at which nitrogen is supplied [28]. Phosphorus has been called "the key to life" because it is directly involved in most life processes. Phosphorus in the cell becomes united with carbon, hydrogen, oxygen, nitrogen and other elements to form complex organic molecules. Phosphorus is an essential component of the genetic material of the cell nucleus. The cell can't divide unless there is adequate phosphorus to form the extra nucleus, so phosphorus deficiency therefore causes stunting, delayed maturity and shriveled seeds, it also has the very important capacity of forming bonds of more than one energy level. This permits the storage, transfer and release of energy within the plants through such materials as ADP and ATP.

Potassium is needed in relatively large amounts by all plants. It aids in the uptake of other nutrients and their movement within the plant. The presence of potassium and other ions in solution helps in maintaining the osmotic concentration necessary to keep the cells turgid [29]. The role of NPK fertilization on promoting different vegetative growth characters (plant height, No. of branches, No. of leaves, root length, fresh and dry weights of leaves, branches and roots), enhancing growth parameters of *Codiaeum variegatum* L. plants could be explained by recognizing its fundamental involvement in the very large number of enzymatic reactions that depend on NPK fertilization as well as other metabolic, energy transfer and biological processes discussed earlier. Similar results were obtained by Zaghloul *et al.* [3], Atta-Alla *et al.* [4] and Reem [2] on *Philodendron domesticum* L., *Cordyline terminalis* and *Codiaeum variegatum*, respectively. Pal and Biswas [30] recorded that the best results when tuberose plants were fertilized with NPK at 15:15:20 g m^{-2} respectively. Also, Khan and Iftikhar [31] on gladiouls concluded that N P.K at the different rates enhanced growth characteristics.

Effect of BA: Data presented in Table 2 showed that the application of benzyladenine (BA) had a significant stimulatory effect on growth parameters of croton plants.

However, the most effective treatment which had the tallest plants, the highest number of leaves, branches, root length, diameter of stem and the largest leaf area when application of BA at the concentration of 20 ppm. The increments were (12.8, 38.1, 21.4, 20.7, 25.8 and 19.2%), respectively, compared with control plants. These results may be because of accumulation of greater photosynthates leading to better growth parameters [32]. Recently, Rawia and Bedour [33] on croton plants found that application of BA gave the highest number of leaves. The increment percentages of all growth parameters were less with BA at 40 ppm compared with control plants by (6.7, 22.5, 6.1, 9.9, 21.7 and 6.8%), respectively. This increment in plant height may be due to the role of cytokinin (BA) in increasing cell division in apical meristems and cambium [34]. Our results are comparable with those obtained by Mazrou *et al.* [35] on sage plant, El-Keltawi and Croteau [36] on sage and mint plants and

Table 3: The influence of foliar application with NPK (Kristalon), BA and their interaction on growth characters of *Codiaeum variegatum* L. plants (Mean data of the two seasons)

Treatments	Plant height (cm)	No. of leaves	No. of branches	Root length (cm)	Diameter of stem (cm)	Leaf area (cm^2)	Fresh weight (g)			Dry weight (g)		
							Leaves	Branches	Roots	Leaves	Branches	Roots
Control	66.3	258	10.3	24.7	1.12	3749	118.1	56.8	25.2	25.3	19.8	11.2
NPK 4 g pot^{-1}	81.7	343	15.3	36.5	1.32	5686	194.4	87.6	47.2	30.9	31.2	21.5
NPK 8 g pot^{-1}	77.3	330	13.7	35.6	1.28	5636	177.5	83.3	43.6	28.0	27.8	18.9
BA at 20 ppm	71.0	301	11.7	33.0	1.24	4983	148.2	66.6	36.8	27.0	23.1	17.0
BA 20 ppm + NPK 4 g pot^{-1}	94.7	511	19.0	46.0	1.95	7220	267.8	121.1	69.8	39.7	44.1	31.0
BA 20 ppm + NPK 8 g pot^{-1}	88.4	471	17.0	38.0	1.50	5762	247.7	98.8	54.7	37.2	33.2	24.7
BA at 40 ppm	67.7	273	10.3	29.9	1.22	4374	104.7	57.4	28.7	24.3	20.5	12.7
BA 40 ppm + NPK 4 g pot^{-1}	89.0	493	17.0	39.8	1.94	6006	257.8	100.6	66.2	37.1	34.8	29.1
BA 40 ppm + NPK 8 g pot^{-1}	83.7	373	14.3	36.7	1.37	5723	239.2	90.3	52.5	34.9	31.7	23.7
LSD at (%)	3.82	38.71	1.1	3.5	0.04	694	21.82	10.49	2.45	2.45	3.84	1.5

Eraki [10] on *Hibiscus sabdariffa* L. The increment in branch number as a result of BA application may be attributed to its influence on counteracting or eliminating the apical dominance [37].

It could be also observed from data in Table 2 that both BA concentrations used 20 and 40 ppm were efficient significantly in increasing fresh and dry weights of leaves, branches and roots of *Codiaeum variegatum* plants, in both seasons compared with the control plants. The increment in the herb fresh weight could be explained through the role of BA in stimulating xylem differentiation and vascular strand development, consequently more absorption of water and nutrients from the soil, which was reflected in more growth, as mentioned by Sorokin and Thimann [38]. Also, the increase in the herb fresh weight could be attributed to the increment in plant height and number of branches as a result of overcoming the apical dominance of the plant which formed more leaves.

In this connection, our results have been supported by Mazrou [39] on *Datura innoxia* and Eraki [10] on *Hibiscus sabdariffa* plants, showed that foliar application of BA significantly increased plant height, number of branches/plant as well as fresh and dry weight/herb than the control.

Data in Table 2 showed that the heaviest fresh and dry weights expressed in terms of leaves, branches and roots were obtained from plants received BA at the concentration of 20 ppm which increased fresh weight by 35.5, 25.8 and 39.0%, respectively over control plants as well as dry weight of these parameters increased by 23.1, 27.4 and 40.7%, respectively over the control. These results in general are in harmony with those obtained by Menesi *et al.* [40] who reported that the greatest values of fresh and dry weighs resulted from BA at 25 mg L^{-1} on some ornamental plants. Also, El-Sayed *et al.* [12] on *Polianthus tuberosa* and Menesi *et al.* [13] on *Calandula officinalis* who concluded that BA application increased the fresh and dry weights of roots.

Effect of interaction between NPK and BA: Table 3 showed that the interaction between NPK fertilizer and BA application on plant growth parameters in term of plant height, number of leaves, number of branches, root length, diameter of stem and leaf area were significantly increased in the two seasons and verified that combined treatment of Kristalon fertilizer at the level of 4 g pot^{-1} and BA at 20 ppm was highly efficient in increasing croton growth parameters as compared with the other treatments. These increments reached 42.8, 98.0, 84.5, 86.2, 74.1 and 92.5%, compared with untreated plants, respectively. However, the minimum values of these parameters were recorded in the the treatment of BA at 40 ppm + NPK 8 g pot^{-1}. The highest increases in fresh and dry weights of leaves, branches and roots were found in plants treated with BA at 20 ppm + NPK at 4 g pot^{-1}, followed by BA at 40 ppm + NPK at 4 g pot^{-1}. However, no studies have been conducted in this respect.

Table 4: Effect of NPK fertilizer on chemical constituents of *Codiaeum variegatum* L. plants (Mean data of the two seasons)

	Chl. a (mg g^{-1}) F.W.			Chl. b (mg g^{-1}) F.W.			Total Chl. (mg g^{-1}) F.W.			Carotenoids (mg g^{-1}) F.W.			
Treatments	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Total carbohydrates DW (%)
zControl	0.351	0.781	1.325	0.286	0.464	0.567	0.637	1.245	1.892	0.369	0.474	1.144	28.1
NPK (4 g p^{-1})	0.517	1.176	2.421	0.474	0.728	1.572	0.991	1.904	3.993	0.334	0.724	1.283	37.1
NPK (8 g pot^{-1})	0.469	1.116	2.304	0.409	0.659	1.483	0.878	1.775	3.787	0.388	0.709	1.316	33.0
LSD at 5%	0.009	0.042	0.012	0.010	0.039	0.007	0.010	0.055	0.015	0.004	0.005	0.007	1.60

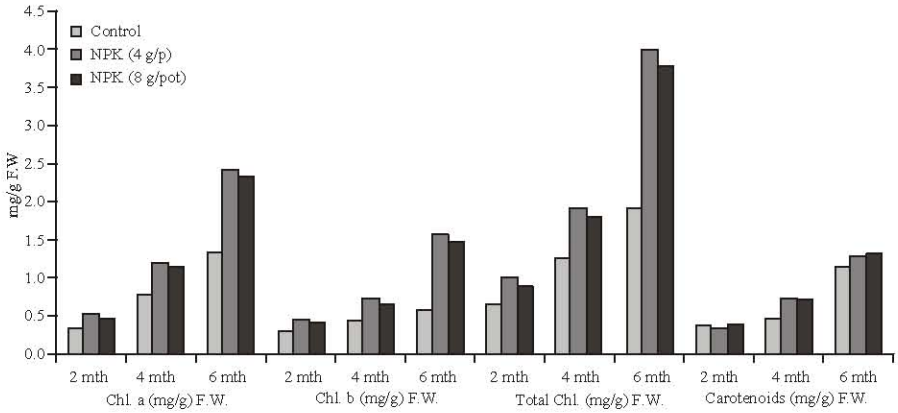

Fig. 1: Effect of NPK fertilizer on chl. a, b, total chl.and caroteniods of *Codiaeum variegatum L.* plants

Effect on chemical constituents:

Effect of NPK fertilizer on photosynthetic pigments and total carbohydrates percentage: Data in Table 4 and Fig. 1 revealed that the photosynthetic pigments increased gradually during plant age in both control and treated plants. However, total chlorophylls in croton leaves as well as carotenoids were in harmony with growth parameters due to Kristalon fertilizers. This is reasonable since chlorophylls activity depends on growth status. In general, photosynthetic pigments Chl a, b and carotenoids were stimulated by adding Kristalon (NPK) fertilizers compared with control plant. The magnitude of increase Chl a, b and total chlorophylls were more pronounced with Kristalon applied at the rate of 4 g pot^{-1}, while increasing the level up to 8 g pot^{-1} caused a significant reduction. The same effect was found by Shedeed [41] on croton, Abdel-Wahid [42] on Strelitzia plant and Reem [2] on *Codiaeum variegatum* L. after 2 and 6 months from planting these were increases in the content of carotenoids with the application of NPK at 8 g pot^{-1}, while after 4 months, the content of carotenoids increased with the application of 4 g pot^{-1}. These results are characteristically accompanied by Abou- Dahab [24] on *Chlorophytum comosum*, Hanafy [7] on roselle plants, El-Fouly [43] on *Peperomia obtusifolia*, El-Sayed [44] on *Brassaia actinophylla* and Hassan [45] on *Aspidistra elatior*, they reported that NPK increased the content of Chl a and b. These results resembled those reported by Atta-Alla *et al.* [4] on *Cordyline terminalis* and El-Kiey and El-Bana [6] on *Philodendron burguedy*. The highest chl. a and b values were recorded with Kristalon at 2 g L^{-1} on *Philodendron domesticum* L. [3].

Total carbohydrates showed a parallel trend to the growth parameters in response to NPK fertilizers (Table 4). This may be due to that the unit of carbohydrates depend to some extent on the states of plant growth. It is evident that carbohydrate contents were significantly increased in croton leaves fertilized with NPK compared with the control plants, the low level of NPK (4 g pot^{-1}) increased carbohydrates content by about 32.0% over the control, whereas the higher level reduced it to 17.4%. Greater carbohydrate accumulation due to increased photosynthesis caused by the optimum balance and supply of plant nutrients present in substrate [32].

Nitrogen is a constituent of most organic compounds such as amino acids, many enzymes and energy transfer materials such as chlorophyll, ADP and ATP. Photosynthesis produces soluble sugars from CO_2 and H_2O, but the process can't go on to the production of proteins. Thus, severe shortage of nitrogen will halt the processes of growth and reproduction.[28]. Phosphorus compounds are essential for photosynthesis,

Table 5: Effect of benzyladenine (BA) on chemical constituents of *Codiaeum variegatum* L. plants. (Mean data of the two seasons)

	Chl a (mg g^{-1}) F.W.			Chl b (mg g^{-1}) F.W.			Total Ch (mg g^{-1}) F.W.			Carotenoids (mg g^{-1}) F.W.			
Treatments	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Total carbohydrates %D.W
Control	0.368	0.897	1.910	0.323	0.514	1.116	0.691	1.411	3.026	0.317	0.533	1.076	30.6
BA 20 ppm	0.513	1.144	2.082	0.440	0.704	1.273	0.953	1.848	3.355	0.329	0.698	1.363	34.5
BA 40 ppm	0.456	1.031	2.058	0.406	0.633	1.234	0.862	1.664	3.292	0.446	0.674	1.304	33.1
LSD at 5%	0.009	0.042	0.012	0.010	0.039	0.007	0.010	0.055	0.015	0.004	0.005	0.007	1.60

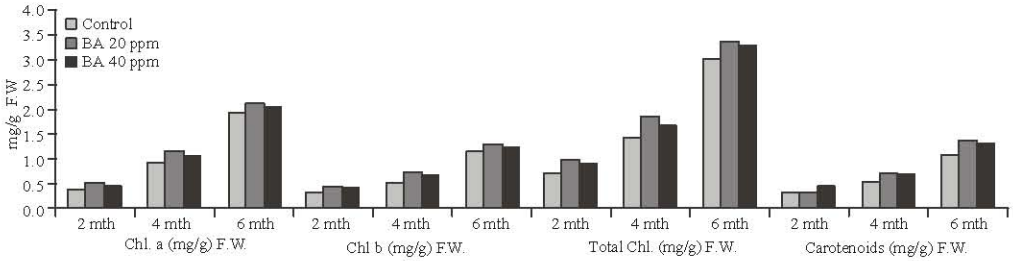

Fig. 2: Effect of benzyladenine (BA) on chl. a, b, total chl. and carotenoids of Codiaeum variegatum L. plants.

the interconversion of carbohydrates and related glycolysis, amino acid metabolism and biological oxidation. Lack of phosphorus, therefore, hampers metabolic processes such as the conversion of sugar into starch and cellulose. Potassium is also important in metabolism and formation of soluble sugars and proteins. Such important physiological roles enable potassium to perform its functions which lead to an increase in various vegetative growth [29].

In fact, the unique role of NPK in photosynthesis, energy compounds and other important physiological processes, which reflected directly on increasing the content of chlorophyll a, b and carotenoids, as well as NPK % in the leaves, were indirectly the cause of enhancing and augmenting all other vegetative growth of *Codiaeum variegatum* L. plants. This explanation could be insured as the low NPK fertlzation rate used in this experiment was much more effective than the high one.

Effect of BA on photosynthetic pigments and total carbohydrates percentage: Concerning the effect of benzyladenine (BA) on croton plants, Table 5 and Fig. 2 showed that, BA significantly increased photosynthetic pigments (Chl a, b, total Chl and carotenoids) over the control plants. These results are in agreement with Iman and Youssef [46] on *Hibiscus sabdariffa* L., Zayed *et al.* [47] on the same plant and Menesi *et al.* [40] on some ornamental plants, they stated that application of BA increased Chl a, b and carotenoids.

The relative percentage of increments over the control reached 9.0 and 7.7% for chl a, 14.1 and 10.5% for chl b, 10.8 and 8.7% for total chl and 26.6 and 21.1% for carotenoids, respectively, for the lower concentration (20 ppm) and the higher one (40 ppm) used at the end of plant age. With regard to the effect of BA on total carbohydrate percentage on croton plants, data in Table 5 concluded that application of BA at 20 and 40 ppm significantly increased total carbohydrate %. The increments were (12.7 and 8.16%, respectively)compared with control plants. These results could be explained through the role of BA in increasing the synthesis of total carbohydrates in roselle plants which is converted into sugars especially in the phase of fruit ripening as mentioned by Krishnamoorthy [34]. These results agree with those reported by Abou-El-Ghait [48] on carnation plants, Hassanein [11] on *Pelargonium graveolens*, Mazrou *et al.* [35] on roses, Mazrou [39] on datura, Iman and Youssef [46], Eraki [10] and Zayed *et al.* [47] on *Hibiscus sabdariffa* and Menesi *et al.* [40] on the some ornamental plants, they stated that BA treatment increased total carbohydrates.

Effect of interaction on photosynthetic pigments, total carbohydrates and macronutrients: The data represented in Table 6 and Fig. 3 showed the effect of combined treatments of NPK and BA on chl a, b, total chl. and carotenoids of croton plants. It is clear from the data that foliar application of BA at 20 ppm + NPK 4 g pot^{-1} resulted in a significant increase in chl. a after 2, 4 and

Table 6: The influence of foliar application with NPK, BA and their interaction on Chemical constituents of *Codiaeum variegatum* L. plants (Mean data of the two seasons)

	Chl. a (mg g^{-1}) F.W			Chl. b (mg g^{-1}) F.W			Total chl. (mg g^{-1}) F.W			Carotenoids (mg g^{-1}) F.W				Macronutrients D.W (%)		
Treatments	Two Months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Two months	Four months	Six months	Total carbohdrates	%N	P	K
Control	0.285	0.660	1.231	0.264	0.424	0.508	0.549	1.084	1.739	0.273	0.429	0.552	26.2	1.5	0.41	2.92
NPK 4 g pot^{-1}	0.412	1.024	2.377	0.394	0.597	1.421	0.806	1.621	3.798	0.349	0.607	1.369	32.1	2.0	0.53	3.33
NPK 8 g pot^{-1}	0.408	1.007	2.123	0.311	0.521	1.417	0.719	1.528	3.540	0.328	0.563	1.308	33.4	2.0	0.50	3.12
BA 20ppm	0.436	0.944	1.367	0.322	0.537	0.634	0.758	1.481	2.001	0.329	0.418	1.593	29.4	1.8	0.47	3.12
BA20+NPK4g	0.581	1.287	2.479	0.551	0.761	1.647	1.132	2.048	4.126	0.306	0.857	1.230	41.9	3.2	0.67	4.17
BA20+NPK8g	0.521	1.201	2.399	0.448	0.814	1.539	0.969	2.015	3.938	0.351	0.819	1.267	32.2	2.2	0.63	3.54
BA40 ppm	0.332	0.737	1.378	0.271	0.431	0.559	0.603	1.168	1.937	0.504	0.573	1.289	28.7	1.8	0.45	3.00
BA40+NPK4g	0.557	1.215	2.406	0.479	0.825	1.651	1.036	2.040	4.057	0.348	0.707	1.250	37.1	2.3	0.65	3.75
BA40+NPK8g	0.479	1.140	2.390	0.470	0.642	1.494	0.949	1.782	3.884	0.485	0.743	1.375	33.4	2.2	0.62	3.54
LSD at 5%	0.016	0.072	0.021	0.017	0.068	0.11	0.017	0.095	0.027	0.007	0.009	0.012	2.77			

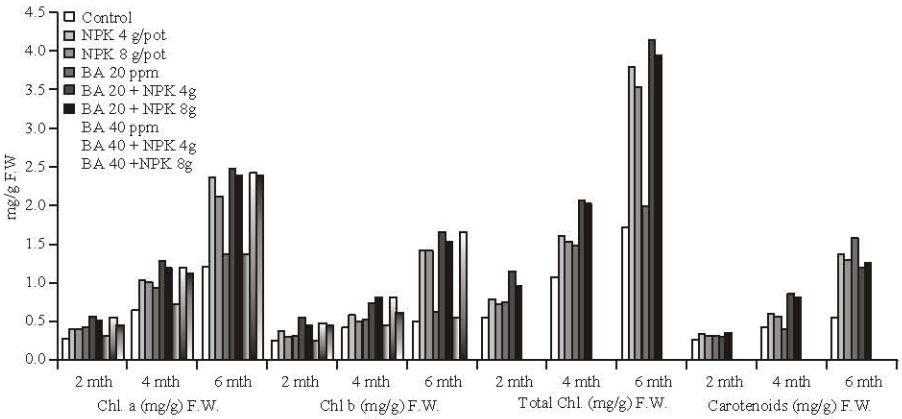

Fig. 3: The influence of foliar application with NPK, BA and their interaction on Chl a ,b ,total chl. and crotenoids of Codiaeum variegatum l. plants

6 months from planting. They were (103.8, 95.0 and 101.3%respectively). compared with control plants, while the highest content of chl b was obtained from the treatments of BA 20 ppm + NPK 4 g, BA 40 ppm + NPK 4g and BA40 ppm +NPK 4 g during 2,4 and 6 months by (108.7, 94.5 and 225.0%, respectively). compared with control. Concerning the highest content of carotenoids, it was obtained with the application of BA at 40 ppm, BA at 20 ppm + NPK 4g and BA at 40 ppm at the 2, 4 and 6 months, over the control by (84.6, 99.7 and 188.5%, respectively).

The interaction between NPK fertilizers and BA doses was significant for total carbohydrates in croton plants. However, croton plants fertilized with NPK at the rate of 4 g pot^{-1} and sprayed with BA 20 ppm gave the highest content in total carbohydrates, the increment reached 59.9% over control.

It could be observed that the lowest percentage of N, P and K were recorded in control leaves of croton plant. However, increasing the rate of NPK fertilizers from 4 g pot^{-1} up to 8 g pot^{-1}, the percentages of N and P were nearly the same,but had a slight decreasing effect on K percent. Table 6 also shows that no clear differences were recorded for N, P and K percentages when plants were sprayed with BA either 20 ppm or 40 ppm, while there were increases could be noted in N, P and K percentages of croton leaves by using NPK fertilizers combined with BA treatment at the concentration of 20 ppm. These results pointed in the same direction of Abou-Dahab [24], El-Fouly [43], El-Sayed [44], Abdel-Wahid [42] and Hassan [45] on *Chlorophytum comosum, Peperomia obtusifolia, Brassaia actinophylla, tuberose and Aspidistra elatior,* respectively, they found that NPK fertilization was the most effective treatment for increasing N, P and K contents.

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