

Effect of Different Ratios Nano-Fertilizer and Gibberellic Acid on the Vegetative Growth and Chemical Compositions of *Codiaeum Variegatum* (L.) cv. Gold Dust

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Received: 11/5/2020

Abstract: A pot experiment was conducted in greenhouse and nursery at Ornamental Farm Faculty of Agriculture, Suez Canal University, Ismailia Governorate Egypt, during the two seasons of 2018 and 2019. The aim of this work is to study the effect of different treatments of Hyper feed Nano-fertilizer NPK (19:19:19) Nano-fertilizer rates (0, 1.5, 3.0, 4.5 g/L) added every 15 days with irrigation water drench on the pot with 400 mL and monthly foliar application with Gibberellic acid (GA₃) at (0, 100, 200 and 300 ppm) either alone or in combination from the 1st of May to the 1st of October on the vegetative growth and some chemical constituents of *Codiaeum variegatum* (L.) cv. Gold dust plants. The results showed that Nano-fertilizer plus GA₃ was the most effective compound to improving all growth parameters of *Codiaeum* plants, followed by Nano-fertilizer, while GA₃ was the second in order. Among Nano-fertilizer treatments, the highest level of Nano-fertilizer at 4.5 g/L was optimum for growth of *Codiaeum* plants. Nano-fertilization every 15 days with Hyper feed Nano-fertilizer NPK (19:19:19) at 4.5 g/l combined with foliar spray of both GA₃ at 300 ppm resulted in the highest significant values for plant height, stem diameter, number of leaves/plant, leaf area and fresh and dry weights of plant, fresh and dry weights of leaves, stems and roots/plant. Data also showed that the previously mentioned combination resulted in the highest contents of N, P, K, Total carbohydrates, and Total chlorophyll in *Codiaeum* leaves.

Keywords: *Codiaeum variegatum*, Nano-fertilizer, Hyper feed, NPK, Gibberellic acid (GA₃)

INTRODUCTION

Production of foliage plants has grown steadily throughout the world due to their attractive foliage growth and leaf colors which varying in shape, size and growth habit etc. In addition, foliage plants production continues to increase rapidly worldwide for outdoor and indoor ornamentation and decoration. However, the production of these plants using the usual fertilization methods is insufficient to meet current demand. The Nano-fertilization and growth regulators such as Gibberellic acid (GA₃) were used as a recent and fast the growth to introduce the required stock plants of the foliage plants to the market in a short time.

Codiaeum variegatum cv. Gold dust commonly known as Croton and sometimes called Joseph's coat, belongs to the Family Euphorbiaceae, is one of the most popular ornamental indoor plants because of colorful foliage colors and various leaf shapes. This plant is essential in decoration for purifying interior air (Esmail, 2008; Elsadek *et al.*, 2012).



Fig. (1): *Codiaeum variegatum* cv Gold Dust

Nano-fertilizers would be a revolution in the field of agriculture. The use of Nano-fertilizers to control food supply can be an economical powerful tool for sustainable agriculture and the environment, with rising Nano-strategies indicating a high surface area-to-volume ratio (Subramanian *et al.*, 2015). Nano-fertilizers improve the availability of nutrients to the growing plants that improves chlorophyll formation, photosynthesis rate, dry matter production and improves overall plant growth (Salama, 2012; Suriyaprabha *et al.*, 2012; Jameel and Al-Tai, 2018).

Additionally, previous study reported that monthly fertilization on containerized *Magnolia grandiflora* L. transplants with Hyper feed Nano-fertilizer NPK (19:19:19) at the medium level 3g/pot was optimum for growth of magnolia transplants (AbdelKader *et al.*, 2016). However, Nano-TiO₂ treated *Spinacia oleracea* seed produced plant recorded more dry weight, higher photosynthetic rate, chlorophyll-a formation compared to the control (Zheng *et al.*, 2005). This improvement translocation of photosynthesis from source (leaves) to sink (economic part of the plant it may be grain, tuber, bulb, stem, fiber and leaves) resulting in improved yield and quality parameters from Nano-fertilizers treated plants compared to control or traditional fertilizers treated plants (Bozorgi, 2012).

On the other hand, the stimulating impact of gibberellic acid (GA₃), which is known to be one of the endogenous growth regulators, could be attributed to its unique roles in plant growth and development as reported by many researchers. GA₃ is the principal component in *Gibberella* culture (Chandran *et al.*, 2020). Meanwhile, the effect of GA₃ on the growth of various plants has been reported by (Leopold, 1964) who stated that GA₃ is

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capable of modifying the growth pattern of treated plants by affecting levels of DNA and RNA, cell division and expansion, biosynthesis of enzymes, protein, carbohydrates and photosynthetic pigments.

On different ornamental plants, several studies examined the beneficial effects of GA₃ at the range of 50-300 ppm including: *chrysanthemum* (Schmidt *et al.*, 2003), *Araucaria heterophylla* (Gul *et al.*, 2006), *Iris nigricans* Dinsm (Al-Khassawneh *et al.*, 2006), *Codiaeum variegatum* (Shedeed *et al.*, 1991; Eid and Abou-Leila, 2006; Soad *et al.*, 2010), *Stevia rebaudiana* Bertoni (Salama, 2008), *Cryptostegia grandiflora* (Hussein, 2009), *Schefflera arboricola* (El-Sayed, 2014; Sardoei and Asil, 2014), *Cupressus macrocarpa* (Ashour, 2018), *Gladiolus grandiflorus* (Farooq *et al.*, 2020) and they indicated that vegetative growth characteristics, contents of nutrients, photosynthetic pigments, total indoles and total soluble phenols were prompted significantly by application GA₃ as well as they concluded that GA₃ is used to regulate plant growth by increasing cell division and elongation.

The objective of this study was to investigate the effect of Hyper feed Nano-fertilizer and Gibberellic acid on the vegetative growth and chemical composition of *Codiaeum variegatum*.cv. Gold Dust.

MATERIALS AND METHODS

Pot experiments were carried out in greenhouse and nursery at Ornamental Farm at Faculty of Agriculture, Suez Canal University, Ismailia Governorate Egypt, during two seasons 2018 and 2019.

The objective of this study was to investigate the effect of either Nano fertilization, Gibberellic acid (GA₃) alone or in combination on the vegetative growth and chemical constituents of *Codiaeum variegatum* (L.) cv. Gold Dust. On March, 1st for both seasons 8-10 cm long cuttings having 2-3 leaves were taken from terminal parts of Croton shoots, of the healthy stock plants grown well in the Farm of Department of Horticulture, Faculty of Agriculture and were planted in pots (10 cm) filled with fertile soil. At the end of March, under the greenhouse conditions (44% shade and full sun, Relative humidity percentage (RH: 58-60%) rooted cuttings were replanted in 18 cm pots filled with a mixture of compost, sand at the proportion of 1:2 (V: V) in both seasons Table (A). Uniformly plants were selected for the experiments, were taken from healthy plants grown in the nursery of the Faculty of Agriculture, Suez Canal University.

Table (A): Some physical and chemical characteristics of the experimental media

Mechanical Analysis						
Sand (%)	Clay (%)		Loam (%)		Texture	
76.2	15.9		7.9		Sandy Loam	
Chemical Analysis						
Density	*O.C (%)	*O.M (%)	*S.P (%)	*E.C (dsm ⁻¹)	PH (1:2.5)	
1.36	0.963	1.66	30	3.23	7.68	
Total N (%)			Total P (%)		Total K (%)	
0.532			0.347		0.10	
Soluble cations (meq·L ⁻¹)			Soluble anions (meq·L ⁻¹)			
SO ₄ ⁻	Cl ⁻	HCO ₃ ⁻	Na ⁺	K ⁺	Mg ²⁺	Ca ²⁺
22.3	6.0	4.20	3.0	0.5	13	16

*O.C: Organic Carbon, *O.M: Organic Matter, *S.P: Saturation Point, *E.C: Electrical Conductivity

On May 1st the plants were irrigated with the dose of Hyper feed every 15 days with irrigation water drench on the pot with 400 mL while, GA₃ was applied as a foliar application with 30 days interval starting one day after Hyper feed application for five months, the plants irrigated when needed. This study included the following treatments: four levels of Nano-fertilizer Hyper feed 0, 1.5, 3, and 4.5 g/L and four levels of spraying of GA₃ 0, 100, 200 and 300 ppm and their interaction at factorial experiment in a completely randomized block, Using 16 treatments, each was replicated three times, five plants per replication, thus 15 plants were used in each treatment design. Uniformly plants were selected for the experiment, Nanotechnology-fertilizer namely Hyper feed motawazen was obtained from the company BIO NANO TECH at Mansoura-Dakahlia-Egypt, which recorded in Table (B). While, Growth regulator as

Gibberellic acid 40% (Berelex sachets, one sachet contains one gram of the active ingredient Gibberellic acid) and attained from Shoura Chemicals at Cairo-Egypt.

At the 1st of October of each season the following parameters were determined in the two successive seasons: Plant height (cm), number of branches/plant, Stem diameter (mm), number of leaves/plant, Root length (cm), Leaf area (cm²) and fresh (F.W) and dry (D.W) weights of leaves, stem and roots/plant (g).

Chlorophyll a and b were determined according to (Von Wettstein, 1957), total carbohydrates in the dry leaves were estimated after (Herbert *et al.*, 1971), N% according to (Ling, 1963) and P% was determined in dry leaves according to (Chapman and Pratt, 1962). K% was determined by flame Photometer according to the method described by (Page *et al.*, 1982).

The data were computed and analyzed using COSTAT program and the differences between the means of treatments were determined by using LSD test after (Heinisch, 1962).

Table (B): Some chemical properties of Nano-fertilization

Hyper Feed (19 – 19 – 19)	
Content	%
Total Nitrogen (N)	19
Phosphor P₂O₅	19
Potassium K₂O	19
Fe	0.48
Mg	0.80
Mn	0.24
Zn	0.35
B	0.05
Cu	0.08
Amino Acid	1.15
Algae Extract	0.52
Mo	100 ppm
Co	100 ppm

RESULTS AND DISCUSSION

Effect of Hyper feed Nano-fertilization and GA₃ on the vegetative growth of Croton plant:

Plant height (cm):

Data in Table (1) and Fig. (1), show that all treatments with Hyper feed, GA₃ and their combinations significantly increased the plant height compared to control plants. With regard to the results of both seasons, it was clear that the tallest plants were produced from plants fertilized with Hyper feed at 4.5g/L and sprayed with GA₃ at 300 ppm. This treatment was the most effective for the production of tallest plants as 60.30 cm compared to 15.48 cm for control in the first season. This was true in the second season. The differences between all treatments were significant. This may be due to a significant increase in the length of the main stem internodes and/or internodes length with respect to the main effect of Nano-fertilizers in modification of plant gene expression and associated biological pathways which ultimately affect plant height as reported by (Ghormade *et al.*, 2011), and increasing plant height may be due to the direct potential effect of GA₃ on both cell division and cell enlargement as mentioned by (Lokesh *et al.*, 2018) on *Stevia rebaudiana* Bertoni. These results are in line with those obtained by (AbdelKader *et al.*, 2016) on *Magnolia grandiflora* L., (Soad *et al.*, 2010) on *Codiaeum variegatum*, they found that the highest values of growth variables were obtained by using Hyper feed (19:19:19) Nano NPK and using GA₃.

Stem diameter (mm):

Data presented in Table (1) show nearly the same trend as that of plant height that all treatments of Hyper feed, GA₃ and their combinations significantly increased the stem thickness for the Croton plants compare to control. In both seasons, Data show that highest dose of Hyper feed (4.5 g/L) combined with highest ratio of GA₃ at 300 ppm gave the thickest stems 11.56 mm compared to 3.21 for control in the first season. The same trend has been achieved in the second season. On the other hand, the differences between all treatments and the control plants were significant. Concerning to the main effect of Nano-fertilizer (Suppan, 2017 and Singh, 2017a) indicated that, Nano-fertilizer enhance stem diameter through, increasing the meristematic activity and stimulation of cell elongation in plants and in this respect, (AbdelKader *et al.*, 2016) on *Magnolia grandiflora* plants reported that mean stem diameter was increased by using Hyper feed. Also, the effect of spraying GA₃ on increasing the stem diameter may be due to the direct possible effect of GA₃ on cellular processes, by stimulating cell division, lengthening cells cause increased growth as indicated by (Sardoei and Asil, 2014 and El-Sayed, 2014) on *Schefflera arboricola* plants.

Number of branches/plant:

Data presented in Table (1) show that all treatments of Hyper feed, GA₃ and combination between them significantly increased the number of branches for the Croton plants over control in both seasons. With respect to both seasonal data also reveals the most effective treatment were the high level of Hyper feed (4.5 g/L) combined with high concentration of GA₃ at 300 ppm gave the highest number of branches as 12, 13.67 compared to 2, 2 for control in both seasons, respectively. The differences between all treatments were significant. Similar results were obtained by (Qureshi *et al.*, 2018), which indicate that Nano-fertilizers significantly improve overall growth of the plant which eventually affect number of branches of plant. Moreover, The effect of spraying GA₃ on increasing the number of branches may be attributed to its impact on stimulating enzymes and proteins biosynthesis, cambial activity cell division and cell elongation as indicated by (Ashour, 2018) on *Cupressus macrocarpa* plants.

Root length (cm):

In the first season, the data of the response of root length to different ratios of Nano-fertilizer and GA₃, revealed that applying Hyper feed at 4.5 g/L plus GA₃ at 300 ppm were the most effective treatment for increasing root length to the maximum value of 34.23 cm for Croton plant (Table 2), the same trend has been achieved in the second season. This treatment significantly increased root length over control. Increasing the root length could be due to reflection of the better vegetative growth of treated plants as affected by Nano-fertilizers as mentioned by (Singh, 2017b). On the other hand, (Ashour, 2018) on *Cupressus macrocarpa* found that GA₃ increased the root length of plants.

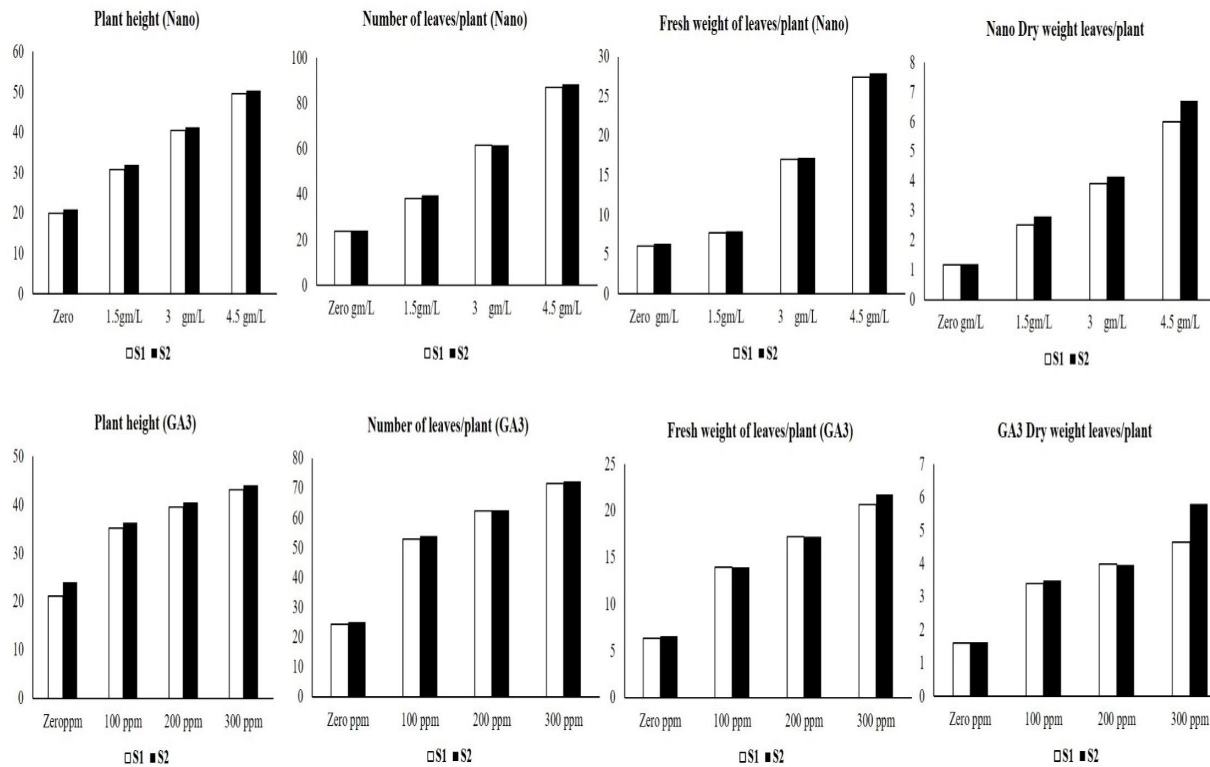


Figure (1): Effect of different ratios of Nano-fertilizer and GA₃ on some vegetative growth parameters of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Number of leaves/plant:

Data in Table (2) and Fig. (1), indicate that the application of different ratios of Hyper feed, GA₃ and combination between them significantly increased the number of leaves of Croton plants over the control. In the first season, the treatment with Hyper feed at 4.5 g/L mixed with GA₃ at 300 ppm gave the highest number which were 117 leaves/plant compared to 16 for control. This was true in the second season. The differences between these treatments were significant in both seasons. Generally, using all ratios of Nano-fertilizer markedly increased the number of leaves/plant. Such increase may be due to the effect of this Nano-fertilizer on increasing plant height and metabolites needed for increasing leaf formation, as mentioned by (Singh, 2017b). Furthermore, the effect of spraying GA₃ on increasing the number of leaves may be attributed to its direct possible impact on enhancing the formation of leaves. Similar results were obtained by (Abdel Kader *et al.*, 2016) on *Magnolia grandiflora* L. and (El-Sayed, 2014) on *Schefflera arboricola* plants found that Hyper feed and GA₃ increased the number of leaves/plant.

Leaves area (cm²):

Data confirmed also, similar trend of results when the leaf area is concerned since the highest levels of Nano-fertilizer plus GA₃ ratios elongated the leaf area as shown in Table (2). It can be seen that, in the both seasons, the largest leaf area was recorded with fertilizing plants with 4.5 g/L of Hyper feed plus 300 ppm of GA₃ for Croton plants. In this regard,

(AbdelKader *et al.*, 2016), reported that leaf area was increased by the use of Hyper feedon *Magnolia grandiflora* L plants. Also, (Sardoei and Asil, 2014) on *Schefflera arboricola* L. plants indicated that leaf area was significantly affected by spraying GA₃.

Fresh and dry weight of leaves/plant (g):

The fresh and dry weight of leaves of Croton plants are presented in Tables (3 and 4) and Fig. (1), indicate that in both seasons, the different ratios of Nano-fertilizer also GA₃ which were used in this study had significant effects on fresh and dry weight of leaves. Nano-fertilization with Hyper feed (4.5 g/L) and spraying (300 ppm) GA₃ markedly increased the fresh and dry weights of leaves of Croton plants compared to control and other treatments. Such increments were significant when compared to control. These increases over control were 37.10, 8.18 g and 38.21, 10.83 in both seasons for Croton plants over control 2.63, 0.66 and 2.58, 0.62, respectively. In this connection, (Singh, 2017b) reported that Nano-fertilizer enhance leaf area index, number of leaves/plant, dry matter production and rate of the photosynthesis which result more production and translocation of photosynthets to different parts of the plant. Similar results were reported by (Jameel and Al-Tai, 2018) on sweet fennel, cumin and anise and (Mahmoodi *et al.*, 2018) on *Borago officinalis* L. As well as, (El-Khateeb *et al.*, 2010) on *Calia Secundiflora* found that GA₃ gave marked increases in the fresh and dry weights of leaves, it can be attributed to the increase both plant height and number of leaves/plant.

Table (1): Effect of Nano-fertilizer Hyper feed and GA₃ on the vegetative growth of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		Plant height number of branches/plant stem diameter														
Hyper Feed	GA ₃	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		15.48	18.53	21.5	24.66	20.04	2	3.33	5	6	4.25	3.21	3.89	4.26	5.46	4.21
1.5 gm/L		20.33	30.46	34.51	38.31	30.90	3.33	4	4.67	7	4.58	4.29	5.65	5.85	6.41	5.55
3 gm/L		25.63	41.43	45.53	49.20	40.45	5	4.67	5.33	8	5.75	5.15	6.24	7.76	8.38	6.88
4.5 gm/L		30.43	50.30	56.40	60.30	49.63	6.33	8.67	11	12	9.50	6.30	9.11	10.32	11.56	9.32
Mean GA ₃		22.97	35.18	39.49	43.12		4.17	5.17	6.5	8.25		4.74	6.22	7.05	7.95	
L.S.D. at 0.05 for Nano						0.186					0.594					0.106
L.S.D. at 0.05 for GA ₃						0.212					0.730					0.101
L.S.D. at 0.05 for Nano×GA ₃						0.426					1.460					0.199
		Second season 2019														
Zero		16.51	19.47	22.53	25.73	21.06	2	4	5	7	4.5	3.51	3.86	4.44	6.46	4.57
1.5 gm/L		21.53	31.65	35.38	39.26	32.00	3.67	4	5	7.33	5	4.67	5.46	5.88	8.46	6.12
3gm/L		26.50	42.50	46.63	49.70	41.33	4.33	4.67	5.33	8.33	5.67	5.71	6.82	7.88	10.40	7.70
4.5 gm/L		31.47	51.43	57.43	61.30	50.41	6.33	8.67	11	13.67	9.92	6.54	9.23	10.73	13.52	10.01
Mean GA ₃		24.00	36.26	40.50	44.0		4.08	5.33	6.58	9.08		5.11	6.34	7.23	9.71	
L.S.D. at 0.05 for Nano						0.192					0.681					0.094
L.S.D. at 0.05 for GA ₃						0.282					0.562					0.144
L.S.D. at 0.05 for Nano×GA ₃						0.564					1.123					0.907

Table (2): Effect of Nano-fertilizer Hyper feed and GA₃ on the vegetative growth of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		No. of leaves/plant					Leaves area (cm) ²					Root length (cm)				
Hyper Feed	GA ₃	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		16	22	26	32	24	60.90	65.51	71.63	77.77	68.95	8.33	11.50	14.27	17.23	12.83
1.5 gm/L		21	36	43	53	38.25	86.59	106.80	112.54	127.74	108.42	13.40	20.47	22.53	24.33	20.18
3 gm/L		27	62	74	84	61.75	92.45	132.43	137.54	142.41	126.21	18.40	25.57	27.30	29.10	25.09
4.5 gm/L		33	92	106	117	87	97.48	147.50	151.38	157.54	138.48	23.40	30.13	32.30	34.23	30.02
Mean GA ₃		24.25	53	62.25	71.5		84.36	113.06	118.28	126.36		15.88	21.92	24.10	26.23	
L.S.D. at 0.05 for Nano						0.381					0.198					0.112
L.S.D. at 0.05 for GA ₃						1.264					0.129					0.100
L.S.D. at 0.05 for Nano×GA ₃						2.528					0.259					0.199
		Second season 2019														
Zero		16	22	26	33	24.25	63.54	68.36	76.48	79.87	72.06	9.23	12.40	15.73	19.30	14.17
1.5 gm/L		23	36	44	55	39.50	89.49	109.50	115.61	129.68	111.07	13.77	21.47	23.40	25.67	21.08
3 gm/L		28	64	72	83	61.75	95.62	135.48	139.87	145.37	129.09	19.40	26.23	28.27	30.40	26.08
4.5 gm/L		34	94	108	118	88.50	99.21	149.64	155.69	158.76	140.82	24.47	31.50	33.57	35.43	31.24
Mean GA ₃		25.25	54	62.50	72.25		86.97	115.64	121.91	128.42		16.72	22.90	25.24	27.70	
L.S.D. at 0.05 for Nano						0.853					0.967					0.112
L.S.D. at 0.05 for GA ₃						0.869					0.719					0.141
L.S.D. at 0.05 for Nano×GA ₃						1.737					1.439					0.889

Table (3): Effect of Nano-fertilizer Hyper feed and GA₃ on the vegetative growth of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		Leaves F.W (g)					Stem F.W (g)					Roots F.W (g)				
Hyper Feed	GA ₃	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		2.63	5.28	7.18	9.22	6.08	1.68	1.86	2.42	3.89	2.46	1.69	2.26	2.64	4.11	2.68
1.5 gm/L		4.33	6.19	9.16	11.22	7.73	2.61	4.24	6.24	8.54	5.41	2.47	4.83	6.84	7.75	5.47
3 gm/L		8.21	15.17	19.13	25.22	16.98	3.55	9.23	11.50	15.25	9.88	3.63	8.12	12.15	15.23	9.78
4.5 gm/L		10.16	29.19	33.19	37.10	27.42	4.47	20.22	26.12	29.18	19.99	4.54	17.09	21.08	25.12	16.96
Mean GA ₃		6.33	13.96	17.21	20.69		3.08	8.89	11.57	14.22		3.08	8.07	10.68	13.05	
L.S.D. at 0.05 for Nano						1.349					0.822					0.491
L.S.D. at 0.05 for GA ₃						0.698					0.758					0.644
L.S.D. at 0.05 for Nano×GA ₃						1.397					1.517					1.283
		Second season 2019														
Zero		2.58	5.28	7.25	10.24	6.34	1.43	2.41	2.86	4.22	2.73	1.60	2.59	3.22	4.26	2.92
1.5 gm/L		4.17	6.25	9.18	12.19	7.94	2.85	4.21	6.20	9.27	5.63	2.81	5.13	7.29	9.49	6.18
3 gm/L		8.28	15.10	19.30	26.25	17.23	3.88	9.57	11.17	16.24	10.21	3.95	8.87	12.60	16.23	10.41
4.5 gm/L		11.25	29.13	33.17	38.21	27.94	5	20.55	26.74	31.26	20.89	4.83	17.88	21.83	27.07	17.9
Mean GA ₃		6.57	13.93	17.22	21.72		3.29	9.18	11.74	15.25		3.30	8.61	11.24	14.26	
L.S.D. at 0.05 for Nano						0.348					0.378					0.263
L.S.D. at 0.05 for GA ₃						0.713					0.535					0.368
L.S.D. at 0.05 for Nano×GA ₃						1.427					1.070					0.735

Table (4): Effect of Nano-fertilizer Hyper feed and GA₃ on the vegetative growth of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		Leaves D.W (g)					Stem D.W (g)					Roots D.W (g)				
Hyper Feed	GA ₃	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		0.66	1.17	1.35	1.54	1.18	0.53	0.64	0.87	1.20	0.81	0.44	0.53	0.74	0.95	0.66
1.5 gm/L		1.68	2.50	2.67	3.16	2.53	0.76	1.62	1.89	2.36	1.66	0.67	1.35	1.48	1.56	1.27
3 gm/L		1.89	3.78	4.36	5.66	3.92	0.98	2.80	3.84	4.29	2.98	0.83	1.84	2.62	3.76	2.26
4.5 gm/L		2.18	6.14	7.49	8.18	5.99	1.37	5.71	6.20	7.71	5.25	1.27	4.14	5.75	6.29	4.37
Mean GA ₃		1.60	3.40	3.99	4.64		0.91	2.69	3.20	3.89		0.80	1.96	2.65	3.14	
L.S.D. at 0.05 for Nano						0.093					0.078					0.104
L.S.D. at 0.05 for GA ₃						0.079					0.083					0.054
L.S.D. at 0.05 for Nano×GA ₃						0.157					0.166					0.107
		Second season 2019														
Zero		0.62	1.19	1.41	1.61	1.21	0.55	0.67	0.83	1.21	0.82	0.47	0.57	0.74	0.95	0.68
1.5 gm/L		1.71	2.49	2.80	4.24	2.81	0.81	1.57	1.91	3.52	1.95	0.63	1.36	1.43	2.65	1.52
3 gm/L		1.93	3.81	4.36	6.5	4.15	0.99	2.81	3.24	5.72	3.19	0.87	1.76	2.29	4.67	2.40
4.5 gm/L		2.26	6.51	7.29	10.83	6.72	1.42	5.15	6.85	9.27	5.68	1.23	4.6	5.2	8.81	4.96
Mean GA ₃		1.63	3.50	3.97	5.80		0.94	2.55	3.21	4.93		0.79	2.07	2.42	4.27	
L.S.D. at 0.05 for Nano						0.147					0.056					0.074
L.S.D. at 0.05 for GA ₃						0.108					0.073					0.075
L.S.D. at 0.05 for Nano×GA ₃						0.213					0.151					0.151

Fresh and dry weight of stem (g):

Data in Tables (3 and 4) revealed that the application of different ratios of Nano-fertilizer and GA₃ increased the fresh and dry weight of stems for Croton plants when compared with control. However, the highest rate of Hyper feed as 4.5 g/L and about GA₃ as 300 ppm gave the heaviest fresh and dry weight of the stem as 29.18, 7.71 g for Croton plants in the first season. This was also true in the second season. The differences between these treatments were significant in both seasons. The increase in the vegetative weight may be attributed to the increase in the plant height and leaves number of treated plants. These results are in agreement with (Mahmoodi *et al.*, 2018) on *Borago officinalis* L. and (Salama, 2012) on *Phaseolus vulgaris* L. and *Zea mays* L. indicated Nano-fertilizers increase availability of nutrient to the growing plant which increase chlorophyll formation, photosynthesis rate, dry matter production and result improve overall growth of the plant. Moreover, (El-Sayed, 2014) on *Schefflera arboricola* found that the application of GA₃ increased the fresh and dry weight of stems.

Fresh and dry weight of roots (g):

The fresh and dry weight of roots as affected by different levels of Nano-fertilizer and GA₃ are presented in Tables (3 and 4). The data indicate that Hyper feed 4.5 g/L and GA₃ 300 ppm gave the heaviest fresh and dry weight of roots/plant of Croton as (25.12, 6.29 g) and (27.07, 8.81 g) in the first and second seasons. In this respect, (Mohamadipoor *et al.*, 2013), on *Spathyphyllum illusion* plant revealed that application of Nano-fertilizer as drench method is better to increase fresh and dry weight of roots because of more activity of root for nutrient uptake from medium, as well as (Ashour, 2018) on *Cupressus macrocarpa* plants showed that the application of GA₃ increased the fresh and dry weight of roots.

Chemical compositions**N, P and K % in leaves:**

The percentage of N, P and K in leaves of Croton plant are shown in Table (5). The results indicate that application of different levels of Nano-fertilizer and GA₃ increased N, P and K % in the leaves. The highest percentages of N, P and K in the leaves were recorded in the plants fertilized with combination of Hyper feed at 4.5 g/L and GA₃ at 300 ppm as 4.72, 0.97, 4.93% and 4.76, 0.98, 4.98% for Croton in the both seasons, respectively compared to 1.25, 0.35, 3.13% and 1.23, 0.38, 3.17% with control. Similar conclusions were reported by Kaviani and Negahdar (2016) on *Buxus hyrcana* Pojark and (Sabir *et al.*, 2014) on grapevines that Nano-fertilizer notably enhanced the concentrations of N, P, K in leaves. In addition, (El-Sayed, 2014) on *Schefflera arboricola* plant concluded that GA₃ increased N, P and K content in the leaves. This increase in mineral composition can be due to the role of GA₃ in stimulating protein synthesis (Eid and Mazher, 2004), as a result of the increase in plant production, the uptake of N, P and K increased.

Chlorophyll a, b and carbohydrates content in leaves:

Data in Tables (6 and 7) showed that the application of different levels of Nano-fertilizer and GA₃ at any levels increased chlorophyll a, b and carbohydrates content in the leaves of Croton plant in both seasons. The highest contents percentage of Chlorophyll a, b and carbohydrates were obtained from the plants fertilized with mixture of Hyper feed at 4.5 g/L and GA₃ at 300 ppm. The same trend has been achieved in both seasons. Logically, a higher content of chlorophyll and total carbohydrates would accurately mean better photosynthesis, hence more assimilates accumulated with the final result of better growth and quality of plant produced. The obtained results are in agreement with those reported by (Kaviani and Negahdar, 2016) on *Buxus hyrcana* Pojark and (Tarafdar *et al.*, 2014) on *Pennisetum americanum* whose found chlorophyll content in leaves was increased with Nano-fertilization. Also, (El-Sayed, 2014) on *Schefflera arboricola* plant indicated that GA₃ increased the total carbohydrates %.

CONCLUSION

From the above results, it could be concluded that the effect of combination of Hyper feed at 4.5 g/L plus GA₃ at 300 ppm on *Codiaeum variegatum* (L.) cv. Gold Dust plant gave the best growth among the other treatments. The control plant gave the least records in this concern. It could be recommended that the application of Hyper feed at 4.5 g/L every 15 days plus monthly foliar spray of GA₃ at 300 ppm are important to increase the vegetative growth and to improve the quality of *Codiaeum variegatum* (L.) cv. Gold Dust plant.

REFERENCES

- AbdelKader, H. H., E. A. H. El-Boraie, A. M. Hamza and M. F. R. Badawya (2016). Effect of mineral fertilization with some growth regulators on growth of *Magnolia grandiflora* L. Seedling. I. Effect on Vegetative Growth. J. Plant Prod., 7: 401-407.
- Al-Khassawneh, N. M., N. S. Karam and R. A. Shibli (2006). Growth and flowering of black iris (*Iris nigricans* Dinsm.) following treatment with plant growth regulators. Sci. Hortic., 107: 187-193.
- Ashour, H. A. (2018). Influence of gibberellic acid and silicon different sources on growth and chemical constituents of Monterey Cypress (*Cupressus macrocarpa*'Goldcrest Wilma') Plants. Middle East J., 7: 210-226.
- Bozorgi, H. R. (2012). Study effects of nitrogen fertilizer management under nano iron chelate foliar spraying on yield and yield components of eggplant (*Solanum melongena* L.). J. Agric. Biol. Sci., 7: 233-237.

Table (5): Effect of Nano-fertilizer Hyper feed and GA₃ on the chemical compositions of *Codiaeum variegatum* (L.) cv. Gold Dust plant leaves during 2018 and 2019 seasons

Parameters	First season 2018															
	GA ₃	N %					P %					K %				
Hyper Feed		Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		1.25	1.43	1.63	1.82	1.53	0.35	0.43	0.45	0.47	0.43	3.13	3.32	3.42	3.81	3.42
1.5 gm/L		2.53	3.03	3.18	3.32	3.01	0.52	0.72	0.74	0.77	0.69	3.94	4.14	4.31	4.42	4.20
3 gm/L		2.75	3.47	3.67	3.87	3.44	0.55	0.83	0.84	0.87	0.78	4.04	4.51	4.55	4.63	4.43
4.5 gm/L		2.92	4.26	4.52	4.72	4.11	0.67	0.93	0.95	0.97	0.88	4.12	4.72	4.82	4.93	4.65
Mean GA ₃		2.36	3.05	3.25	3.43		0.52	0.73	0.75	0.77		3.81	4.17	4.28	4.45	
L.S.D. at 0.05 for Nano						0.012					0.001					0.004
L.S.D. at 0.05 for GA ₃						0.014					0.001					0.005
L.S.D. at 0.05 for Nano×GA ₃						2.810					2.432					3.109
Second season 2019																
Zero		1.23	1.58	1.75	1.96	1.63	0.38	0.44	0.46	0.48	0.44	3.17	3.37	3.48	3.86	3.47
1.5 gm/L		2.63	3.08	3.13	3.38	3.05	0.54	0.73	0.75	0.78	0.70	3.98	4.18	4.33	4.46	4.24
3 gm/L		2.86	3.58	3.73	3.92	3.52	0.56	0.84	0.86	0.88	0.79	4.07	4.54	4.56	4.74	4.48
4.5 gm/L		2.98	4.34	4.62	4.76	4.18	0.68	0.94	0.96	0.98	0.89	4.15	4.78	4.87	4.98	4.69
Mean GA ₃		2.42	3.14	3.31	3.51		0.54	0.74	0.76	0.78		3.84	4.22	4.31	4.51	
L.S.D. at 0.05 for Nano						0.018					0.002					0.029
L.S.D. at 0.05 for GA ₃						0.018					0.002					0.026
L.S.D. at 0.05 for Nano×GA ₃						3.550					4.213					5.154

Table (6): Effect of Nano-fertilizer Hyper feed and GA₃ on the chemical compositions of *Codiaeum variegatum* (L.) cv. Gold Dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		T.C % leaves					T.C % Roots					T.C % Stem				
Hyper Feed	GA ₃	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
Zero		8.33	9.52	9.72	9.92	9.37	6.12	7.43	7.62	7.71	7.22	4.13	5.72	5.81	5.91	5.40
1.5 gm/L		10.28	11.81	12.34	12.42	11.72	8.52	9.12	9.82	9.91	9.35	6.52	7.33	7.51	7.62	7.25
3 gm/L		10.34	13.52	14.72	14.91	13.38	8.73	10.43	10.62	10.81	10.15	6.74	7.74	7.83	7.92	7.56
4.5 gm/L		10.47	15.61	16.52	16.83	14.86	8.93	11.53	11.61	12.72	11.20	6.93	8.52	8.72	9.81	8.10
Mean GA ₃		9.86	12.62	13.33	13.52		8.08	9.63	9.92	10.29		6.08	7.33	7.47	7.82	
L.S.D. at 0.05 for Nano						0.005					0.010					0.004
L.S.D. at 0.05 for GA ₃						0.003					2.349					0.003
L.S.D. at 0.05 for Nano×GA ₃						1.720					4.698					2.176
		Second season 2019														
Zero		8.64	9.56	9.77	9.99	9.49	6.18	7.55	7.68	7.78	7.30	4.18	5.77	5.88	5.99	5.46
1.5 gm/L		10.68	11.85	12.36	12.47	11.84	8.56	9.16	9.87	9.98	9.40	6.56	7.36	7.57	7.68	7.30
3 gm/L		10.89	13.56	14.78	14.97	13.55	8.77	10.46	10.67	10.88	10.20	6.74	7.77	7.88	7.98	7.60
4.5 gm/L		10.98	15.67	16.58	16.89	15.03	8.98	11.55	11.64	12.79	11.24	6.97	8.59	8.78	9.89	8.56
Mean GA ₃		10.30	12.66	13.38	13.58		8.12	9.68	9.97	10.36		6.12	7.37	7.53	7.89	
L.S.D. at 0.05 for Nano						0.006					0.004					0.005
L.S.D. at 0.05 for GA ₃						0.004					0.005					0.004
L.S.D. at 0.05 for Nano×GA ₃						2.780					3.293					2.701

T.C=Total carbohydrate

Table (7): Effect of Nano-fertilizer Hyper feed and GA₃ on the Photosynthetic pigments of *Codiaeum variegatum* (L.) cv. Gold dust plant during 2018 and 2019 seasons

Parameters		First season 2018														
		Chloro. (a)					Chloro. (b) mg/l					Total Chloro. (a+b) mg/l				
GA ₃	Hyper Feed	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano	Zero ppm	100 ppm	200 ppm	300 ppm	Mean Nano
	Zero	0.92	0.94	0.95	1.05	0.97	0.61	0.71	0.76	0.81	0.73	1.53	1.64	1.71	1.86	1.69
	1.5 gm/L	1.12	1.18	1.22	1.26	1.20	0.85	1.01	1.07	1.13	1.02	1.97	2.19	2.28	2.39	2.21
	3 gm/L	1.14	1.33	1.43	1.49	1.35	0.92	1.18	1.24	1.27	1.16	2.06	2.51	2.66	2.73	2.49
	4.5 gm/L	1.16	1.53	1.62	1.73	1.51	0.95	1.33	1.37	1.43	1.27	2.11	2.86	2.99	3.16	2.78
	Mean GA ₃	1.09	1.25	1.31	1.38		0.84	1.06	1.11	1.16		1.92	2.30	2.41	2.54	
	L.S.D. at 0.05 for Nano					0.015					0.008					0.003
	L.S.D. at 0.05 for GA ₃					0.007					0.002					0.004
	L.S.D. at 0.05 for Nano×GA ₃					4.660					4.860					2.310
		Second season 2019														
	Zero	0.95	0.97	0.99	1.08	1.00	0.66	0.74	0.78	0.84	0.76	1.61	1.68	1.74	1.92	1.74
	1.5 gm/L	1.13	1.19	1.24	1.28	1.21	0.87	1.04	1.10	1.15	1.04	2.03	2.23	2.34	2.43	2.26
	3 gm/L	1.15	1.35	1.45	1.48	1.36	0.96	1.21	1.26	1.29	1.18	2.11	2.56	2.71	2.77	2.54
	4.5 gm/L	1.17	1.56	1.66	1.77	1.54	0.99	1.36	1.39	1.46	1.30	2.16	2.92	3.05	3.24	2.85
	Mean GA ₃	1.10	1.27	1.34	1.41		0.87	1.09	1.13	1.19		1.98	2.35	2.46	2.59	
	L.S.D. at 0.05 for Nano					0.004					0.004					0.019
	L.S.D. at 0.05 for GA ₃					0.005					0.004					0.011
	L.S.D. at 0.05 for Nano×GA ₃					3.260					2.701					2.282

Chloro: Chlorophyll

- Chandran, V., S. Shahena, M. Rajan and L. Mathew (2020). Controlled release of plant hormones for modifying crop yield, in: Controlled Release of Pesticides for Sustainable Agriculture, pp. 253-266. Springer, Cham.
- Chapman, H. D. and P. E. Pratt (1962). Methods of analysis for soils, plants and waters. Soil Sci., 93: 68.
- Eid, R. A. and B. H. Abou-Leila (2006). Response of Croton plants to gibberellic acid, benzyl adenine and ascorbic acid application. World J Agric Sci., 2: 174-179.
- Eid, R. A. and A. A. M. Mazher (2004). Effect of gibberellin spray on growth and some chemical constituents of *Casuarina gluca* seedlings grown under diluted sea water conditions. J. Agric. Sci. Mansoura Univ., 29: 7305-7320.
- El-Khateeb, M. A., E. A. Nasr, A. N. Fahmy and A. H. H. Dorgham (2010). Effect of GA3 and growth biostimulants on growth and chemical composition of *Califia secundiflora* plants. J. Hortic. Sci. Ornament. Plants, 2: 118-124.
- El-Sayed, M. (2014). Effect of Gibberellic acid and Paclobutrazol on growth and chemical composition of *Schefflera arboricola* plants. Middle East J., 3: 782-792.
- Esmail, S. E. A. (2008). Physiological studies on Croton plant. PhD Thesis.
- Ghormade, V., M. V. Deshpande and K. M. Paknikar (2011). Perspectives for nano-biotechnology enabled protection and nutrition of plants. Biotechnol. Adv., 29: 792-803.
- Gul, H., A. M. Khattak and N. Amin (2006). Accelerating the growth of *Araucaria heterophylla* seedlings through different gibberellic acid concentrations and nitrogen levels. J Agric Biol Sci., 1: 25-29.
- Heinisch, O. (1962). Steel, RGD, and JH Torrie: Principles and Procedures of Statistics. (With special Reference to the Biological Sciences) McGraw-Hill Book Company, New York, Toronto, London 1960, 481 S., 15 Abb.; 81 s 6 d. Biometrische Zeitschrift, 4: 207-208.
- Herbert, D., P. J. Philipps and R. E. Strange (1971). Carbohydrate analysis. Methods Enzym, B5: 265-277.
- Hussein, M. M. M. (2009). Effect of gibberellic acid and chemical fertilizers on growth and chemical composition of *Cryptostegia grandiflora*, R. Br. plants. Mansoura Univ. J. Agric. Sci.
- Jameel, D. A. and A. A. S. Al-Tai (2018). Effect of NPK compound fertilizer normal and nano on some growth traits and oil content of three species of Apiaceae plants. Res. J. Pharm. Technol., 11: 301-307.
- Kaviani, B. and N. Negahdar (2016). Effects of biological nano-fertilizer on the morphological, physiological and proliferation traits and quality of *Buxus hyrcana* Pojark. Bangladesh J. Bot. 45, 1135-1142.
- Leopold, A. C. (1964). Plant growth and development. Plant Growth Dev.
- Ling, E. R. (1963). Determination of total nitrogen by semimicro Kjeldahl method. Dairy Chem., 11: 23-84.
- Lokesh, C. H., J. S. Hiremath, P. S. Mahantesh, A. G. Sharatbabu, M. R. Pooja and M. Nishchitha (2018): Effect of nitrogen and GA3 on suppression of flowering for enhancement of vegetative phase in stevia (*Stevia rebaudiana* Bertoni.). Int J Curr Microbiol App Sci., 7: 412-419.
- Mahmoodi, P., M. Yarnia, V. Rashidi, R. Amirnia and A. Tarinejhad (2018). Effects of nano and chemical fertilizers on physiological efficiency and essential oil yield of *Borago officinalis*. Appl Ecol Env. Res., 16: 4773-4788.
- Mohamadipoor, R., S. Sedaghatthoor and A. M. Khomami (2013). Effect of application of iron fertilizers in two methods 'foliar and soil application' on growth characteristics of *Spathyphyllum illusion*. Eur J Exp Biol., 3: 232-239.
- Page, A. L., R. H. Miller and D. R. Keeney (1982). Methods of soil analysis, part 2. Chem. Microbiol. Prop. 2.
- Sabir, A., K. Yazar, F. Sabir, Z. Kara, M. A. Yazici and N. Goksu (2014). Vine growth, yield, berry quality attributes and leaf nutrient content of grapevines as influenced by seaweed extract (*Ascophyllum nodosum*) and nanosize fertilizer pulverizations. Sci. Hortic., 175: 1-8.
- Salama, A. (2008): Morphological, anatomical and chemical studies on stevia plant and its response to the growth regulator GA3. J. Hortic. Sci., 2: 23-25.
- Salama, H. M. (2012). Effects of silver nanoparticles in some crop plants, common bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). Int Res J Biotechnol., 3: 190-197.
- Sardoei, A. S. and M. H. Asil (2014). Response of application of gibberellic acid and benzyladenine to *schefflera (schefflera arboricola* l.) plants. Dama International, 3.
- Schimidt, C. M., R. A. Bellé, C. Nardi, K. Toledo and A. dos (2003). The gibberellic acid (GA), in the cut chrysanthemum (*Dedranthema grandiflora* Tzevelev.)" viking": planting summer/autumn. Ciênc. Rural Braz.
- Shedeed, M. R., K. M. El-Gamassy, M. E. Hashim and A. M. N. Al-Mulla (1991). Effect of fulfertil fertilization and growth regulators on the vegetative growth of Croton plants. Ann. Agric. Sci. Egypt.
- Singh, M. D. (2017a). Nano-fertilizers is a new way to increase nutrients use efficiency in crop production. Int. J. Agric. Sci. ISSN 0975-3710.
- Singh, M. D. (2017b). Nano-fertilizers is a new way to increase nutrients use efficiency in crop production. Int. J. Agric. Sci. ISSN 0975-3710.
- Soad, M. M. I., T. S. Lobna and M. M. Farahat (2010). Vegetative growth and chemical constituents of Croton plants as affected by foliar application of benzyl adenine and gibberellic acid. J. Am. Sci., 6.

- Subramanian, K. S., A. Manikandan, M. Thirunavukkarasu and C. S. Rahale (2015). Nano-fertilizers for balanced crop nutrition, in: Nanotechnologies in Food and Agriculture. Springer, pp. 69-80.
- Suppan, S. (2017). Applying nanotechnology to fertilizer: Rationales, research, risks and regulatory challenges, in: The Institute for Agriculture and Trade Policy Works Locally and Globally. This Article Originated as a Presentation in Spanish via Skype to an International Seminar of the Brazilian Research Network on Nanotechnology, Society and Environment, 21 pp. Brazil.
- Suriyaprabha, R., G. Karunakaran, R. Yuvakkumar, V. Rajendran and N. Kannan (2012). Silica nanoparticles for increased silica availability in maize (*Zea mays* L.) seeds under hydroponic conditions. *Curr. Nanosci.*, 8: 902-908.
- Tarafdar, J. C., R. Raliya, H. Mahawar and I. Rathore (2014). Development of zinc nanofertilizer to enhance crop production in pearl millet (*Pennisetum americanum*). *Agric. Res.*, 3: 257-262.
- Von Wettstein, D. (1957). Chlorophyll-letale und der submikroskopische Formwechsel der Plastiden. *Exp. Cell Res.*, 12: 427-506.
- Zheng, L., F. Hong, S. Lu and C. Liu (2005). Effect of nano-TiO₂ on strength of naturally aged seeds and growth of spinach. *Biol. Trace Elem. Res.*, 104: 83-91.

تأثير المعدلات المختلفة من أسمدة النانو وحمض الجبريليك على النمو الخضري والمحتوى الكيماوى لنبات الكروتون "صنف العدسى"

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أجرى هذا البحث بمزرعة قسم البساتين كلية الزراعة جامعة قناة السويس بمحافظة الإسماعيلية خلال موسمي ٢٠١٨ & ٢٠١٩ بهدف دراسة تأثير تركيزات (صفر، ١,٥، ٣، ٤,٥) جرام/لتر من السماد المركب التجاري والمصنع بتقنية النانوتكنولوجى (هيبيرفييد) المتوازن ١٩:١٩:١٩ نتروجين: فوسفور: بوتاسيوم وهذا السماد منتج من شركة بايونانوتكنولوجى لإنتاج الأسمدة و الرش بـحمض الجبريليك شهريا بالمستويات (صفر، ١٠٠، ٢٠٠، ٣٠٠) جزء في المليون، إما منفردا أو مجتمعة من أول شهر مايو ولمدة ٥ شهور على النمو الخضري والمركبات الكيماوية لنباتات الكروتون. وقد تم تسميد نباتات الكروتون مرة كل ١٥ يوم بسماد الهيبيرفييد بإضافته إلى ماء الري بمعدل ٤٠٠ مل/نبات خلال فترة الرش بـحمض الجبريليك مرة كل شهر. وكانت أهم النتائج المتحصل عليها كالتالى: أدى إضافة التركيزات المختلفة من كلاً من: سماد الهيبيرفييد والجبريللين إلى زيادة طول النبات وسمك الساق وعدد الأوراق، والمساحة الورقية، وطول الجذر وزيادة محتوى الأوراق من الكلوروفيل أ، ب والكلوروفيل الكلى والنسبة المئوية لكل من الكربوهيدرات والنتروجين والفوسفور والبوتاسيوم لنباتات الكروتون. وأظهرت النتائج أن المعاملة الأكثر فاعلية لتحسين نمو نباتات الكروتون كانت عند استخدام المزيج من سماد الهيبيرفييد بمعدل ٤,٥ جرام/لتر والجبريللين بمعدل ٣٠٠ جزء في المليون حيث حققت أعلى القيم من ارتفاع النبات وسمك الساق وعدد الأفرع وعدد الأوراق والمساحة الورقية، وطول الجذر والوزن الجاف والرطب لكلاً من الأوراق والجذور والساق وكذلك أعطت أعلى زيادة معنوية من محتويات النتروجين والفوسفور والبوتاسيوم والكلوروفيل والكربوهيدرات في أوراق نباتات الكروتون. من النتائج السابقة يمكن أن يوصى باستخدام سماد النانو هيبيرفييد المتوازن ١٩:١٩:١٩ بمعدل ٤,٥ جرام/لتر مرة كل ١٥ يوم و الرش بالجبريللين شهرياً بمعدل ٣٠٠ جزء في المليون للحصول على أفضل نمو خضري ومحتوى كيماوي لنبات الكروتون للوصول بالشتلات إلى حجم من النمو يصلح للتسويق في أقصر وقت ممكن.