World Journal of Agricultural Sciences 9 (4): 335-344, 2013
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2013.9.4.1759

Synergistic Effect of Indole Acetic Acid and Kinetin on Performance, Some Biochemical Constituents and Yield of Faba Bean Plant Grown under Newly Reclaimed Sandy Soil

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Abstract: Two field experiments were conducted at the Research and Production Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt during two successive winter seasons 2011/2012 and 2012/2013 to study the effect of indole acetic acid (IAA) at 0, 50 and 75 mg/l and kinetin (Kin) at 0, 50, 75 and 100 mg/l individually or in combination on two faba bean cultivars (Nubaria 1 and Giza 843). Results revealed that IAA and/or Kin treatments had positive effects on growth criteria (plant height, leaves number, fresh and dry weight per plant), photosynthetic pigments (chlorophyll a, b and carotenoids), total carbohydrate, polysaccharide, free amino acid, proline and total phenolic contents in the two cultivars. Furthermore, endogenous hormones (IAA, GA_3 and zeatin) were increased concomitantly with decrease in ABA content particularly at treatment of 50 mg/l IAA + 75 mg/l kinetin in the two cultivars. Seed yield and yield components (number of pods/plant, pods yield /plant, 100 seeds weight and biological yield/plant) as well as total carbohydrates and proteins in the yielded seeds were significantly improved at all treatments in the two cultivars. Meanwhile, vicine contents were significantly decreased at all treatments. It is worthy to mention that, performance of Nubaria 1 cultivar was more pronounced than that of Giza 843 cultivar when grown under newly reclaimed sandy soil conditions i.e. Under control treatment, seed yield/faddan (one faddan= 0.42 ha) of Nubaria 1 cultivar was 47.17% over that of Giza 843 cultivar. Meanwhile, response of Giza 843 cultivar to all applied treatments was more effective than Nubaria 1 cultivar.

Key words: Chemical composition · Growth promoters · New lands · Vicine · *Vicia faba* · Yield

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important legumes in the Middle East countries and its cultivation leads to the increase of soil nitrogenous compounds. Faba bean seeds are excellent sources of proteins (20-40%), carbohydrates (50-60%) and fairly good sources of thiamin, niacin, calcium and iron [1]. On the other hand, seeds contain toxic glycosides as pyrimidine derivatives namely vicine (2, 6, diamino-4, 5-dihydroxypyrimidine, 5, B-glycopyranosoide) that decreased the nutritive value of faba bean and responsible for favism in humans [2]. The highest vicine content was in fresh green cotyledons that gradually declined until the dry matter percentage of seeds reached about 40% [3]. In Egypt, the balance between production and consumption of faba bean represented about 60 % of the national demands. For this reason, efforts should be directed towards increasing and improving faba bean yield, in order to minimize the gap between production and consumption. Therefore, increasing plant productivity is one of the main targets in Egyptian agricultural policy, this could be achieved either by horizontal expansion (cultivation in newly reclaimed land) or by vertical expansion (using growth regulators). Egyptian newly reclaimed sandy land is characterized as arid and semi-arid regions with poor soil nutrients, low organic matter, low water holding capacity and unfavorable environmental conditions (drought, temperature fluctuation, etc). These factors reduced plant growth and development as well as limited the crop production.

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Plant growth regulators (PGRs) are known to influence plant growth and development at very low concentrations but inhibit plant growth and development at high concentrations [4]. Moreover, response of plant to PGRs may vary with species, varieties, environmental conditions, physiological and nutritional status, stage of development and endogenous hormonal balance [5]. Plants have the ability to store excessive amounts of exogenously supplied hormones in the form of reversible conjugates which release active hormone when the plants need them during the growth period [6]. Ammanullah *et al*. [7] mentioned that plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink thereby helping in effective flower formation, fruit and seed development and ultimately enhancing the productivity of crops. Of the various plant growth regulators which regulate growth under normal or stress conditions are auxins. Generally, auxins are the best hormones for use because they are non-toxic to plants over a wide range of concentration and effective in promoting root system of large number of plant species. Auxins might regulate cell elongation, cell division, tissue swelling, formation of adventitious roots, callus initiation, induction of embryogenesis and promoting cell wall loosening at very low concentrations [8]. The principal auxin in plants is indole-3-acetic acid (IAA) that produced mainly in the shoot apex bud and young leaves of plants. Other meristematic tissues, flowers, fruits and young seeds have also been shown to be sites of this hormone production. IAA has wide range of effects on many processes such as cell division, vascular tissue differentiation, root initiation, flowering, fruit setting, ripening, senescence and gravitropism [9]. Furthermore, IAA stimulated cell elongation and apical dominance [10], increased photosynthetic activities [11] and activated the translocation of carbohydrates during their synthesis [12].

Closely associated in function with auxins are another group of endogenous plant growth substances, the cytokinins. The major site of cytokinin biosynthesis in higher plants is the root, then transported to the aerial portions of the plant through the xylem. These hormones have potent effects on plant physiology and are intimately involved in the regulation of cell division, apical dominance, chloroplast development, anthocyanin production and maintenance of the source-sink relationship [13]. In addition, cytokinins are regarded as the most important senescence-retarding hormones and their exogenous application has been demonstrated to prevent the degradation of chlorophyll and photosynthetic proteins as well as reverse leaf and fruit abscission [14]. Kinetin is synthetic cytokinins known to significantly improve plant growth and development even grown under environmental stress. It stimulates leaf expansion, development of reproductive organs and delays senescence [15]. The simultaneous interaction of growth hormones i.e. auxins and cytokinins in regulating various aspects of growth and differentiation appears to be a general feature of higher plants.

This study aimed to investigate the influence of foliar application of IAA and/or kinetin on growth, yield and its components as well as some biochemical constituents of two faba bean cultivars grown under newly reclaimed sandy soil.

MATERIALS AND METHODS

Plant Materials and Experimental Conditions: Two field experiments were conducted at the Research and Production Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt, during two successive winter seasons of 2011/2012 and 2012/2013 The seeds of two faba bean cultivars (Nubaria 1 and Giza 843) were obtained from the Legumes Crops Research Department, Agricultural Research Center, Giza, Egypt. The physical and chemical soil analysis was determined according to Chapman and Pratt [16] as shown in Table 1.

The experiments were laid out in split-split plot design with three replicates/ treatment. Faba bean cultivars were randomly assigned in main plots, while IAA at three concentrations (0, 50 and 75 mg/l) were distributed randomly in sub-plots and kinetin at four concentrations (0, 50, 75 and 100 mg/l) were randomly assigned in sub-sub plots. The plot area was 10.5 m^2 (3 meter long and 3.5 meter width and 60 cm apart between rows i.e. equal 1/400 faddan (one faddan =0.42 ha). Seeds of faba bean were sown in hills spaced 20 cm apart at both sides of ridge on the middle on November during the two growing seasons. Thinning was carried out at 15 days after sowing (DAS) to leave two plants per hill. Phosphorus and potassium fertilizers in the form of calcium super-phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) were added during seed bed preparation at the level of 31 and 24 kg/faddan, respectively, while nitrogen fertilizer as ammonium nitrate (33.5% N) was added at the rate of 75 kg N/faddan. Irrigation was carried out using the sprinkler irrigation system where plants were irrigated every 5 days for two hours. The plants were sprayed twice at 45 and 60 days

Table 1: Physical and chemical analysis of experimental soil.

Season	Sand %	Silt %	Clay %	Soil texture	pH	OM %	$CaCO_3$ %	EC dS/m	Soluble N (ppm)	Available P (ppm)	Exchangeable K (ppm)
2011/2012	91.2	3.7	5.1	Sandy	8.1	0.30	1.4	0.3	8.1	3.2	20.0
2012/2013	92.3	3.9	3.8	Sandy	7.9	0.26	1.5	0.3	9.2	4.1	22.1

after sowing with freshly prepared solutions of IAA and Kin at different levels individually or in combination. Meanwhile, untreated plants were sprayed by distilled water to serve as control.

Data Recorded: Plant samples were collected at 75 DAS for determination of some growth parameters (plant height, leaves number/plant, fresh and dry weights per plant), photosynthetic pigments, total soluble carbohydrate, total carbohydrate, total free amino acid, proline, total phenolic contents and endogenous growth hormones (IAA, GA_3, ABA, Zeatin, Zeatin riboside and Zeatin glucoside). At harvest the following characters were recorded at random of ten guarded plants from each plot: number of pods/plant, pods yield/plant (g), seed yield/plant (g), 100 seeds weight (g) and biological yield/plant (g). The whole plot was harvested to determine seed yield/ faddan (Kg). The yielded seeds were cleaned and crushed to determine total carbohydrate, total protein and vicine content.

Chemical Analysis: Chlorophyll a, chlorophyll b and carotenoids were determined using method described by Moran [17]. Total soluble carbohydrates were determined according to Smith *et al.* [18]. The phenol-sulphuric acid method was used for the determination of total carbohydrates [19]. Polysaccharides were calculated by subtracting total soluble carbohydrates from total carbohydrates. Free amino acid content was determined with the ninhydrin reagent method [20]. Proline was estimated according to Bates *et al*. [21]. Total phenolic compounds were determined according to the method described by Zhang and Wang [22]. Based on the results of first season (2011/2012), the most promising treatments were selected for determination of endogenous regulators. These endogenous growth hormones namely auxins (as indole acetic acid IAA), gibberellic acid (as GA_3), abscisic acid (ABA) and cytokinins (as zeatin) were extracted according to Wasfy and Orrin [23]. IAA, GA_3 and ABA contents were determined by Gas Liquid Chromatography (GLC) according to the method described by Wasfy and Orrin [23] and cytokinin content was determined by High Performance Liquid Chromatography (HPLC) according to the method described by Muller and Hilgenberg [24]. The protein content in the yielded seeds was determined according to Bradford [25]. The vicine content of the yielded seeds was determined according to Ramasay and Griffiths [26].

Statistical Analysis: The statistical analysis of the obtained results were carried out according to Snedecor and Cochran [27] and the combined analysis was conducted for the data of the two seasons after tested the variances homogeneity of both seasons according to Gomez and Gomez [28]. The least significant difference (LSD) was used to compare between different means.

RESULTS AND DISCUSSION

Growth Criteria: Data of the vegetative growth criteria of the two faba bean cultivars under the effect of applied growth regulators are presented in Table 2. The obtained results show that application of the two growth regulators

Table 2: Effect of IAA and/or Kin on growth criteria of two faba bean cultivars at 75 days after sowing (average of two seasons)

Treatments		Plant height (cm)		Leaves number/plant		Plant fresh weight (g)		Plant dry weight (g)	
IAA mg/l	Kin mg/l	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	48.50	40.00	13.00	13.00	27.30	23.65	4.90	3.69
	50	52.00	43.00	14.00	13.50	32.60	25.90	5.33	4.91
	75	56.50	44.50	14.00	15.50	33.05	28.90	6.65	5.50
	100	60.00	46.00	14.50	16.00	38.95	30.15	8.00	5.90
50	0	51.90	43.15	14.50	15.67	30.65	26.77	6.40	5.00
	50	56.00	44.69	15.00	16.00	41.30	37.80	8.05	5.90
	75	66.50	55.00	18.00	17.67	45.00	40.00	8.72	7.35
	100	65.00	53.00	17.00	17..00	43.60	39.80	8.40	6.65
75	0	54.00	45.50	14.50	16.00	35.33	34.15	7.75	6.02
	50	61.00	51.00	15.00	16.33	39.25	36.00	7.95	6.50
	75	65.50	53.50	16.00	16.00	42.75	39.45	8.05	7.05
	100	63.00	50.00	15.00	15.67	40.75	39.58	8.00	6.05
LSD at 5%		2.13		0.15		1.55		0.11	

Table 3: Effect of IAA and/or Kin on photosynthetic pigments (mg/g fresh weight) of two faba bean cultivars at 75 days after sowing (average of two seasons)

Treatments		Chlorophyll a		Chlorophyll b		Carotenoids		Total pigments	
IAA mg/l	Kin mg/l	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	1.303	1.025	1.114	0.964	0.313	0.281	2.730	2.270
	50	1.456	1.152	1.118	0.998	0.352	0.306	2.926	2.456
	75	1.688	1.352	1.321	1.073	0.476	0.363	3.485	2.788
	100	1.921	1.425	1.407	1.125	0.624	0.378	3.952	2.928
50	0	1.548	1.254	1.301	1.024	0.399	0.348	3.248	2.626
	50	1.624	1.724	1.493	1.215	0.432	0.381	3.549	3.320
	75	2.346	1.823	1.692	1.415	0.497	0.462	4.535	3.700
	100	2.146	1.789	1.591	1.314	0.452	0.463	4.189	3.566
75	0	1.821	1.385	1.521	1.247	0.424	0.403	3.766	3.035
	50	2.043	1.754	1.787	1.315	0.434	0.432	4.264	3.501
	75	2.200	1.809	1.569	1.351	0.484	0.435	4.253	3.595
	100	2.094	1.740	1.324	1.274	0.432	0.435	3.850	3.449
LSD at 5%		0.046		0.036		0.012		0.138	

(IAA and Kin) individually or in combination caused significant increases in the growth criteria (plant height, number of leaves/ plant, fresh and dry weight of plant) in both cultivars as compared with control plants. The highest values of growth criteria were obtained from the application of 50 mg/l IAA + 75 mg/l Kin treatment as compared with those obtained from the control and other treatments. On the other hand, the lowest values of growth criteria were recorded by control. Regarding IAA treatments individually, it was found that treating the two faba bean cultivars by 75 mg/l IAA was the most effective treatment. Meanwhile, the most effective Kin treatment individually was 100 mg/l. These findings were true in the two cultivars. It is worthy to mention the superiority of Nubaria 1 cultivar over Giza 843 cultivar in plant height as well as fresh and dry weight of plant at all applied treatments. IAA was reported to augment the growth and development of plants by stimulating a wide range of processes, including cell elongation and tissue growth, phototropism and gravitropism, apical dominance, lateral root initiation, differentiation of vascular tissues, embryogenesis, senescence, fruit setting and ripening [9]. In addition, the promoting effect of IAA may be attributed to enlarging leaves and increasing photosynthetic activities [11], increasing cell division and accumulation of building units accompanied by greater saccharides content [29]. These increments in growth criteria (Table 2) under the effect of IAA treatments are similar to those reported by Eleiwa *et al*. [30] on barley and Kaya *et al*. [31] on maize. The promoting effect of kinetin may be ascribed to stimulating the mobilization of nutrients towards the buds thereby increasing cell division and/or increasing the differentiation of the vascular connection between the axillary buds and the main stem [32]. The increments in plant height may be due to the role of kinetin in increasing cell division in apical meristems and cambium. In addition, the increments in the fresh and dry weight of faba bean plant could be explained through the role of kinetin in stimulating xylem differentiation, consequently more absorption of water and nutrients from the soil, which reflected on growth. The obtained data due to kin treatments are similar to those obtained by Yarnia and Tabrizi [33] on onion plant.

Photosynthetic Pigments: The changes in chlorophyll a, chlorophyll b, carotenoids and total photosynthetic pigments in response to IAA and/or Kin treatments are shown in Table 3. Data reveal that IAA and/or Kin treatments caused significant increases in photosynthetic pigment constituents as compared with corresponding controls in the two cultivars. The highest values of total photosynthetic pigments in the two cultivars were recorded by treatment of 50 mg/l IAA+ 75 mg/l kin. The obtained results of IAA treatments are similar to those obtained by Ibrahim *et al.* [34] on faba bean and Kaya *et al*. [31] on maize. Jacobs [35] found that, IAA presumably acts as a coenzyme in the metabolism of higher plants, thus it plays an important role in the formation of the photosynthetic pigments. These increases in pigments content may be attributed to the promotion of pigments synthesis and/or retardation of pigments degradation [36]. Further, the role of Kin in increasing the photosynthetic pigments in the two faba plants cultivars was confirmed earlier by Ibrahim *et al.* [37] on *Vicia faba* and Alam *et al*. [38] on *Catharanthus roseus*. It has been also recorded that cytokinin retarded chlorophyll breakdown via inhibition of chlorophyllase [39]. Petrenko and Biryukova [40] deduced that kinetin increased the concentration of carotenoids which protect chlorophylls against photo-oxidation process.

Table 4: Effect of IAA and/or Kin on endogenous hormones (µg/100 g fresh weight) of two faba bean cultivars at 75 days after sowing.

Treatments		IAA		GA_3		ABA		Zeatin		Zeatin riboside		Zeatin glucoside	
IAA (mg/l)	Kin (mg/l)	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	48.54	43.56	54.35	42.35	20.35	22.35	30.35	25.68	13.35	11.67	8.35	8.12
0	100	70.36	53.65	62.35	65.35	18.36	20.35	49.35	46.68	20.68	21.68	16.35	11.35
50	75	96.35	84.35	88.35	75.35	14.36	17.35	60.35	59.35	27.35	23.35	19.25	14.35
75	0	88.35	74.35	72.35	69.25	16.35	18.69	40.35	38.39	18.00	17.35	11.68	9.98

Table 5: Effect of IAA and/or Kin on carbohydrate constituents (%), free amino acid, proline and phenolic contents (mg/100g dry weight) of two faba bean cultivars at 75 days after sowing (average of two seasons)

Treatments		Total soluble carbohydrates		Polysaccharides		Total carbohydrates		Free amino acid		Proline		Phenolic contents	
IAA (mg/l)	Kin (mg/l)	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	1.48	1.38	18.41	15.38	19.89	16.76	92.71	82.40	39.91	30.07	114.75	120.51
	50	1.44	1.45	18.91	16.31	20.35	17.76	114.50	109.44	46.72	33.56	140.23	141.58
	75	1.42	1.54	19.97	18.44	21.39	19.98	129.25	120.84	63.37	41.47	153.71	148.77
	100	1.38	1.63	19.75	19.19	21.13	20.82	134.39	132.34	83.09	52.97	161.79	166.29
50	0	1.49	1.56	20.03	19.44	21.52	21.00	138.13	131.68	54.21	45.52	150.56	157.75
	50	1.51	1.40	21.34	19.95	22.85	21.35	153.00	139.91	67.29	52.71	151.46	161.79
	75	1.55	0.98	22.70	22.96	24.25	23.94	190.94	164.39	92.15	78.60	177.89	177.98
	100	1.69	0.82	20.63	20.39	22.32	21.21	175.55	144.39	78.72	72.43	171.93	167.64
75	0	1.57	1.37	19.55	19.76	21.12	21.13	143.00	136.35	65.52	53.04	162.20	172.59
	50	1.48	0.90	21.36	20.64	22.84	21.54	144.95	117.95	81.93	63.04	168.54	175.00
	75	1.40	0.86	22.62	22.81	24.02	23.67	161.83	127.76	82.53	62.61	172.58	175.28
	100	1.33	0.61	21.67	21.53	23.00	22.14	166.92	153.27	83.93	76.27	175.28	170.79
LSD at 5%		0.02		0.57		0.38		15.22		3.17		3.11	

Endogenous Phytohormones: Based on the obtained results in the first season, 75 mg/l IAA and 100 mg/l Kin as individual treatments as well as treatment of 50 mg/l IAA+75 mg/l Kin as combined treatments were selected for determination of endogenous growth regulators as shown in Table 4. Data show that individual treatments of 75 mg/l IAA and 100 mg/l Kin as well as combined treatment of 50 mg/l IAA + 75 mg/l Kn increased IAA, GA_3 and cytokinins (zeatin, zeatin riboside and zeatin glucoside) contents concomitant with decline in ABA contents in the two faba bean cultivars. It is clear that, IAA at 50 mg/l + Kin at 75 mg/l was the most effective treatment as it caused the highest contents of growth phytohormones (IAA, GA_3 and cytokinins) and the lowest contents of ABA in both cultivars. The increases in the content of the endogenous growth promoters might be attributed to the increase in their biosynthesis and/or decrease in their degradation and conjugation. The obtained results concerning the effect of IAA are similar to those of El-Saeid *et al*. [41] on cowpea and Barakat [42] on wheat. Regarding the stimulating effect of Kin, the obtained results are similar to those reported by Khalil *et al*. [43] on lentil. In this connection, Letham *et al*. [44] reported that cytokinins increased auxin contents in treated tissues by retarding the destruction of endogenous auxin through decreasing the activity of IAA-oxidase and causes a slight increase in the level of free IAA as well as preventing the transformation of active free auxins into inactive forms. Moreover, Hopkins and Hünter [45] mentioned that exogenously applied growth promoters had potent effects in protecting zeatin and zeatin riboside from oxidation by cytokinin oxidase and the exogenously applied kinetin may be converted into more stable cytokinin compound. On the other hand, the decline in ABA contents could be attributed to the shift of the common precursor isopentenyl pyrophosphate into the biosynthesis of cytokinins and/or gibberellins instead of ABA [45].

Carbohydrate Constituents: Total carbohydrate and polysaccharide contents of the two faba bean cultivars were significantly increased in response to different concentrations of IAA and/or Kin treatments as compared with those of control plants (Table 5). The maximum increases in the two parameters were observed at treatment of 50 mg/l IAA and+75 mg/l Kin in both cultivars. Regarding soluble carbohydrates, it was found that two faba bean cultivars showed opposite responses to Kin treatments individually as well as combination between 50 mg/l IAA+ all levels of Kin treatments,

whereas, soluble carbohydrates in both cultivars were decreased under the effect of 75 mg/l IAA+ all levels of Kin treatments relative to control plants. The accumulation of carbohydrate contents due to IAA treatments might be linked with the efficiency of photosynthetic apparatus, which leads to the increase in plant growth and dry matter production [46]. Moreover, IAA activates the translocation of carbohydrates during their synthesis [47]. The obtained results of IAA are similar to those reported by Reda *et al*. [48] on chamomile, Barakat [42] on wheat and Eleiwa *et al*. [30] on barley. Regarding Kin treatments, our results are in good agreement with those reported by Reda *et al*. [48] on chamomile and Fawzy *et al.* [49] on snap bean.

Free Amino Acid, Proline and Total Phenolic Contents: Data in Table 5 clearly indicate that IAA and/or Kin treatments significantly increased free amino acid and proline contents in the two faba bean cultivars relative to untreated ones. The most pronounced treatment was 50 mg/l IAA + 75 mg/l Kin in the two cultivars. In this concern, the stimulatory effect of IAA may be due to the enhancement of nitrogen or nitrate uptake by plants [50] and increased rate of amino acid synthesis [51]. Similar results of IAA treatments were obtained by Kaya *et al*. [52] on maize and Barakat [42] on wheat. Regarding Kin treatments, similar results were obtained by Ibrahim *et al*. [37] on faba bean and Kaya *et al*. [52] on maize. Data in Table 5 show significant increases in total phenolic contents of the two faba bean cultivars under the effect of IAA and/or Kin treatments as compared with control plants. Moreover, 50 mg/l IAA + 75 mg/l Kin treatment caused the highest significant increases in phenolic contents of the two cultivars. Similar results of IAA treatments were obtained by Naguib *et al.* [53] on periwinkle plants. Regarding cytokinin, Dawood and Sadak [54], Ayad and Gamal El-Din [55] reported that benzyladenine treatments significantly increased phenolic compounds in canola and lupine plants respectively. Ibrahim *et al*. [37] reported that treatment of faba bean plant with kin at 50 ppm increased free amino acid and phenolic contents. The increases in phenolic contents in response to IAA and Kin may be attributed to the increase in carbohydrate synthesis (Table 5). Moreover, the increase in total phenolic content was concur with the increase in IAA contents (Table 4) and led to the suggestion that most of phenolic compounds are diphenols and polyphenols which may be inhibit IAA-oxidase activity.

Yield and Yield Attributes: Data in Table 6 indicated that IAA and / or Kin treatments caused significant increases in seed yield/plant (g), seed yield/faddan (kg) and yield attributes (number of pods/plant, pods yield/plant (g), 100-seed weight (g) and biological yield/plant) of the two faba bean cultivars. Furthermore, the highest values of seed yield were obtained from the application of 50 mg/l IAA +75 mg/l Kin treatment in the two cultivars. It is worthy to mention that, seed yield/faddan of Nubaria 1 cultivar at control treatment was more pronounced than that of Giza 843 cultivar i.e. the seed yield /faddan of Nubaria 1 cultivar was 47.17% over that of Giza 843 cultivar. Meanwhile, response of Giza 843 cultivar to all applied treatments was more effective than Nubaria 1 cultivar. The increase in the yield could be a reflection of the promotive effect of growth regulators on plant growth

Table 6: Effect of IAA and/or Kin on yield and yield attributes of two faba bean cultivars (average of two seasons).

Treatments		Number of pods/plant		Pods yield/plant (g)		Seed yield/plant (g)		Seed yield /faddan (Kg)		100-seeds weight (g)		Biological yield/plant (g)	
IAA (mg/l)	Kin (mg/l)	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	3.33	2.33	10.63	6.17	8.00	5.17	403.2	213.0	60.0	61.0	13.13	11.50
	50	4.00	3.33	12.30	8.93	9.00	6.30	470.4	423.4	72.5	70.2	18.37	15.03
	75	5.33	5.00	16.20	14.17	10.03	10.73	538.4	622.7	85.8	77.2	20.77	19.36
	100	7.67	5.33	16.63	16.90	11.87	11.90	783.1	755.5	89.0	79.2	22.00	22.37
50	0	4.33	4.67	16.00	10.67	9.50	8.17	472.6	549.0	65.2	67.3	20.83	15.13
	50	8.67	5.67	17.90	16.70	16.90	14.40	530.8	734.9	68.0	61.0	25.40	19.80
	75	9.33	7.33	21.43	19.40	19.77	17.52	997.3	844.5	120.0	88.4	27.50	24.30
	100	8.00	6.33	18.96	15.99	15.52	15.30	842.9	795.4	93.2	79.2	24.03	23.30
75	0	6.67	6.67	17.50	14.63	14.63	9.73	797.4	653.9	84.5	87.5	21.07	20.67
	50	7.67	7.33	18.83	15.99	15.60	13.00	915.5	742.4	94.0	86.0	24.50	22.67
	75	7.00	6.00	19.87	16.67	16.83	14.77	934.2	826.9	108.0	87.3	26.00	24.67
	100	6.00	5.00	17.87	15.03	15.27	11.43	806.1	769.7	96.4	82.4	25.07	23.27
LSD at 5%		0.25		1.01		0.62		11.31		0.10		0.03	

Table 7: Effect of IAA and/or Kin on some chemical compositions of the yielded seeds of two faba bean cultivars (average of two seasons).

Treatments		Total carbohydrates%		Protein%		Vicine (mg/100g dry weight)		Vicine reduction (%)	
IAA (mg/l)	Kin (mg/l)	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843	Nubaria 1	Giza 843
0	0	46.28	44.24	21.70	20.82	332.10	477.46	--	--
	50	48.89	46.42	23.00	22.21	311.35	457.41	6.25	4.20
	75	49.45	48.75	23.68	22.81	294.85	444.26	11.22	6.95
	100	50.78	49.25	24.68	23.12	274.90	438.60	17.22	8.14
50	0	49.78	46.75	22.51	21.71	240.10	398.87	27.70	16.46
	50	52.98	49.76	24.68	22.72	217.40	376.71	34.54	21.10
	75	53.22	50.74	25.81	24.91	155.50	286.12	53.17	40.07
	100	51.61	49.66	24.75	23.21	162.50	295.12	51.07	38.19
75	0	50.05	48.35	23.82	22.81	231.95	356.72	30.16	25.29
	50	50.56	48.88	23.71	23.42	215.70	312.88	35.05	34.47
	75	52.72	50.29	24.04	23.81	204.60	305.71	38.39	35.97
	100	52.98	49.59	24.48	23.98	201.50	311.71	39.33	34.71
LSD at 5%		2.02		0.16		13.11		3.13	

(Table 2) and marked increases in the photosynthetic pigments content (Table 3), which could lead to increase in photo-assimilates and greater transfer of assimilates to the yield (Table 6). In this concern, Ammanullah *et al*. [7] reported that plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink thereby helping in effective flower formation, fruit and seed development and ultimately enhancing the productivity of crops. Arif *et al*. [56] mentioned that IAA is the major naturally occurring auxin that increases stem elongation, cell expansion, growth rate and yield. The results of IAA treatments (Table 6) are in agreement with those obtained by El-Saeid *et al*. [41] on cowpea and Abdoli *et al.* [57] on wheat. Krishnamoorthy [58] reported that cytokinin influenced the direction of transport of organic metabolites and minerals and their accumulation in the developing fruits and seeds. In addition, kinetin prevents flower abortion and permits the initiation of seed development [59]. The obtained results of Kin treatments are similar to those of Khalil *et al.* [43] on lentil and Faizan and Bano [60] on safflower.

Chemical Composition of the Yielded Seeds: Data in Table 7 reveals that IAA and / or Kin treatments significantly increased total carbohydrate and protein contents in the yielded seeds of the two cultivars compared with the control plants. Treatment at 50 mg/l IAA + 75 mg/l Kin was the most effective treatment as it caused the highest total carbohydrate and protein contents of the yielded seeds. These results agree with the findings of Ibrahim *et al*. [34] on faba bean for IAA treatments and Tagade *et al.* [61] on soybean for kin treatments. Leopolda and Kriedeman [62] reported that kinetin plays an important role in protein synthesis through activation of nucleic acid synthesis. It can be suggested that application of growth regulators especially IAA and kinetin encourages the absorption of nitrogen from the soil and activated the photosynthetic process through their influence on some enzymatic action. The activation of these processes might cause the increase in protein and carbohydrate percentage in the seeds [63]. Data in Table 7 indicate that foliar application of IAA and / or Kin significantly decreased the contents of vicine in the two cultivars relative to control plants. The most pronounced effect was observed at treatment of IAA at 50 mg/l + Kin at 75 mg/l where the percentage of reduction reached to 53.17% in Naubaria 1 cultivar and 40.07% in Giza 843 cultivar as compared with control plants. In this connection, Bjerg *et al*. [64] stated that both environmental and genetic factors seem to affect the contents of favism causative agents in faba bean seeds. Furthermore, Gaber *et al*. [65] indicated that foliar application or seed presoaking with certain growth regulators decreased the contents of vicine in the yielded seeds. The reduction in the contents of vicine may be attributed to the effect of these factors on metabolic pathway of vicine precursor (orotic acid) formation which responsible for the formation of pyrmidine ring of these toxic constituents [66].

CONCLUSION

It could be concluded that IAA and/or kinetin treatments had an enhancement effect on growth, some chemical constituents as well as yield quantity and quality of the two tested faba bean cultivars. The most pronounced treatment was 50 mg/l IAA +75 mg/l Kin. It is

imperative to mention that performance of Nubaria 1 cultivar was more promising than Giza 843 cultivar when grown under newly reclaimed sandy soil at Nubaria province. Meanwhile, seed yield (Kg/faddan) of Giza 843 cultivar responded more effectively to all applied treatments than Nubaria 1 cultivar.

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