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STIMULATION OF GROWTH AND OIL PRODUCTION IN CUMIN PLANT

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ABSTRACT: A pot experiment was carried out during two successive seasons (2017/ 2018 and 2018/2019) at Medicinal and Aromatic Plants Research Department in Dokki. The aim of this work was to study the effect of foliar application of phenylalanine (Phe) and *p*-nitro phenylacetic acid (PNPAA) each of them alone at (0, 50, 100 and 150 ppm) on cumin (*Cuminum cyminum* L.) plant growth, fruits yield, volatile oil production and its major chemical constituents. In general results indicated that, the foliar application of phenylalanine or *p*-nitrophenylacetic acid significantly increased vegetative growth expressed as (plant height, number of branches per plant) and produced higher fruits yield (g)/plant as well as volatile oil percentage and oil yield compared with control in the two seasons. Moreover, the highest values were obtained from phenylalanine or *p*-nitrophenylacetic acid at 150 ppm. Cumin plants showed more effective response to *p*-nitrophenylacetic acid (PNPAA) than phenylalanine (Phe). As for GLC analysis, the results showed that in general the highest percentage of *p*-menth-1-en7-ol and cumin aldehyde (*p*-isopropylbenzaldehyde) the main constituents in the volatile oil achieved with the treatment *p*-nitrophenylacetic acid at 150 ppm. The high concentration of phenylalanine and *p*-nitrophenylacetic acid (150 ppm) had significant increments in total phenols, total flavonoids and antioxidant activity compared with control. There was a significant increase in phenylalanine ammonia-lyase (PAL) activity compared to control. Also, there was an increment in IAA, GA_3 and low level of ABA. It was observed that *p*-nitrophenylacetic acid (150 ppm) was superior to phenylalanine (150 ppm) in all afore mentioned characters.

Key words: Cumin, phenylalanine, *p*-nitrophenylacetic acid, fruits yield, oil constituents.

INTRODUCTION

Cumin (*Cuminum cyminum* L.) is an annual important plant belongs to Apiaceae family. The fruits are carminative (Bettaieb *et al.,* 2012 and Hashemian *et al.,* 2013) aromatic, stomachic, stimulant. Also, the fruits of cumin are used extensively as a spice and flavoring for culinary purposes in many cuisines. The volatile oil is responsible for characteristic cumin odor. This odor and flavor are principally attributed to the aldehydes present. Cuminaldehyde (*p*-isopropylbenzaldehyde) is the major component in the volatile oil of cumin fruits. In addition, it can stimulate different biological effects such as antimicrobial, anti-inflammatory, antioxidant and anticancer (Oroojalian *et al.,* 2010).

Phenylalanine is an essential amino acid that plays an important role in the interconnection between primary and secondary metabolism in plants. Phenylalanine is used as a protein building block and it is also as a precursor for numerous plant compounds that are necessary for plant growth, development, reproduction and defense against different types of stresses (Pascual *et al.,* 2016).

Phenylalanine provide plant with important precursors of aromatic secondary metabolites such as alkaloids, flavonoids, lignins, and aromatic antibiotics. Many of these compounds are bioactive as well as playing important roles in plant defense against biotic and abiotic stresses and environmental interactions (Hamberger *et al.,* 2006; Maeda and Dudareva, 2012). The application of phenylalanine during vegetative and flowering stages caused an enhancement in plant growth (Habba, 2003 and Reham *et al*., 2016). Small and Morris (1990) reported that phenylacetic acid stimulates the elongation of coleoptile segments of oats (*Avena sativa*) and intermodal of beans (*Phaseolus vulgaris*).

Phenylalanine ammonia-lyase (PAL) is one of the most important enzymes that plays important role in regulation phenylpropanoid biosynthesis in plants and growth response. It catalyzes the first step of the conversion of L-phenylalanine to cinnamic acid, linking primary metabolism with secondary metabolism. This step is significant for metabolic engineering and hyper-expression of the major phenylpropanoid, methyl chavicol (Wang *et al.,* 2014). PAL is controlling primary metabolism to secondary metabolism in the phenylpropanoid metabolic pathway. This metabolic pathway not only produces concentrated tannins, flavonoids and lignin, but also produces less-studied benzene compounds and phenolic glycosides.

Recent research has established that NO_2 is a phytohormone, the exogenous application of NO_2 positively regulates plant growth. Also, NO_2 is immigrant or departure group with the ability to replace (Takahashi and Morikawa, 2014).

The goal of this work was to study the effect of foliar application of different concentrations of phenylalanine (Phe) and *p*-nitrophenylacetic acid on growth and volatile oil production of cumin plants.

MATERIALS AND METHODS

This study was carried out during two successive seasons 2017/2018 and 2018/2019 at Medicinal and Aromatic plants Research Department, Dokki, Egypt.

Plant materials and procedures:

The fruits of cumin (*Cuminum cyminum* L.) were obtained from the Experimental Farm of Medicinal and Aromatic Plants Research Department, El-Kanater El-Khairia and sown on 15th November in the two seasons.

Chemical fertilizers:

Chemical fertilizers (NPK) were added as ammonium sulphate (20.6% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at the recommended level in three doses. The 1st one (all phosphorous amount) was added during soil preparation, the rest (NK) doses were applied in two equal splits, after 30 and 60 days from sowing.

Treatments:

Foliar application of phenylalanine and *p*-nitrophenylacetic acid each of them solely were done four times. The first dose was given 30 days after sowing and was repeated three times after 15 days interval, seven treatments were conducted as follow: (1) control (untreated plants); (2), (3) and (4) phenylalanine (Phe) at 50, 100 and 150 ppm, respectively; (5), (6) and (7) *p*-nitrophenylacetic acid (PNPAA) at 50, 100 and 150 ppm, respectively.

Data recorded:

The following data were recorded:

1. Plant height (cm).
2. Number of branches/pant.
3. Fruits yield (g)/plant.
4. Volatile oil percentage (% v/w) was determined according to (British Pharmacopeia, 1963).

5. Volatile oil yield (ml) /plant.
6. The main constituents of cumin fruits volatile oil were determined by subjecting oil samples (of the 2nd season to gas liquid chromatography (GLC) analysis as recommended by (Hoftman, 1967 and Bunzen, 1969).
7. Determination of total phenols: total phenols content was determined in fruits by using Folin- Ciocalteu assay, as described by (Amin *et al.,* 2006).
8. Determination of total flavonoids content: total flavonoids content was determined in fruits by using previously reported method by (Chang *et al.*, 2002).
9. Antioxidant activities: the antioxidant activity (in percent) was evaluated in fruits by 1, 1-diphenyl-2-picrylhydrazyl radical scavenging method according to the procedure of (Chen *et al.,* 2008).
10. Phenylalanine ammonia-lyase (PAL) activity: PAL activity was determined in fresh herb. The crude enzyme extract was assayed by using the methods of (Zucker,1965; McCallum and Walker 1990).
11. Determination of Plant hormones: plant hormones were determined in fresh herb according to the method described by (Horemans *et al*., 1984).

Layout of experiment:

The experiment layout was designed in complete randomized blocks included seven treatments each treatment was replicated three times and every replicate consisted of nine pots. The recorded data were statistically analyzed according to (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Effect of phenylalanine and *p*-nitrophenylacetic acid on vegetative growth:

Data in Table (1) showed that, all concentrations of phenylalanine (Phe) and *p*-nitrophenylacetic acid each of them alone significantly increased plant height and number of branches/plant as compared to control in the two seasons. The best results were obtained from phenylalanine (Phe) at 150 ppm which gave 22.24 and 22.60 (cm) plant height and 5.78 and 6.08 branches/plant in both seasons. These results are in agreement with the findings of (Gamal-El-Din *et al.,* 1997) they mentioned that phenylalanine treatment increased vegetative growth of lemon grass.

The highest values were recorded in case of those plants treated with *p*-nitro phenyl acetic acid at 150 ppm, the values were

Table 1. Effect of phenylalanine and *p*-nitrophenylacetic acid on vegetative growth of cumin plants during 2017/ 2018 and 2018/2019 seasons.

Treatments	Growth characters			
	1st season		2nd season	
	Plant height (cm)	Number of branches /plant	Plant height (cm)	Number of branches /plant
Control	17.50	3.33	17.82	3.67
Phenylalanine (Phe) at 50ppm	19.13	3.89	19.53	4.44
Phenylalanine (Phe) at 100ppm	20.87	4.67	21.92	5.00
Phenylalanine (Phe) at 150ppm	22.24	5.78	22.60	6.08
***p*-nitrophenylacetic acid (PNPAA) at 50 ppm**	23.69	6.33	25.18	6.44
***p*-nitrophenylacetic acid (PNPAA) at 100 ppm**	26.83	7.11	28.47	7.33
***p*-nitrophenylacetic acid (PNPAA) at 150 ppm**	28.89	7.44	29.88	7.56
L.S.D.at 5%	1.35	0.50	0.90	0.28

28.89 and 29.88 (cm) for plant height and 7.44 and 7.56 for branches/plant in the two seasons. These results may be attributed to both nitro (NO_2) group and phenylacetic acid are phytohormones which increased shoot biomass (Jin *et al.,* 2009).

Effect of phenylalanine and *p*-nitrophenylacetic acid on fruits yield (g)/plant:

All concentrations of phenylalanine (Phe) or *p*-nitrophenylacetic acids; 50, 100 and 150 ppm significantly increased fruits yield per plant as compared to control in both seasons. High fruits yield per plant 3.07 and 3.13 (g)/plant were recorded in the plant received phenylalanine (Phe) at 150 ppm in 1st and 2nd seasons, respectively Table (2). These results may be due to the beneficial effect of amino acids which facilitate nutrients absorption by the roots. Khalilzadeh *et al.* (2012) mentioned that, amino acids play essential role in plant metabolism and protein assimilation which are necessary for cell formation. Moreover, amino acids regulate photosynthesis and plant production.

The most effective treatment in this concern was *p*-nitrophenylacetic acid (PNPAA) at 150 ppm which gave 3.26 and 3.32 g fruits/plant in the 1st and 2nd seasons, respectively. Such effect may be due to the regulation of the growth and reproductive of plants by exogenous nitro (NO_2) group (Santner and Estelle, 2009). Also, phenylacetic acid (PAA) is a natural auxin has the ability to regulate cell division, cell growth, ethylene biosynthesis, root development, leaf formation, apical dominance and differentiation of vascular tissues and fruit setting (Finet and Jaillais, 2012).

Effect of phenylalanine and *p*-nitrophenylacetic acid on volatile oil production:

Volatile oil percentage and its yield ml/plant:

It could be noticed that the application of phenylalanine (Phe) or *p*-nitrophenylacetic acid (PNPAA) at 150 ppm showed a significant increase in volatile oil percentage and yield over control in the two seasons Table (3). The best results were obtained from plants treated with *p*-nitrophenyl acetic acid (PNPAA) at 150 ppm, giving 4.96 and 5.02% and yield 0.17 and 0.18 ml/plant in both seasons. However, phenylalanine at 150 ppm occupied the second rank. Similar results were observed by (Talaat and Youssef, 2002), they mentioned that foliar application of amino acids significantly increased volatile oil percentage and yield on basil plants.

Table 2. Effect of phenylalanine and *p*-nitrophenylacetic acid on fruits yield of cumin plants during 2017/ 2018 and 2018/2019 seasons.

Treatments	Fruits yield (g) / plant	
	1st season	2nd season
Control	2.57	2.65
Phenylalanine (Phe) at 50 ppm	2.78	2.81
Phenylalanine (Phe) at 100 ppm	2.91	2.96
Phenylalanine (Phe) at 150 ppm	3.07	3.13
p-nitrophenylacetic acid (PNPAA) at 50 ppm	3.13	3.20
p-nitrophenylacetic acid (PNPAA) at 100 ppm	3.22	3.25
p-nitrophenylacetic acid (PNPAA) at 150 ppm	3.26	3.32
L.S.D.at 5%	0.026	0.042

Table 3. Effect of phenylalanine and *p*-nitrophenylacetic on volatile oil production of cumin plants during 2017/ 2018 and 2018/2019 seasons.

Treatments	1st season		2nd season	
	Volatile oil percentage	Volatile oil yield (ml) /plant	Volatile oil percentage	Volatile oil yield (ml) /plant
Control	4.01	0.10	4.09	0.11
Phenylalanine (Phe) at 50 ppm	4.17	0.12	4.25	0.13
Phenylalanine (Phe) at 100ppm	4.36	0.13	4.49	0.14
Phenylalanine (Phe) at 150ppm	4.52	0.14	4.64	0.15
***p*-nitrophenylacetic acid (PNPAA) at 50 ppm**	4.69	0.15	4.74	0.16
***p*-nitrophenylacetic acid (PNPAA) at 100 ppm**	4.84	0.16	4.86	0.17
***p*-nitrophenylacetic acid (PNPAA) at 150 ppm**	4.96	0.17	5.02	0.18
L.S.D.at 5%	0.05	0.01	0.03	0.01

From the above results it could be concluded that, *p*-nitrophenylacetic acid (PNPAA) was more effective than phenylalanine (Phe) regarding volatile oil production as well as all growth characters. This effectiveness of *p*-nitrophenylacetic acid (PNPAA) than phenylalanine (Phe) may be attributed to nitro (NO_2) group which is considered as phytohormone so, positively regulates and improves growth of plant (Takahashi and Morikawa, 2014) also, phenylacetic acid (PAA) is a natural auxin plays a central role in plant growth and reproductive (Schneider *et al.,* 1985). EL-Zefzafy *et al.*, (2016) reported that foliar application of phenylalanine significantly promoted the growth and volatile oil production.

Effect of phenylalanine and *p*-nitrophenylacetic acid on chemical composition of volatile oil:

Data presented in Table (4) showed that *p*-menth-1-en7-ol (ranged from 43.23 and 45.29%) and cuminaldehyde (*p*-isopropylbenzaldehyde ranged from 19.45 to 33.11%) were the main components of volatile oil.

Concerning the effect of phenylalanine (Phe), data indicated that all treatments increased cuminaldehyde (*p*-isopropyl-benzaldehyde) percentage in volatile oil. Increasing the concentration of phenylalanine (Phe) gradually increased cuminaldehyde percentage as compared to control. In general, treating cumin plants with *p*-nitrophenyl acetic acid (PNPAA) at 150 ppm gave the highest values of *p*-menth-1-en7-ol (45.29%) and cuminaldehyde (33.11%), respectively compared with control (untreated plants). The most effective treatment was *p*-nitrophenylacetic acid (PNPAA) at 150 ppm in this concern.

These results may be due to the activity of phenylalanine ammonia-lyase (PAL), the first enzyme of phenylpropanoid pathway. It was found to be directly involved in 2-hydroxy-4-methoxybenzaldehyde biosynthesis, which route of another fragrant cuminaldehyde (*p*-isopropylbenzaldehyde) (Giridhar *et al.,* 2004). Elicitation is a standard method to enhance the phenolic metabolism in excised plant tissue, organs and cell cultures (Kneer *et al.,*1999). In another report, correlation of shikimate pathway with 2-hydroxy-4-methoxy-benzaldehyde biosynthesis has been established considering the possible biosynthesis path in yeast extract-elicited *Hemidesmus indicus* roots (Kundu *et al.,* 2012). An evidence of C_2 side –chain cleavage activity was also found in *Hemidesmus indicus* roots that catalyzed the C_2 side –chain cleavage the C_6- C_1 compound (4-hydroxybenzaldehyde). This phenomenon supports the proposed pathway of vanillin

Table 4. Effect of phenylalanine and *p*-nitrophenylacetic acid on GLC analysis of volatile oil of cumin fruits during 2018 /2019 season.

Components	Treatments						
	Control	Phe 50 ppm	Phe 100 ppm	Phe 150 ppm	PNPAA 50 ppm	PNPAA 100 ppm	PNPAA 150 ppm
α –Thujene	0.80	0.86	0.70	0.92	0.90	-	-
β –pinene	14.40	12.91	12.83	16.34	15.46	12.11	8.36
Myrcene	13.20	14.14	14.26	13.25	13.00	11.02	8.21
α-phyllandrene	6.09	1.70	5.02	0.40	5.09	3.60	3.84
***p*-cymene**	0.24	5.23	0.28	5.21	1.21	-	-
γ –Terpinene	0.71	0.50	0.15	1.26	0.20	-	-
Cuminaldehyde	19.45	19.90	20.17	21.15	21.30	23.01	33.11
***p*-menth-1-en7-ol**	43.23	42.31	43.38	39.05	40.42	49.08	45.29
β- caryophylene	0.62	0.46	0.27	0.48	0.35	-	-
Unknown	1.50	1.99	2.94	1.94	2.07	1.18	1.19

biosynthesis through the formation of hydroxybenzaldehyde by a chain-cleaving mechanism. Inhibition of shikimate pathway decreased this C_2 chain-cleaving enzyme, which also emphasizes that shikimate pathway modulates the downstream enzymes involved in 2-hydroxy-4-methoxy-benzaldehyde biosynthesis. There are no reports available on the downstream enzymes of 2-hydroxy-4-methoxy-benzaldehyde biosynthesis after C_2 side-chain shortening.

Therefore, there is a scientific trials need for much research in the future. This information establishes cuminaldehydes promising group of compounds with simple, small structure from pharmacological and industrial perspective. Therefore, it is important to study the biosynthetic routes of cuminaldehydes characterization of involved enzymes. It will be useful for metabolic engineering of the cuminaldehyde contents in plants for industrial purposes. The final product of shikimate pathway, chorismate, is converted to prephenate, a branch point in phenylalanine (Phe) synthesis, by a chorismatemutase (Lee *et al.,*1995; Herriman and Weaver,1999). Some species are capable of synthesizing an unusual variant of L-phenylalanine, the amino derivative L-*p*-aminophenylalanine (L-PAPA), but utilizing the PABA (*p*-aminobenzoic acid) precursor 4- amino-4-deoxychorismic acid instead of chorismic acid. Thus, amino derivatives of prephenic acid and pyruvic acid are elaborated. Phenylpyruvate is subsequently converted to Phe by a phenylpyruvate aminotransferase (Tzin *et al.,* 2009; Maeda *et al.,* 2010 and Yoo *et al.,* 2013). It has been suggested that PAA (phenylacetic acid) biosynthesis in plants also occurs via phenylpyruvate (Taylor and Wightman, 1987). It has further been proposed that the enzymes responsible for IAA biosynthesis are involved in the conversion of Phe to PAA (Sugawara *et al.,* 2015).Although it should be noted that transamination is a reversible process (Jensen and Gu, 1996). Interestingly, the aminotransferases discussed in relation to Phe biosynthesis in *Petunia hybrida* (Yoo *et al.,* 2013). Results presented here supported the theory that PAA is derived from phenylpyruvate as suggested by (Sugawara *et al.,* 2015). We were unable to detect the endogenous species of phenylacetic acid in our feeding studies. Introduction of feedback-insensitive *p*-nitrophenylacetic acid (PNPAA) also led to increased production of many shikimate-derived metabolites, including plant benzaldehyde. In brief, the importance of cuminaldehyde (*p*-iso-propylbenzaldehyde) in natural products research cannot be overlooked as they have functional and potential roles in medicine, agriculture and industry. Therefore, up to date knowledge is required for further progress in *p*-iso-propylbenzaldehyde research. In this paper, we discuss the available scientific literature regarding the occurrence of cuminaldehyde in plants as natural products, medicinal properties and biosynthesis. Thus, we aim to compile information on the research in this field and review the latest advances in the fragrant *p*-isopropylbenzaldehyde research.

In general, biosynthesis of benzenoids from phenylalanine requires shortening of the carbon skeleton side chain by a C_2 unit which can potentially occur via either the β-oxidative pathway or non-oxidatively (Boatright *et al.,* 2004). Experiments with stable isotope-labeled precursors in tobacco leaves (Ribnicky *et al.,* 1998) reported that benzoic acid is derived from phenylalanine converted to cinnamic acid via β oxidative pathway first product benzoyl CoA, which can be hydrolyzed by thioesterase to free benzoic acid. In contrast, labeling experiments together with initial enzyme characterization, in *Hypericuman dosaemum* cell cultures (Ahmed *et al.,* 2002) confirmed the existence of a pathway of non –oxidative conversion of cinnamic acid to benzaldehyde subsequent formation of benzoic acid, which can be converted to benzoyl CoA (Beuerle and Pichersky, 2002). In vivo isotope labeling and metabolic flux analysis of the benzenoid network in *Petunia hybrida* flowers revealed that both pathways yield benzenoid compounds and that benzylbenzoate is an intermediate between L- phenylalanine and benzoic acid (Boatright *et al.,* 2004). Transgenic *Petunia hybrida* plants were generated in which expression of benzoyl CoA: phenylethanol/benzyl alcohol benzoyltransferase (BPBT), the gene encoding the enzyme that uses benzoyl CoA and benzyl alcohol to make benzylbenzoate formation decreased endogenous pool of benzyl acid and methyl benzoate emission but increased emission of benzylalcohol and benzylaldehyde, confirming the contribution of benzylbenzoate to benzoic acid formation (Orlova *et al.,*2006).

Data in Table (5) indicated that high concentration of phenylalanine (Phe) 150 ppm significantly increased total phenols, total flavonoids and antioxidant activity as compared to control. Total phenolic content expressed as mg Gallic acid Equivalent GAE/g fruits and flavonoids content expressed as mg Querctine Equivalent (QE)/g fruits, the enzyme activity was referred to as fresh weight (U/g FW). Maximum phenolic content was in plants treated with (PNPAA) at 150 ppm. The value was 28.5 mg GAE/g fruits. The same results were observed in total flavonoids content where maximum was 16.29 mg QE/g fruits.

Data showed that cumin fruits had potent antioxidant capable of scavenging DPPH free radicals. The best results were obtained from *p*-nitrophenylacetic acid at 150 ppm which gave 86.09%. The results are in agreement with (Gamal EL-Din and Abd El-Wahed, 2005) reported that the effects of foliar application of phenylalanine on chamomile (*Matricaria chamomilla* L., Rausch.) led to significant increases in total phenols.

Also, data in Table (5) revealed that there was a significant increase in Phenylalanine ammonialyase (PAL) activity compared with the control in cumin plants treated with phenylalanine (Phe) and *p*-nitrophenylacetic acid (PNPAA) at concentrations 50, 100 and 150 ppm. These results were in agreement with (Bahadur *et al.,* 2012) who reported that pea leaves treated with different concentrations (100 and 150 ppm) of phenylalanine (Phe) caused increment in PAL activity in compared with control.

Data represented in Table (6) showed increments in gibberellin (GA_3) and indole acetic acid (IAA) in plants treated with phenylalanine and PNPAA. The highest concentration of GA_3 (5.82 mg/100 g) and IAA (1.05 mg/100 g) were in plants treated with PNPAA at concentration of 150 ppm. A reduction in abscisic acid (ABA) level was concomitant with increments in GA_3 and IAA estimated in plants treated with PNPAA

Table 5. Effect of phenylalanine and *p*-nitrophenylacetic acid on total phenols, total flavonoids and antioxidant activity of cumin plants during 2018 /2019 season.

Treatments	Total phenols (mg/g)	Total flavonoids (mg/g)	Antioxidants (%)	Enzyme activity (U/g FW)
Control	17.71	8.27	65.06	0.146
Phenylalanine (Phe) at 50 ppm	19.97	10.12	67.03	0.168
Phenylalanine (Phe) at 100 ppm	22.00	13.03	69.56	0.245
Phenylalanine (Phe) at 150 ppm	23.72	13.85	72.30	0.288
***p*-nitrophenylacetic acid (PNPAA) at 50 ppm**	25.46	14.82	77.17	0. 325
***p*- nitrophenylacetic acid (PNPAA) at 100 ppm**	26.45	15.15	81.40	0.351
***p*-nitrophenylacetic acid (PNPAA) at 150 ppm**	28.50	16.29	86.09	0.376
L.S.D. at 5%	2.81	2.04	3.77	0.021

Table 6. Effect of phenylalanine and *p*-nitrophenylacetic acid treatments on phytohormone contents (mg/100 g).

Treatments	GA3	IAA	ABA
Control	2.11	0.77	0.71
Phenylalanine (Phe) at 50 ppm	3.22	0.82	0.65
Phenylalanine (Phe) at 100 ppm	3.68	0.97	0.57
Phenylalanine (Phe) at 150 ppm	4.04	1.01	0.45
***P*-nitrophenylacetic acid (PNPAA) at 50 ppm**	5.09	1.02	0.32
***p*-nitrophenylacetic acid (PNPAA) at 100 ppm**	5.34	1.04	0.29
***p*-nitrophenylacetic acid (PNPAA) at 150 ppm**	5.82	1.05	0.25

at concentration 150 ppm. The results are in agreement with (Talaat *et al.,* 2014) reported that phenylalanine led to increase in level of growth hormones (IAA, GA_3, total cytokinins) and low level of ABA. The increases in growth hormones levels could be attributed to the increase in their biosynthesis and/or decrease in their degradation. On the other hand, the reduction in ABA level could be due to the shift of the common precursor isopentenyl pyrophosphate to biosynthesis of cytokinins and/or gibberellins instead of ABA (Hopkins and Huner, 2004). Plant phenolic, as physiological regulator or chemical messenger, inhibit the IAA catabolism (dihydroxy B-ring flavonoids) or limit the IAA synthesis (monohydroxy B-ring flavonoids) (Mathesius, 2001).

Recommendation:

It could be recommended to spray cumin plants with *p*-nitrophenylacetic acid at 150 ppm to increase growth, fruits yield and volatile oil production as well as oil quality.

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تحفيز النمو وإنتاج الزيت في نبات الكمون

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أجريت هذه التجربة في قسم بحوث النباتات الطبية والعطرية بالدقي، خلال موسمي ٢٠١٨/٢٠١٧، ٢٠١٩/٢٠١٨ بهدف دراسة تأثير رش نباتات الكمون بالفنيل الانين وكذلك البارانيتروفينيل استيك اسيد كلاً منهما على حده بتركيز (صفر، ٥٠، ١٠٠، ١٥٠ جزء في المليون) على نمو نباتات الكمون ومحصول الثمار وإنتاج الزيت (نسبة الزيت ومحصول الزيت ومكونات الزيت). بوجه عام أدت المعاملة بالفنيل الانين أو البارانيتروفينيل استيك اسيد الى زيادة معنوية في النمو الخضري (ارتفاع النبات، عدد الأفرع) ومحصول الثمار ونسبة الزيت الطيار ومحصول الزيت وكانت الزيادة تدريجية مع زيادة التركيز مقارنة بالكنترول وذلك في كلا الموسمين. أما بالنسبة لتحليل مكونات الزيت فقد كانت أفضل النتائج من النباتات التي عوملت بالبارانيتروفنيل استيك اسيد بتركيز ١٥٠ جزء في المليون حيث أنها أعطت أعلى نسبة من المكونين الرئيسين في الزيت الطيار، كما أوضحت النتائج أن المعاملة بالتركيز المرتفع ١٥٠ جزء في المليون من الفنيل الانين أو البارانيتروفينيل استيك اسيد الى زيادة معنوية في نسبة الفينولات والفلافونيدات ومضادات الأكسدة ونشاط إنزيم الفنيل الانين أمونياليز. كما أدت الى زيادة في نسبة هرمون الجبرلين والإندول استيك اسيد ونقص في حمض الأبسيسك. ومن الملاحظ أن المعاملة بالبارانيتروفينيل استيك اسيد (١٥٠ جزء في المليون) تفوقت معنوياً في جميع الصفات السابقة على المعاملة بالفنيل الانين (١٥٠جزء في المليون).