Response of Foeniculum Vulgare Plant to NPK Doses and Some Biostumulants

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ABSTRACT: *Foeniculum Vulgare* Mill (family Apiaceae) is a strong aromatic and medicinal plant. It used for various proposes i.e., in food, cosmetic and medicinal industries. Therefore,field experiment was conducted during 2016/2017 and 2017/2018 seasons in private Farm at Maghnin village, Koum Hamada city, Elbehera Governorate, Egypt, to study the response of fennel plant to NPK doses and some biostumulants. The experiment was setup as a split plot design, whereas NPK doses (25, 50, 75, 100% from suggested dose which was 150, 150 and 50 kg/fed of ammonium sulphate, calcium superphosphate and potassium sulphate, respectively) were as main plots, and biostumulants treatments (ascorbic, salicylic and tryptophan acids)were arranged as sub plots. The obtained results indicated that 100% NPK dose gave significant increases in vegetative growth and flowering traits weight of 100 fruits, essential oil %, yield/pant and chemical composition parameters under study (N,P,K and carbohydrate %) while 75% NPK dose achieved a significant higher fruit yield/plant. Application of 100 mg/l of each ascorbic, salicylic and tryptophan acids together was the most effective treatment in increasing the values of vegetative growth and flowering traits, yield of seeds, essential oil production and chemical composition parameters in comparison to the other treatments of such acids. While the interaction treatment of 100% NPK dose combined with 100 mg/l of each used acids together recorded higher significant values of such parameters mentioned before in two seasons.
Keywords: *Foeniculum Vulgare*, NPK fertilizers, ascorbic acids salicylic acid and tryptophan.

INTRODUCTION

Fennel (*Foeniculum Vulgare Mil* , Fam. Apiaceae) is a strong aromatic and medicinal plant native to North Africa, Mediterranean region, southern Europe and Asia. In Egypt, fennel fruits are considered an important export spice, the country cultivates about 11000 feddans of fennel, mostly in Assiut and Qena Governorates, as a winter annual herb. The constituents of fennel volatile oil are anethole, limonene, fenchone, estragole, safrole, α-pinene, camphene, β-pinene, β-myrcene and p-cymene (Saravanaperumal and Terza, 2012).The fruits of the plant are used for folk medicine for its antispasmodic and stomachic, sedative, balsamic, cardiotonic, digestive, lactogogue and tonic properties.The essential oil is used for cosmetics and pharmaceutical products and it has a valuable antioxidant, antibacterial, anticancer and antifungal activity (Bahmani *et al.,* 2012). Fertilizer management is an important factor for a successful growth of officinal plants and the identity of suitable fertilizers in plants could have the desirable effects on quantitative and qualitative indices (Arab *et al*., 2015). Mineral fertilizers (e.g. N, P, K…etc.) have a number of different negative influences on both the environment and health of humans due to accumulation of nitrate in growing plants, ground water and soil. Overusing chemical fertilizers has changed the biological ecosystem, affecting non-target organisms and adversely influencing microorganisms in the soil. To mitigate the risk of the bad effects of mineral fertilizers, it is necessary to replace chemical fertilizers by organic or biological fertilizers which are able to provide plant nutrients and also increase the

sustainability of agro-ecosystems in the long term (Moradi *et al.,* 2011). Plant bio-stimulants (e.g. salicylic acid, tryptophan and ascorbic acid) are effective when applied in small doses, thus leads to the plant growth and production enhancement (Li and Ni, 1996). Plant bio-stimulants are organic materials that appear to impact several metabolic procedures such as respiration, photosynthesis, nucleic acid synthesis and ion uptake and when applied in small quantities, improve the plant growth and development (Castro and Vieira, 2001). Therefore, this work was conducted to increasing the growth, essential oil% and yield productivity of fennel plant, as well as, reduce environmental pollution by reducing rates of N, P, and K fertilizers by sprinkling with salicylic, tryptophan and ascorbic acids.

MATERIAL AND METHODS

Fennel seeds of local variety (*Foeniculum Vulgare* Mill) was sown on 1st and 2nd Nov.2016 and 2017 seasons, respectively in rows 60 cm apart and hills 30 cm in between. The experimental unit was 2X2 m^2 contains 24 plants (4 rows, each row was cultured with 6 plants). After complete germination the seedlings were thinned to one plant / hill on 21st and 23rd Dec. 2016 and 2017 seasons, respectively.Soil samples of the experimental area in private Farm at Maghnin village, Koum Hamada city, El-Behera Governorate, Egypt, were collected at 10, 20 and 30 cm in depth then mixed carefully to determine the physical and chemical parameters (Table 1) according to Jackson (1973).

Table (1). Some physical and chemical parameters of the experimental soil.

Physical parameters

Sand %	Silt%	Clay%	Textural class
24.68	35.71	39.61	Clayey

Chemical parameters

pH	EC	O.M	Soluble Cations(meq/l)			Soluble onions(meq/l)			
			Ca	Mg	Na	Co_3^{--}	Hco_3^-	So_4^{--}	Cl^-
7.51	1.47	1.44	1.62	5.00	7.40	0	4.00	6.80	4.00

The experiment design:

The experiment was setup as a split plot design whereas, NPK fertilizers were arranged at random in the main plots and the used acids were arranged at random in the subplots, The experiment was replicated three times each replicate contained 20 treatments (4 NPK doses X 5 treatments of used acids).

The treatments of NPK were: 1) 100% NPK dose (suggested dose = 150+150+50kg/fed of ammonium sulphate (20.5% N), calcium super phosphate (15.5 % P_2O_5) and potassium sulphate (48% K_2O), respectively, 2) 75% NPK dose, 3) 50% NPK dose, and 4) 25% NPK dose. Where, calcium superphosphate was added as one dose at soil preparation before planting. While ammonium sulphate and potassium sulphate were divided into two equal doses, first dose was added

two days after the thinning and the second one was added one month from the first dose in the two seasons.

The treatments of the used acids were: 1) Control (disteld water), 2) 200 mg/l of each ascorbic acid (AA) and salisylic acid (SA), 3) 200 mg/l of each (AA)and tryptophan acid (TA), 4) 200 mg/l of each (SA) and (TA), and 5) 100 mg/l of each (AA), (SA) and (TA).Where, the plants were sprayed 3 times on 26th and 30th Dec., 26th and 30th Jan. and 25th Feb. and 1st March in 2016/217 and 2017/2018 seasons ,respectively. The plants were sprayed in morning to run off.

Data recorded, at the full flowering stage on 15th April and 21st for both seasons ,respectively, the following traits were measured 1) Vegetative and flowering traits [plant height(cm), shoots number/plant, main stem diameter at 5 cm from soil surface(mm), umbels number/plant and umbels diameter (cm)],2) leaf green color degree (SPAD units) was estimated by Minolta SPAD-502, Japan (Markwell *et al* ., 1995), 3) Leaf NPK , where N% was determined by the modified micro–Kejeldahle method (Chemists and Horwitz, 1990), P% by colorimetrically spectronic (20) spectrophotometer (Murphy and Riley, 1962), and K% by flame photometer (Cotteine *et al*.,1982) and 4) At harvesting time on 4th Jun and 1st Jun. in the two seasons, respectively. The following traits were recorded. Dry weight/plant (g), fruits weight/ plant (g), weight of 100 fruits (g) , total carbohydrate percentage in seeds according to Herbert *et al. (*1971), essential oil % in the air dried fruits (British Pharmacopoeia, 1963), whereas,

essential oil % = $\frac{\text{volume oil graduated tube}}{\text{sample weight}}$ × 100 and essential oil yield/plant = essential oil % × fruits weight /plant (ml).

The statistical analysis:

Duncan's Multiple Rang Test was used to compare the treatments mean at 0.05 level of probabily according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

3.1 Effect of NPK doses, used acids and their interaction on vegetative and flowering parameters:

In respect to NPK doses, data in Table 2 showed that 100% NPK dose resulted in significant increases in vegetative growth traits (plant height, shoots number/plant main stem diameter, leaf green color degree (LGCD) and dry weight /plant) and flowering traits (umbels number /plant and umbel diameter) in comparing to the 75, 50 and 25% NPK doses in the two seasons. Too, it is noticed that the differences among the NPK doses reached the significant level ($p < 0.05$) for all such traits mentioned before, expect for number of shoots in the first season and umbel diameter in the second one, whereas the difference between 100% and 75% doses did not reach the significant level.

This result may be due to that 100% suggested NPK dose was suitable for reaching the soil with N, P, and K nutrients, because N, P and K are essential to all crops .N is the element that most limits crop yield.

Most of N in plants is an organic form: nucleic acids, amino acids proteins, some vitamins, harmonies, membrane component, coenzymes and pigment. P is an essential component of the energy transfer compounds (ATP, ADP and other nuclei proteins), the genetic information system, cell membranes and phospho-lipids. K is serving as an enzyme activator or cofactor for some enzymes, it also aided in the maintenance of osmotic potential and water uptake (Khorshidi *et al.,* 2009). These results are in accordance to these of Abaas (2014) who found that the highest values of all growth parameters of sage plant were obtained at 230 kg N ha^{-1} +80 kg P ha^{-1}. He added that the effect of N and P may belong to role of them in accumulation of chlorophyle material which very important in photosynthesis process and other physiological processes in plant. Likewise, Waskela *et al.* (2017) cleared that 60+40+40 NPK kg ha^{-1} exhibited significant maximum growth, yield attributes, yield and quality of fennel. Additionally, Al-Mansour *et al.* (2018) revealed that application of recommended FYM (10 t ha^{-1}) along with recommended NPK (160:80:80 kg ha^{-1}) recorded the highest fresh herbage yield of sweet basil.

Table (2). The Mean Effect of NPK doses on vegetative and flowering traits of fennel in 2016/2017 and 2017/2018 seasons

Parameters	NPK doses (kg/fed)							
	1st season				2nd season			
	100%	75%	50%	25%	100%	75%	50%	25%
Plant height (cm)	180.90A	175.53B	170.02C	165.03D	165.54A	160.59B	155.78C	151.10D
Shoots number/plant	11.53A	11.13AB	10.73B	10.53B	10.53A	10.13B	9.80C	9.73C
Main steam diameter(mm)	4.62A	4.02D	3.48C	3.15D	4.39A	3.81B	3.36C	3.03D
LGCD (spad units)	49.15A	41.29B	38.79BC	34.92C	46.69A	41.79B	37.38C	33.15D
Dry weight/plant (g)	165.91A	147.29B	131.70C	118.36D	94.97A	82.30A	83.55A	76.57C
Umbels number /plant	211.53A	174.80B	153.13C	119.13D	163A	147.26B	122.86C	87.25D
Umbel diameter (cm)	13.74A	13.13B	12.64C	12.19D	12.33A	12.34AB	12.00BC	11.68C

In the same row means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

Regarding the effect of acids treatments data in Table 3 cleared that all treatments of the used acids exhibited significant increases in plant height, shoots number/plant, stem diameter, LGCD, dry weight/plant, umbels number/plant and umbel diameter in compassion to the control treatment in the two seasons expect for shoots number in the first season, where the differences among the all treatment did not reach the significant level. In the sometime, the treatment 100 mg/l of each AA, SA and TA significantly increased the values of aforementioned traits over than the after used stimulants treatments in the both seasons, with exception in case of shoots number in the first season.

It is abvioused from the resulted that the most effectiveness treatment was 100 mg/l of each AA, SA, and TA may be 100 mg/l of each occurred a balance among the used stimulants that reflected on the plant growth .Also, amino acids play wide roles in plants including acting as regulatory and signaling molecules. Amino acids affect synthesis and activity of some enzymes, gene expression, and redox homeostasis (Rai, 2002). Too SA acts on the growth and development of the plant and, for this reason, is also regarded as a plant hormone (Liu *et al.,* 2011). This result was supported by Youssef (2014) revealed that the tallest plant, the highest number of flowering heads and their fresh and dry weights of *Echinacea purpurea* were recorded by 200ppm tryptophan combined with 150ppm Zn. Likewise, Ali *et al*. (2017) on fennel plants found that 100 or 200 ppm ascorbic acid or salicylic acid improved plant growth and flowering traits.

Table (3). The Mean Effect of the used acids on vegetative and flowering traits of fennel in 2016/2017 and 2017/2018 seasons

Parameters	AA,SA and TA treatments (mg/l)									
	1st season					2nd season				
	Control	200mg/l of each AA and SA	200mg/l of each AA and TA	200 mg/l of each SA and TA	100 mg/l of each AA,SA and TA	Control	200mg/l of each AA and SA	200mg/l OF each AA and TA	200mg/l of each SA and TA	100mg/l of each AA,SA and TA
Plant height (cm)	163.62E	167.32D	177.08B	172.16C	184.175 A	142.42E	149.95D	166.13B	157.86C	174.90A
Shoots number/plant	10.33 A	10.58A	11.33 A	11.00A	11.66 A	9.08E	9.50D	10.41B	10.16 C	11.08A
Main steam diameter (mm)	3.45 E	3.65D	3.89B	3.82C	4.27 A	3.30E	3.48D	3.77B	3.64 C	4.04A
LGCD (spad units	37.47C	39.67AB	43.84AB	37.96C	46.26 A	35.78E	37.66D	41.75B	39.63C	43.95A
Dry weight /plant (g)	126.35E	133.55D	147.17B	140.98C	156.04 A	70.89D	78.32C	90.08B	82.72C	99.73A
Umbels number /plant	146.41E	154.83D	173.58B	164.00C	184.41 A	117.75E	123.75D	136.16B	130.16C	143.25A
Umbel diameter (cm)	11.61E	12.29D	13.56B	12.92C	14.24A	11.04E	11.62D	12.84B	12.15C	13.52A

In the same row means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

Table (4). Effect of interaction of NPK doses and used acids on vegetative and flowering traits of fennel in 2016/2017 and 2017/2018 seasons

Treatment		1st season							2nd season						
NPK doses (kg/fed)	AA,SA,TA (mg/l)	Plant Height (cm	Shoots Number /plant	Stem Diameter (mm)	L.GC.D (SPAD Units)	Dry Weight/plant	Umbels Number /plant	Umbels Diameter (cm)	Plant Height (cm	Shoots Number /plant	Stem Diameter (mm)	L.GC.D (SPAD Units)	Dry Weight/plant	Umbels Number /plant	Umbels Diameter (cm)
100%	control	171.20e	11.00a	4.16f	44.27b-f	149.51g	190.66e	12.33ij	149.00o	9.33d	3.96 d	**42.02 g**	**81.27 e-g**	**147.00 e**	**11.51 l**
	200of each AA,SA	175.10d	11.00a	4.56c	46.56a-d	157.17e	199.33d	13.21g	156.86k	10.00c	4.16 c	**44.24 e**	**84.84 d-f**	**155.00 d**	**12.12 gg**
	200of each AA,TA	185.50b	12.00a	4.33df	51.60 ab	172.40b	221.33b	14.39b	173.81	11.00b	4.46 b	**49.02 b**	**100.61 b**	**171.66 b**	**13.49 c**
	200of each SA,TA	180.13c	11.66a	4.73b	49.01a-c	166.95c	213.66c	13.67de	165.10gc	10.66b	4.43b	**46.56c**	**91.17cd**	**163.00c**	**12.82f**
	100 of each AA,SA,TA	192.60a	12.00a	5.30a	54.31a	183.55a	232.66a	15.12a	182.93a	11.66a	4.93a	**51.60a**	**116.98a**	**181.00a**	**14.20a**
75%	control	166.05f	10.33a	3.63i	39.39d-i	132.23j	156.33i	11.78kl	144.36q	9.00d	3.43hi	**37.62l**	**62.53h**	**134.00g**	**11.18n**
	200of each AA,SA	169.83e	11.00a	3.83h	41.71c-h	139.34i	165.00h	12.40i	152.16m	10.00c	3.63fg	**39.59j**	**74.46g**	**141.00e**	**11.78k**
	200of each AA,TA	179.86c	11.33a	4.2ef	46.08a-e	154.61f	184.00f	13.74cd	168.60e	10.66b	3.96d	**43.87**	**91.88cd**	**152.66d**	**13.06e**
	200of each SA,TA	174.73d	11.00a	3.96g	30.65i	146.88h	174.00g	13.41e-g	160.36i	10.00c	3.80e	**41.68h**	**80.83e-g**	**148.33**	**12.40h**
	100 of each AA,SA,TA	187.16b	12.00a	4.43d	48.61a-c	163.42d	194.66e	14.13b	177.46b	11.00b	4.23c	**46.18d**	**101.80b**	**160.33c**	**13.74b**
50%	control	161.03g	7.00b	3.13m	34.77g-i	118.79l	132.33l	11.37m	140.20s	9.00d	3.06k	**33.67q**	**75.52g**	**110.33k**	**10.80o**
	200of each AA,SA	164.66f	10.33a	3.26kl	37.30e-i	125.20k	143.66j	12.00k	147.60p	9.00d	3.23j	**35.44o**	**79.82e-g**	**116.66j**	**11.37lm**
	200of each AA,TA	173.76d	11.00a	3.70i	41.63c-h	137.01i	164.33h	13.26fg	163.53h	10.00c	3.50gh	**39.27k**	**87.00c-e**	**129.00h**	**12.60g**
	200of each SA,TA	169.46e	11.00a	3.43j	36.74 f-i	131.64j	153.66i	12.60hi	155.53l	10.00c	3.30ij	**37.18m**	**81.43e-g**	**122.66i**	**11.97j**
	100 of each AA,SA,TA	181.20 c	11.33 a	3.90 gh	43.51 b-g	145.87 h	171.66 g	14.00 c	172.26 d	11.00 b	3.70 ef	**41.34 r**	**94.00 bc**	**135.66 g**	**13.27 d**
25%	control	156.20h	10.00a	2.86 n	31.43 i	104.88 n	106.33 o	10.96 n	136.13 t	9.00 d	2.76 m	**29.78 t**	**64.26 h**	**79.66 o**	**10.66 o**
	200of each AA,SA	159.70g	10.00a	2.96n	33.09hi	112.51m	111.33n	11.54lm	143.16r	9.00d	2.90lm	**31.35s**	**74.17g**	**82.33o**	**11.22mn**
	200of each AA,TA	169.20e	11.00a	3.30k	36.06f-i	124.67k	124.66m	12.87h	158.60j	10.00c	3.16jk	**34.85p**	**80.85e-g**	**91.33m**	**12.22i**
	200of each SA,TA	164.33f	10.33a	3.16lm	35.44f-i	118.43l	114.66n	12.03jk	150.66n	10.00c	3.03kl	**33.09r**	**77.47fg**	**86.66n**	**11.44l**
	100 of each AA,SA,TA	175.73d	11.33a	3.46j	38.60d-i	131.29j	138.66k	13.55d-f	166.93f	100.66b	3.30ij	**36.67n**	**86.13c-e**	**86.00l**	**12.86f**

In the same column means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

Concerning the interaction effect, the presented results in Table 4 demonstrated that the treatment of 100% NPK dose combined with 100 mg/l of each AA, SA, and TA caused significant increases in plant height, shoots number / plant, main steam diameter, leaf green color degree, dry weight / plant umbels number / plant and umbel diameter in comparison to the other interaction treatments in the two seasons. On the other side, the treatment of 25% NPK dose without spray with stimulants gave the least significant values of such traits, expect for shoots number / plant in the first season .where this fact result from 50% NPK dose without spray with stimulants. The differences among the interaction treatments reached the significant level in the most cases during the both seasons.

These results are in harmony with those of El- Tarawy *et al*. (2012) who reported that the treatment of 75% NPK (112.5, 112.5 and 37.5 kg /fed of ammonium sulphate, calcium superphosphate and potassium sulphate, respectively) plus 200 mg/l of each ascorbic and salicylic acids recorded the best results of branches number /plant, herb fresh and dry weights and umbels number/plant. El-Mahrouk *et al*. (2016) mentioned that the significantly highest values of plant height, shoots number / plant and fresh and dry
weights of sage plant resulted from ¾ NPK dose (225+150+75 kg /fed of ammonium sulphate, calcium superphosphate and potassium sulphate , respectively) plus 200 ppm ascorbic acid .

Effect of NPK doses, used stimulants and their interaction on seed yield, essential oil and chemical composition.

As for NPK doses, data in Table (5) showed that the treatment of 100% NPK dose was the most significant effective in increasing weight of 100 seeds, essential oil % and yield/plant, leaf N, P and K% and total carbohydrates% in fruits in comparing to the other NPK doses in the two seasons .While the significantly highest value of seed yield / plant was recorded for 75%NPK dose in the both seasons. It is clear from the results that the values of such traits decreased gradually with decreasing NPK doses with one exception of seed yield / plant whereas, 75% NPK dose caused an increase over than 100% NPK dose in the two seasons . The results indicated that 100% NPK dose was the suitable for yield, essential oil productively and chemical composition, that may be referred to that NPK play important roles in the physiological, chemical and biochemical processes in plant cell and the genetic information system, which positively reflect on the plant development and its yield and chemical composition. These results confirmed with those of Nik *et al*. (2011) on Ajowan plant who found that 120 kg, N 200 kg P, 150 kg K , 25kg Zn and 25 kg Mg per ha had significant effect on seed yield . Yousuf *et al.* (2014) mentioned that N, P, K and S at 70, 50, 30 and 20 kg / ha gave the highest seed yield of coriander. Waskela *et al*. (2017) found that NPK at 60+60+40 kg/ ha exhibited significant maximum yield of fennel. Al –Mansour *et al*. (2018) showed that the higher essential oil % and yield of sweet basil resulted from 10 t/ha FYM +NPK (160+30+80kg /ha).

Concerning AA, SA, and TA effect, data in Table 6 pointed out that the used treatments of stimulants caused significant increases in yield, essential oil and chemical composition parameters under study over than the control treatment. Meanwhile, the treatment of 100 mg/l of each AA, SA, and TA had positive pronounced effect on such traits in comparing to the other ones in the two seasons. These results may be attributed to that 100 mg/l of each AA, SA, and TA was the suitable level, which caused better balance among them, that reflected on the plant yield and chemical composition. Also, a plant bio-stimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrients content (Patrick, 2015). SA, AA and TA play crucial roles in the regulation of physiological and biochemical processes during the entire life span of the plant (Karnok, 2000; Vicente and Plasencia, 2011 and Rasmy *et al*., 2012).

Table (5). Effect of NPK doses on seed yield, essential oil and chemical in 2016/2017 and 2017/2018 seasons composition of fennel

Parameters	NPK doses (kg/fed)							
	1st season				2nd season			
	100%	75%	50%	25%	100%	75%	50%	25%
Seed yield/plant	57.29B	68.04A	55.21C	45.22D	52.99B	64.15A	53.62B	34.09C
Weight of 100 seed(g)	1.36A	1.22B	1.09C	1.02D	1.31A	1.16B	1.06C	0.97D
Essential oil%	2.38A	1.88B	1.69C	1.49D	2.15A	1.83AB	1.53BC	1.42C
Essential oil yield/plant	1.39A	1.28B	0.93C	0.68D	1.15A	1.17A	0.82B	0.42C
N %	2.57A	2.47B	2.32C	2.24D	2.51A	2.37D	2.20C	2.13D
P %	0.36A	0.33B	0.30C	0.27D	0.32A	0.32A	0.29B	0.25C
K %	3.18A	2.82B	2.52C	2.14D	2.99A	2.70B	2.40C	2.02D
Carbohydrate %	13.84A	13.29B	12.59C	11.74D	11.87A	12.62A	11.96A	11.15A

In the same row means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

These results are similar to those of Ibrahim and Taha (2016) revealed that the highest values of total soluble sugars and N, P and K % of *Ficus microcarpa* were recorded for the plants treated with 150 mg/l tryptophan. Ali *et al*. (2017) found that application of AA at 100 mg/l gave the maximum essential oil yield of fennel. Additionally, Yeganehpoor *et al*. (2017) reported that SA at 1mM led to increment in seed oil of coriander.

Table (6). Effect of the used acids on seed yield essential oil and chemical composition fennel in 2016/2017 and 2017/2018 seasons

Parameters	AA,SA and TA treatments (mg/l)									
	1st season					2nd season				
	Control	200mg/l of each AA and SA	200mg/l OF each AA and TA	200mg/l of each SA and TA	100mg/l of each AA,SA and TA	Control	200mg/l of each AA and SA	200mg/l OF each AA and TA	200mg/l of each SA and TA	100mg/l of each AA,SA and TA
Seed yield/plant (g)	48.09 D	51.52C	56.30B	55.97B	70.31A	43.94D	47.78C	52.70B	48.62C	63.02A
Weight of 100seed(g)	1.05E	1.12D	1.23B	1.17C	1.30A	1.01E	1.07D	1.18B	1.13C	1.24A
Essential oil%	1.70D	1.78CD	1.95 AB	1.87 BC	2.01A	1.57E	1.64D	1.81B	1.73 C	1.91 A
Essential oil yield/plant(ml)	0.81D	0.92C	1.10B	1.06B	1.47A	0.69D	0.79C	0.96B	0.85C	1.24 A
N %	2.21E	2.30D	2.46B	2.41C	2.61A	2.13E	2.19D	2.39B	2.31C	2.49 A
P %	0.28E	0.30D	0.33B	0.32C	0.35A	0.28D	0.29D	0.32B	0.30C	0.33 A
K %	2.36E	2.49D	2.81B	2.67C	2.99A	2.20D	2.42C	2.65B	2.46C	2.87A
Carbohydrate %	11.57E	12.18D	13.57D	12.82C	14.20A	10.72E	11.29D	12.51D	11.80C	13.17A

In the same row means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

In regard to the interaction effect data in Table 7 indicated that the combination treatments of NPK doses and used stimulants had differently exhibit effects on seed yield / plant, essential oil % and yield / plant, weight of 100 seed and percentages of N, P, K and carbohydrate in the two season. Meanwhile, the treatment of 100% NPK dose combined with 100 mg/l of each AA, SA and TA resulted in significant increases in such traits over than the other ones in the both seasons. In the same time, the plants received 25% NPK dose and did not treat with stimulants had the least significant values of such traits aforementioned in the two season.

These results are in agreement with those of El-Tarawy *et al*. (2012) revealed that total carbohydrate % and essential oil productivity of fennel were higher from application of 75% NPK dose + 200 ppm AA+SA. Also, El- Mahrouk *et al*. (2016) cleared that the essential oil yield / plant ,N,P,K and carbohydrate % in sage plant resulted from ¾ NPK dose +200mg /l AA (NPK full dose is 300+200+100kg/fed of ammonium sulphate, calcium super phosphate and potassium sulphate, respectively). Finally, Sakr *et al*. (2018) mentioned that extract of moringa at 6g/l, 600+300+150 kg /fed of NPK, respectively and aloe at 75 ml/l resulted in a positive increase in oil production and chemical composition of *Pelargonium graveolens*.

Table (7).Effect of interaction of NPK doses and used acids on seed yield, essential oil and chemical composition of fennel in 2016/2017 and 2017/2018 seasons

Treatment		1st Season								2nd season							
NPK doses (kg/fed	AA,SA,TA (mg/l)	Seed yield/plant(g)	Weight of 100 seed(g)	Essential oil%	Essential oil yield/ Plant(ml)	N %	P %	K %	Carbohydrate %	Seed yield/plant(g)	Weight of 100 seed(g)	Essential oil%	Essential oil yield/ Plant(ml)	N %	P %	K %	Carbohydrate %
100%	Control	40.93o	1.21a	2.16cd	0.88g-i	2.39a	0.32a	2.80e	12.40fg	39.40i	1.19a	2.02a	0.79gh	2.34ef	0.30a	2.64de	10.74j
	200of each AA,SA	46.70o	1.29a	2.26bc	1.05d-f	2.49a	0.34a	2.98d	13.05de	44.26g-i	1.25a	2.08a	0.92e-g	2.34ef	0.32a	2.80cd	11.31j
	200of each AA,TA	48.66k	1.43a	2.45ab	1.19cd	2.54a	0.38a	2.42b	14.80b	53.63ef	1.36a	2.20a	1.18cd	2.60d	0.36a	3.18ab	12.53cd
	200of each SA,TA	56.13h	1.36a	2.38b	1.33bc	2.60a	0.36a	3.16c	13.74c	49.05f-h	1.32a	2.15a	1.05d-f	2.53c	0.34a	2.97dc	11.57gh
	100 of each AA,SA,TA	94.06a	1.51a	2.66a	2.50a	2.83a	0.40a	3.56a	15.23a	78.64a	1.43a	2.32a	1.82a	2.74a	0.37a	3.35a	13.19b
75%	Control	61.04f	1.10a	1.76f-i	1.07de	2.27a	0.30a	2.49g	11.96h	57.83c-e	1.04a	1.63a	0.94e-g	2.18ij	0.32a	2.33f-h	13.36hi
	200of each AA,SA	64.23e	1.16a	1.85e-h	1.19cd	2.37a	0.32a	2.64f	12.60f	63.43cd	1.10a	1.72a	1.09c-e	2.27gh	0.30a	2.75cd	11.96e
	200of each AA,TA	71.16c	1.28a	2.03de	1.44b	2.57a	0.34a	2.98d	13.96c	65.06bc	1.24a	1.92a	1.25c	2.46d	0.33a	2.80cd	13.26b
	200of each SA,TA	67.61d	1.22a	1.94d-f	1.31bc	2.46a	0.33a	2.81e	13.26d	62.58cd	1.16a	1.82a	1.14cd	2.36a	0.32a	2.64de	12.59c
	100 of each AA,SA,TA	76.17b	1.35 a	1.84e-h	1.40b	2.68a	0.37a	3.17c	14.69b	71.84ab	1.28a	2.05a	1.47b	2.57bc	0.35a	2.98bc	13.95a
50%	Control	49.69jk	0.99 a	1.54j-l	0.76ij	2.13a	0.27a	2.30ij	11.34j	49.35f-h	0.95a	1.36a	0.67	2.02mn	0.26a	2.11hi	10.77j
	200of each AA,SA	52.31i	1.04a	1.59i-k	0.83b	2.22a	0.28a	2.34hi	11.93h	52.37ef	1.00a	1.44a	0.75	2.12kl	0.29a	2.33f-h	11.33hi
	200of each AA,TA	57.93g	1.13a	1.76f-i	1.02e-g	2.41a	0.31a	2.65f	13.22d	55.42d-f	1.11a	1.60a	0.89fg	2.49fg	0.31a	2.51ef	12.56cd
	200of each SA,TA	55.06h	1.10a	1.68g-j	0.92f-h	2.32a	0.30a	2.49j	12.56f	51.72e-g	1.06a	1.52a	0.79gh	2.20ij	0.29a	2.24gh	11.93ef
	100 of each AA,SA,TA	61.06f	1.22a	1.88e-g	1.15de	2.51a	0.33a	2.82e	13.92c	59.23c-e	1.16a	1.70a	1.01d-f	2.39 e	0.32a	2.80cd	13.22b
25%	Control	40.70	0.92a	1.34l	0.54 l	2.06a	0.24a	1.87m	10.57k	29.18j	0.87a	1.26a	0.37j	1.98 n	0.23a	1.57k	10.03k
	200of each AA,SA	42.84n	0.97a	1.42kl	0.61 kl	2.14a	0.25a	1.99l	11.12 j	31.08j	0.92a	1.34a	0.41j	2.06 lm	0.24a	1.86jk	10.56j
	200of each AA,TA	47.47l	1.07a	1.56i-k	0.74 i-k	2.32a	0.28a	2.21jk	12.33g	36.69ij	1.02a	1.50a	0.55ij	2.23 hi	0.27a	2.12g-j	11.71fg
	200of each SA,TA	45.10m	1.02a	1.49j-l	0.76 j-l	2.26a	0.27a	2.20k	11.72i	31.15j	0.97a	1.42a	0.44j	2.14 jk	0.25a	1.99ij	11.12i
	100 of each AA,SA,TA	49.97j	1.13a	1.66h-j	0.83 hi	2.42a	0.30a	2.41gh	12.98e	42.37hi	1.07a	1.58a	0.67hi	2.27 gh	0.28a	2.36fg	12.32d

In the same column means followed by the same letter are not significantly different according to DMRT at 0.05 level probability

CONCLUSION

In order to achieve the best growth, seed yield, seed essential oil production and chemical constituents of fennel plants, it must be fertilized it by 100% NPK suggested dose combined with 100 mg/l of each ascorbic, salicylic and tryptophan acids.

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الملخص العربى

استخدام بعض الأحماض العضوية والأسمدة المعدنية لانتاج نباتات الشمر

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نبات الشمر يتبع العائلة Apiaceae وهو نبات طبى عطرى قوى يجود فى شمال افريقيا وحوض البحر المتوسط وجنوب اوروبا واسيا ويستخدم فى اغراض عديدة فى الطعام ومستحضرات التجميل والمستحضرات الطبية .لذلك نفذت تجربة حقلية خلال موسمى ٢٠١٦/٢٠١٧ و٢٠١٧/٢٠١٨ فى مزرعة خاصة بقرية مغنين مدينة كوم حمادة / محافظة البحيرة / مصر. ونفذت التجربة بنظام القطع المنشقة حيث جرعات NPK كعامل رئيسى (١٠٠،٧٥،٥٠،٢٥ %) من الجرع المقترحة وهى ٥٠،١٥٠،١٥٠ كجم/ف من سلفات الامونيوم وسوبر فوسفات الكالسيوم وسلفات البوتاسيوم على التوالى .ووضعت معاملات المنشطات الحيوية (أحماض الأسكوربيك والساليسيلك والتربتوفان)كعامل تحت رئيسى .وأهم النتائج المتحصل عليها أوضحت أن جرعة ١٠٠% من NPK اعطت زيادات معنوية فى الصفات الخضرية والزهرية ووزن ١٠٠ بذرة ونسبة ومحصول الزيت / نبات والصفات الكيماوية تحت الدراسة . بينما جرعة ٧٥% من NPK حققت أعلى محصول للثمار /نبات .تطبيق المعاملة ١٠٠ مجم/لتر من كل من حمض الأسكوربيك والساليسيلك والتربتوفان زادت معنويا الصفات الخضرية ومحصول الثمار والزيت وكذلك الصفات الكيماوية المدروسة مقارنة بالمعاملات الأخرى للمنشطات المستخدمة خلال الموسمين .بينما معاملة التفاعل بين جرعة ١٠٠%من NPKو١٠٠ مجم /لتر من كل من المنشطات الحيوية المستخدمة حققت زيادات معنوية فى الصفات المدروسة التى ذكرت سابقا .لذلك نوصى بتسميد نباتات الشمر ب ١٥٠+١٥٠+٥٠كجم/ف من أسمدة سلفات الأمونيوم وسوبر فوسفات الكالسيوم وسلفات البوتاسيوم على التوالى والرش ب ١٠٠ مجم /لتر من كل من حمض الأسكوربيك والساليسيلك والتربتوفان وذلك لتحقيق أفضل نمو للصفات الخضرية والزهرية وإنتاجية للثمار والزيت العطرى .