RESPONSE OF FENNEL PLANTS TO NPK, ASCORBIC AND SALICYLIC ACIDS

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ABSTRACT

The present work was carried out at the Experimental Farm of the Fac. Agric., Kafr El-Sheikh Univ. Foliar spray of 100 and 200 ascorbic acid on January 1st and February 1st and salicylic acid on January 15th and February 15th 2009 and 2010 season were applied to fennel plant. Besides the chemical fertilization levels were added as follows : 150 kg / fed. of ammonium sulphate (20% N), 150 kg /fed. of calcium super phosphate (15.5 % P_2O_5) and 50 kg /fed. of potassium sulphate (48 % K_2O) at different rates of 100(control), 75, 50 and 25% from the recommended dosage for this plant. The obtained results can be summarized as follows: 75% NPK +200 ppm of each ascorbic and salicylic acids recorded the best values number of branches/plant, herb fresh and dry weights , fruit yield, essential oil productivity and main components, chlorophyll (a) and (b), total carbohydrates percentage and total phenoils content while control treatment gave the tallest plants and the highest N, P and K percentages for both seasons in comparison to the other treatments . It is recommended to fertilize this plant with 112.5 kg / fed. of each of ammonium sulphate, calcium superphosphate and 37.5 kg / fed. potassium sulphate plus 200 ppm sprays of each ascorbic and salicylic acids.

INTRODUCTION

Fennel (*Foeniculum vulgare*, Mill.) is one of the most important and oldest aromatic and medicinal plants. It was known and used by ancient Egyptian people. Fennel belongs to family Apiaceae . It is largely cultivated in South Europe and Egypt, it is commonly cultivated in

many locations as a winter annual herb .The dried ripe fruits known as fennel are used in food industries, culinary use as a condiment, bakery and medicinal folklore. Also, as infusion and tincture (Lawless, 1997)

The fennel fruits oil of best grade contain 2-6% of volatile oil (depends on its variety).The volatile oil contains chiefly of anethole and fenchone which give the fruits then characteristic odour and taste .Also, fruits contain 10 % of fixed oil . These components are stimulative, carminative, stomachi, expectorant, diuretic, galactenic and antispasmodic (Ferdinant,1977).The essential oil of fennel is used to flavor different food preparations and in perfumery industries. The oil contains fenchone which plays an important role in pharmaceutical and other industries as well as in confectionery (Abdallah *et al.,* 1978). It is still widely used in traditional Arabian medicine as diuretic appetizer and digestive (Karnick , 1994).

N , P and K are very important elements for the growth of plants because they partake in constrictive of many components such as proteins, nuclic acid , phospholipids and carbohydrates

Blokhina *et al.*(2003) stated that ascorbic acid is the most abundant antioxidant which protects plant cells, ascorbic acid is currently considered to be a regulator of cell division and differentiation .They added that ascorbic acid is involved in a wide range of important functions as antioxidant defense, photoprotection and regulation of photosynthesis and growth .Robinson (1973) reported that ascorbic acid acts as a co-enzymatic reactions by which carbohydrates, proteins are metabolized and involved in photosynthesis and respiration processes.

Salicylic acid (SA) is a phenolic derivative , distributed in a wide range of plant species (Raskin *et al.*, 1990) and is classified under the group of plant hormones (Raskin ,1992). SA has direct involvement in plant growth, thermogensis , flower induction and uptake of ions (Kumar *et al.*,1999). It affects ethylene biosynthesis, stomatal movement and also reverses the effects of abscicic acid on leaf abscission , enhancement of the level of

chlorophyll and carotenoid pigments (Moharekar *et al.*, 2003). It is enhancement of photosynthetic rate and modifying the activity of some of the important enzymes are other roles assigned to SA (Hayat and Ahmed 2007).

Al-Shareif (2006) on *Carum carvi* plants reported that spraying plants with salicylic acid at 100, 200 and 300 ppm significantly increased vegetative growth parameters including plant height , branch number and herb dry weights / plant, essential oil percentage and oil yield/plant and /fed. Ayub *et al.*,(2011) used different levels of nitrogen of 0, 30, 45, 60,75, 90, 105 and 120 kg/ ha. for fennel plants and demonstrated that the treatments of 90 kg N/ha. gave the best values for maximizing plant height, 1000 seed weight(g.) , seed yield (t/ha.) and essential oil contents in plants as compared with unfertilized plants. The aim of this study is to evaluate the response of fennel to NPK fertilizers combined with ascorbic and salicylic acids.

MATERIALS AND METHODS

The field experiment was carried out during the two successive growth seasons of 2008/ 2009 and 2009 / 2010 at the Experimental Farm of the Faculty of Agriculture, Kafr El-Sheikh University to study the effect of NPK fertilizers combined with two kinds of antioxidants at different rates on the vegetative growth, fruit yield, volatile oil percentage, oil constituents and chemical composition of *Foeniculum vulgare*, Mill.

Fennel seeds were sown on November 1 st 2008 and 2009 in both seasons on rows 60 cm apart and in hills 30cm in between . After germination the seedlings were thinned to one plant/hill after 21 days of emergence

150 kg / fed. of each ammonium sulphate (20%N) and calcium super phosphate (15.5 % P_2O_5) and potassium, at the rate of 50 kg /fed. of potassium sulphate (48 % K_2O) were used as recommended dose.

Phosphorus fertilizer was added at the soil preparation before planting in each season. Nitrogen and potassium fertilizers were divided into two equal portions in the growth seasons. The first one was added after 45 days after sowing and the second dose was done one month later.

Foliar applications of ascorbic acid on January 1st and February 1st and salicylic acid on January 15th and February 15th in 2009 and 2010 seasons . The treatments were conducted as follows:

1. Control (recommended chemical fertilizer dose).
2. 75% NPK + 100 ppm of each ascorbic and salicylic acids.
3. 75% NPK + 200 ppm of each ascorbic and salicylic acids.
4. 50% NPK + 100 ppm of each ascorbic and salicylic acids.
5. 50% NPK + 200 ppm of each ascorbic and salicylic acids.
6. 25% NPK + 200 ppm of each ascorbic and salicylic acids.
7. 25% NPK + 250 ppm of each ascorbic and salicylic acids.
8. 200 ppm salicylic acid + 300 ppm ascorbic acid.

The experimental layout was a complete randomized blocks design with three replicates. Plot area was 4 m^2 for each replicate contained 18 plants. The mean values of treatments were compared by Duncan's Multiple Range Test according to Snedecor and Cochran (1980).

A sample of soil was taken at 30 cm depth to determine its physical and chemical properties as shown in Table (A)

Data recorded

A- Herb fresh weight (g./plant) at the flowering stage. B- The following data were recorded after harvesting, plant height (cm), number of branches per plant, herb dry

weight (g./plant), seed index (weight of 100 seeds g.) and fruit yield (g./plant) .

C- Essential oil percentage was determined in the air dried fruits according to British Pharmacopoeia (1963) by distilling 50 g. of fruits for 3.00 hours in order to extract the essential oil which was calculated relative to the sample weight for each treatment as the following equation.

$$\text{Volatile oil \%} = \frac{\text{Volume of oil in graduated tube}}{\text{Sample weight}} \times 100$$

Determination of oil yield per plant (ml.)=

$$\frac{\text{Oil percentage} \times \text{Seeds dry weight/plant}}{100}$$

Gas chromatographic analysis was determined for the seeds essential oil in four samples, especially highly percentage oil samples which were analyzed using DsChrom 6200 Gas Chromatograph equipped with a flame ionization detector for separation of volatile oil constituents. The chromatograph apparatus was fitted with capillary column BPX-5, 5% phenyl (equiv.) polysillphenylene-siloxane 30 m x 0.25mmID x 0.25 µm film. Temperature program ramp increase with a rate of 10 ° C / min from 70° to 200° C. Flow rates of gases were nitrogen at 1 ml/min , hydrogen at 30 ml/min and 330 ml/min for air. Detector and injector temperatures were 300° C and 250° C, respectively . The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of volatile oil.

D- chlorophyll (a and b) were determined in fresh samples according to the method described by Moran (1982), total carbohydrates percentage in the dry leaves was determined according to the method described by Herbert *et al.*, (1971), The total phenolis content in the dry seeds was determined with the Folin- Ciocalteu reagent as described by Singleton and Rossi, (1965), Nitrogen content was determined by modified microkjeldahel method as described by A. O .A. C (1970), phosphorus

was determined colometrically using the method described by Murphy and Riley(1962) and potassium was estimated using flame- photometry method according to Cottenie *et al* . (1982).

Table (A) Physical and chemical analysis of the experimental soil

Physical analysis	
Sand %	12.24
Silt %	24.30
Clay %	63.46
Soil texture	Clay
Chemical analysis	
pH	8.48
E.C (ds /m)	2.3
Organic matter%	2.00
Total N %	0.85
Total P (ppm)	3.88
Cations (meq / l)	
Ca^{++}	3.99
Mg^{++}	2.78
Na^{+}	16.44
K^{+}	1.42
Anions (meq/l)	
CO^{--}_3	1.71
HCO^{-}_3	3.72
Cl^{-}	14.9
$SO^{--}4$	4.30

RSULTS AND DISCUSSION

A- Effect of NPK, ascorbic and salicylic acids treatments on the vegetative growth parameters

Its evident from data in Table (1) that the significantly tallest plants resulted from the plants fertilized with NPK full dose (control).While, the significantly highest number of branches was recorded for the treatment of 75

% NPK + 200 ppm of each ascorbic and salicylic acids. Also, the significantly heaviest herb fresh weight in Table (1) and herb dry weight in Table (2) resulted from the plants treated with NPK full dose and 75 % NPK + 200 ppm of each ascorbic and salicylic acids in comparison to the other treatments without significant difference between them in the two seasons. The least values of these parameters were recorded for the treatment of 200 ppm salicylic acid+300 ppm ascorbic acid. The stimulatory effect of NPK , ascorbic and salicylic acids on the plant

height may be due to the important role of NPK in biochemical and physiological process in plant (Devlin,1975), also Shaddad *et al.*, (1990) assumed that the effect of ascorbic acid on plant growth may be due to substantial role in many metabolic and physiological processes . Salicylic acid enhancement growth of the plants might be associated with the regulatory effects of salicylic on cell growth and division (El-Tayeb 2005).

Table(1)Effect of NPK , ascorbic and salicylic acids treatments on plant height(cm), number of branches / plant and herb fresh weight(g./plant) of *Foeniculum vulgare*, Mill. plants in the two successive seasons of 2008/ 2009 and 2009 / 2010.

Treatments	Plant height (cm)		Branch No./plant		Herb fresh weight (g./plant)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	140.13a	141.50a	7.84 b	7.78 b	464.33a	455.33a
T2	132.08c	133.66c	7.22 c	7.16 c	424.33b	430.11b
T3	138.50b	137.90b	8.07 a	7.90 a	457.89a	452.72a
T4	122.33e	123.33e	6.65 e	6.73 e	372.00c	380.67c
T5	124.25d	125.02d	6.95 d	6.88 d	410.00b	398.17c
T6	106.41f	106.11g	6.44 g	6.50 g	332.75d	351.33e
T7	106.69f	108.08f	6.48 f	6.52 f	350.44cd	364.66de
T8	100.77g	102.62h	6.00 h	6.03 h	277.22e	273.40f

T1= NPK full dose (control) .T2=75% NPK + 100 ppm of each ascorbic and salicylic acids. T3=75% NPK + 200 ppm of each ascorbic and salicylic acids. T4=50% NPK + 100 ppm of each ascorbic and salicylic acids. T5=50% NPK +

200 ppm of each ascorbic and salicylic acids. T6=25% NPK + 200 ppm of each ascorbic and salicylic acids. T7=25% NPK + 250 ppm of each ascorbic and salicylic acids.T8=200 ppm salicylic acid + 300 ppm ascorbic acid.

B- Effect of NPK, ascorbic and salicylic acids treatments on fruit yield

The results presented in Table (2) cleared that the highest value of weight of 100 seeds was recorded for the treatment of 50 % NPK + 200 ppm of each ascorbic and salicylic acids, while the significantly highest values of fruit yield/plant resulted from plants treated with 75 % NPK + 200 ppm of each ascorbic and salicylic acids and NPK full dose with non significant difference among themselves in the two seasons. However, the least values resulted from 200 ppm salicylic acid + 300 ppm ascorbic acid in both seasons. The enhancing effect of the treatment of 50 % NPK + 200 ppm of each ascorbic and salicylic acids on the seed weight may be attributed to reducing number of seeds in inflorescences and may explain the lower 100 seeds weight at higher N rates. Generally, high N rate increases seed protein content. Protein utilizes less space on the seed than starch, these reducing the seed weight (Otteson *et al.*, 2007).

Table(2)Effect of NPK, ascorbic and salicylic acids treatments on herb dry weight(g./plant),weight of 100 seeds(g.)and fruit yield (g./plant) of *Foeniculum vulgare*, Mill. plants in the two successive seasons of 2008/ 2009 and 2009 / 2010.

Treatments	Herb dry weight (g./plant)		Weight of 100 seeds (g.)		Fruit yield(g./plant)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	118.00a	112.61a	0.85c	0.84 c	50.42 a	52.33a
T2	106.03bc	104.67ab	0.84d	0.83 d	44.04 ab	46.36ab
T3	110.67ab	109.33a	0.83e	0.84 c	50.55 a	53.00a
T4	96.88cd	98.67abc	0.95b	0.92 b	40.85bc	38.99bc
T5	103.44bc	101.00ab	0.99 a	0.96 a	40.92bc	38.55bc
T6	81.10e	84.67c	0.71g	0.7o f	34.55cd	34.24c
T7	87.61de	91.06bc	0.73 f	0.72 e	38.49bc	38.22bc
T8	65.44f	66.77d	0.63 h	0.60 g	34.55cd	34.24c

T1= NPK full dose (control); T2=75% NPK + 100 ppm of each ascorbic and salicylic acids. T3=75% NPK + 200 ppm of each ascorbic and salicylic acids. T4=50% NPK + 100 ppm of each ascorbic and salicylic acids. T5=50% NPK + 200 ppm of each ascorbic and salicylic acids. T6=25% NPK + 200 ppm of each ascorbic and salicylic acids. T7=25% NPK + 250 ppm of each ascorbic and salicylic acids.T8=200 ppm salicylic acid + 300 ppm ascorbic acid.

C- Effect of NPK, ascorbic and salicylic acids treatments on essential oil productivity and components

It is evident from presented data in Table (3) that the highest essential oil percentage and yield in the fennel seeds resulted from the treatment of 75 % NPK + 200 ppm of each ascorbic and salicylic acids, followed by NPK full dose (control) treatment with significant difference between them in the second season only in case of oil percentage. However, the least values as recorded for the treatment of 200 ppm salicylic acid + 300 ppm ascorbic acid in both seasons. The stimulatory effect of NPK full dose (control) and 75 % NPK + 200 ppm of each ascorbic and salicylic acids on essential oil percentage and yield may be due to that nitrogen has an important role in essential oil biosynthesis. In addition to influence on photosynthesis and respiration for carbon skeleton production, nitrogen is a part of three important coenzymes, ATP, NADPH and Co A which have important role in terpenoid biosynthesis (Sell, 2003),furthermore salicylic acid is assigned divers regulatory role in the metabolism of plants (Raskin 1992 and Popova *et al.*,1997).

Tabie(3)Effect of NPK, ascorbic and salicylic acids treatments on seed essential oil percentage of the dried seeds and essential oil yield /plant (ml) of *Foeniculum vulgare*, Mill. plants in the two successive seasons of 2008/ 2009 and 2009 / 2010.

Treatments	Seed essential oil (%)		Essential oil yield/plant (ml)	
	1st season	2nd season	1st season	2nd season
NPK full dose (control)	2.10 a	2.16 b	1.06 a	1.13 ab
75% NPK + 100ppm of each ascorbic and salicylic acids	1.98 b	2.00 c	0.88 b	0.93 bc
75% NPK + 200ppm of each ascorbic and salicylic acids	2.10 a	2.24 a	1.07 a	1.20 a
50 % NPK+ 100ppm of each ascorbic and salicylic acids	1.90 c	1.84 e	0.78 b	0.72 cd
50 %NPK + 200ppm of each ascorbic and salicylic acids	1.90 c	1.90 d	0.78 b	0.73 cd
25%NPK + 200 ppm of each ascorbic and salicylic acids	1.69 e	1.72 g	0.58 cd	0.59 de
25% NPK+ 250ppm of each ascorbic and salicylic acids	1.82 d	1.80 f	0.70 bc	0.69 d
200 ppm salicylic acid + 300 ppm ascorbic acid	1.55 f	1.40 f	0.44 d	0.40 e

Data presented in table (4) and illustrated in Figures (1, 2, 3 and 4) revealed the presence of 8-12 components of which 5 components of them were identified by the retention times obtained from pure reference compounds. The identified components are methyl chavicole , limonene , 1,8 cineole , myrcene and α -pinene . The highest values of the major component (methyl chavicole) resulted from the treatment of 50 % NPK + 200 ppm of each ascorbic and salicylic acids as recorded 89.65 % followed by 75 % NPK + 200 ppm of each ascorbic and salicylic acids as gave 87.59 %. The least percentage resulted from NPK full dose (control) and 75 % NPK + 100 ppm of each ascorbic and salicylic acids as recorded 85.9 and 85.47 %, respectively . The highest values of limonene component were achieved from the plants treated with 75 % NPK + 200 ppm of each ascorbic and salicylic acids as recorded 6.09 % , followed

by the treatments of NPK full dose and 75 % NPK+ 100 ppm of each ascorbic and salicylic acids as gave 3.77 and 2.37 %, while the least percentage (1.87%) was recorded for 50 % NPK + 200 ppm ascorbic and salicylic acids treatment.

Table (4):Effect of NPK, ascorbic and salicylic acids treatments on the seeds essential oil components percentage of *Foeniculum vulgare*, Mill. plants in the second season of 2009 / 2010.

Oil components	Treatments			
	T1	T2	T3	T4
Methyl chavicole	85.47	85.91	87.59	89.65
Limonene	3.77	2.37	6.09	1.87
1,8 cineole	6.21	3.43	2.18	2.80
Myrcene	0.30	0.23	0.58	-
α -pinene	0.46	-	0.36	-

T1= NPK full dose (control)

T2= 75% NPK + 100 ppm of each ascorbic and salicylic acids

T3= 75% NPK + 200 ppm of each ascorbic and salicylic acids

T4= 50% NPK + 200 ppm of each ascorbic and salicylic acids

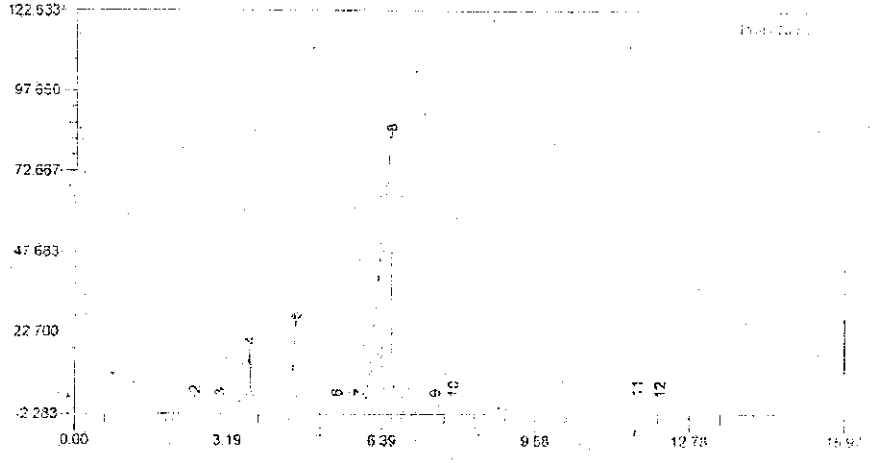

Fig. (1):Chromatogram of fennel seeds oil extracted from plants treated with NPK full dose (control) in the second season (2009 / 2010).

2= α –pinene , 3= Myrcene, 4= Limonene, 5=1,8 Cineole, 8= Methyl chávicole, the rest of numbers are unknown

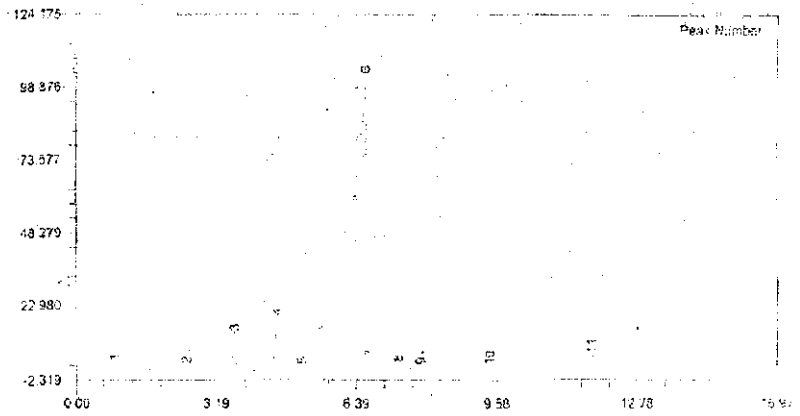

Fig. (2):Chromatogram of fennel seeds oil extracted from plants treated with75% NPK + 100 ppm ascorbic and salicylic acids in the second season (2009 / 2010.)

2= Myrcene, 3= Limonene, 4=1,8 Cineole, 6= Methyl chavicole, the rest of numbers are unknown.

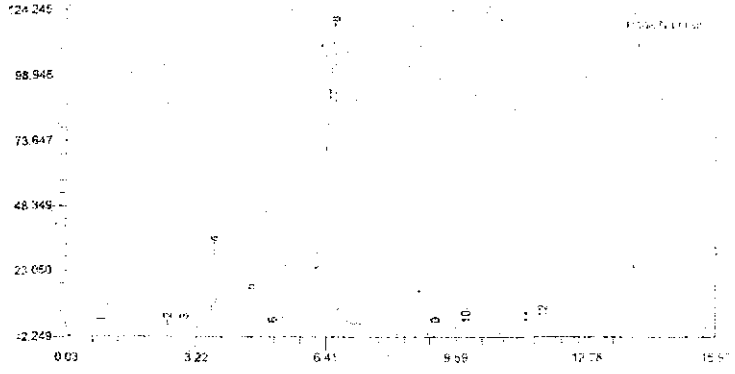

Fig. (3) :Chromatogram of fennel seeds oil extracted from plants treated with75% NPK + 200 ppm ascorbic and salicylic acids in the second season (2009 / 2010.)

2= α –pinene , 3= Myrcene, 4=Limonene, 5=1,8 Cineole, 8= Methyl chavicole, the rest of numbers are unknown

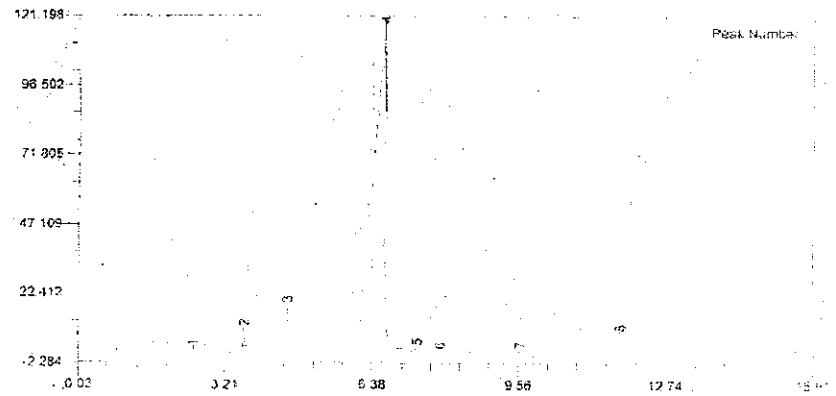

Fig. (4) :Chromatogram of fennel seeds oil extracted from plants treated with 50% NPK + 200 ppm ascorbic and salicylic acids in the second season (2009 / 2010.)

2= Limonene, 3=1,8 Cineole, 4= Methyl chavicole, the rest of numbers are unknown

D- Effect of NPK, ascorbic and salicylic acids treatments on chemical constituents

Its appearing from data in Table (5) that the highest significant chlorophyll (a and b) contents, total carbohydrate percentage and total phenols content resulted from plants treated with 75 % NPK + 200 ppm of each ascorbic and salicylic acids in both seasons . While the treatment of 200 ppm salicylic acid + 300 ppm ascorbic acid gave lower values of above forementioned parameters in both seasons.

The accumulation of photosynthetic pigments as a result of 75 % NPK full dose + 200 ppm ascorbic and salicylic acids treatment may be due to the increase in photosynthetic efficiency that reflected on increasing in both chl a and chl. b contents in the leaves of fennel plants. Blokhina *et al.*, (2003) stated that ascorbic acid has a wide range of important functions as antioxidants

defense, photoprotection and regulation of photosynthesis and growth. Also, the increase in the content of these pigments as a result of salicylic acid treatment, presumably, salicylic acid treated plants might trap more sunlight to increase the rate of photosynthesis as compared to the control plants.

The general increase in total carbohydrates percentage of the treated plants with 75 % NPK+ 200 ppm ascorbic and salicylic acids can be easily explained, since nitrogen supplied by fertilization is essential in the structure of porphyrines, which are found in the cytochrome enzymes essential in photosynthesis. This increase in the cytochrome enzymes results in an increase in the rate of photosynthesis, and promotion in carbohydrates synthesis and accumulation . Moreover, the potassium
added by fertilization acts as an activator for several enzymes involved in carbohydrate metabolism (Devlin,1975), also the role of ascorbic and salicylic acids in increasing the photosynthetic pigments content as mentioned before which reflected on photosynthesis process and led to increase in carbohydrates content .

Table(5)Effect of NPK , ascorbic and salicylic acids treatments on chlorophyll "a", "b"(mg/g. F.W) contents, total carbohydrate percentage and total phenoilc content (mg/g. D.W.) of *Foeniculum vulgare*, Mill. plants in the two successive seasons of 2008/ 2009 and 2009 / 2010.

Treat.	Chlorophyll "a" (mg/ g. f.w)		Chlorophyll" b" (mg/ g. . f.w)		Total carbohydrates (%)		Total phenoilc content (mg/g. d.w.)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1	1.17 b	1.18 c	0.46 a	0.44 a	21.52c	20.31c	0.68 c	0.69 c
T2	1.17 b	1.19 b	0.45 a	0.43 a	22.65b	21.76b	0.71 b	0.72 b
T3	1.20 a	1.21 a	0.50 a	0.47 a	23.10a	24.01a	0.87 a	0.89 a
T4	0.84 c	0.84 e	0.38ab	0.36 ab	15.22e	15.33e	0.62 e	0.61 e
T5	0.84 c	0.85 d	0.38ab	0.37 ab	16.24d	16.48d	0.63 d	0.62 d
T6	0.72 e	0.72 g	0.26bc	0.25 bc	10.95g	12.20g	0.51 f	0.50 g
T7	0.72 d	0.73 f	0.26 c	0.26 bc	12.07 f	13.55 f	0.50 f	0.51 f
T8	0.58 f	0.59 h	0.20 c	0.19 c	9.60 h	10.30h	0.45 g	0.46 h

T1= NPK full dose (control).T2=75% NPK + 100 ppm of each ascorbic and salicylic acids. T3=75% NPK + 200 ppm of each ascorbic and salicylic acids. T4=50% NPK + 100 ppm of each ascorbic and salicylic acids. T5=50% NPK + 200 ppm of each ascorbic and salicylic acids. T6=25% NPK + 200 ppm of each ascorbic and salicylic acids. T7=25% NPK + 250 ppm of each ascorbic and salicylic acids.T8=200 ppm salicylic acid + 300 ppm ascorbic acid.

Data presented in Table (6) revealed that the highest N, P and K percentages in dry leaves resulted from the treatment of NPK full dose (control), followed by 75 % NPK + 200 ppm of each ascorbic and salicylic acids and 75 % NPK + 100 ppm of each ascorbic and salicylic acids during the two seasons . This result may be attributed to the increase in N, P and K cations in the root zone as a result from adding NPK fertilizers. However the least N, P and K % resulted from plants treated with 200 ppm salicylic acid + 300 ppm ascorbic acid in both seasons.

Table (6)Effect of NPK, ascorbic and salicylic acids treatments on nitrogen , phosphorus and potassium percentages in the dry leaves of *Foeniculum vulgare*, Mill. plants in the two successive seasons of 2008/ 2009 and 2009 / 2010.

Treatments	Nitrogen		Phosphorus		Potassium	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
NPK full dose (control)	2.49 a	2.68 a	0.42 a	0.45 a	2.71 a	2.91 a
75% NPK + 100 ppm of each ascorbic and salicylic acids	2.31 b	2.61ab	0.40a	0.42 a	2.53 c	2.72 c
75% NPK + 200 ppm of each ascorbic and salicylic acids	2.31b	2.68 a	0.40a	0.43 a	2.55 b	2.75 b
50 % NPK + 100 ppm of each ascorbic and salicylic acids	2.15c	2.20cd	0.31 b	0.30 ab	2.40e	2.60 e
50 % NPK + 200 ppm of each ascorbic and salicylic acids	2.17 c	2.28 bc	0.30 b	0.32ab	2.41 d	2.62 d
25% NPK + 200 ppm of each ascorbic and salicylic acids	2.05 d	2.02cd	0.21 c	0.20 b	2.23 g	2.38 f
25% NPK + 250 ppm of each ascorbic and salicylic acids	2.05 d	2.04cd	0.22c	0.23 b	2.29 f	2.38 f
200 ppm salicylic acid + 300 ppm ascorbic acid	1.88e	1.82d	0.17 c	0.19 b	2.02 h	2.04 g

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الملخص العربي

استجابة نباتات الشمر للنتروجين والفوسفور والبوتاسيوم ولحامضى الاسكوربيك والسالسيلك

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أجرى هذا البحث بمزرعة بكلية الزراعة جامعة كفر الشيخ خلال موسمي ٢٠٠٨/٢٠٠٩، ٢٠٠٩/ ٢٠١٠ لدراسة تأثير إضافة السماد النيتروجيني والفوسفوري والبوتاسي مع حامضى الاسكوربيك والسالسيلك بمعدل ١٠٠ ، ٢٠٠ جزء في المليون لكل منهما حيث تم الرش الورقي لحامض الاسكوربيك فى الأول من يناير والأول من فبراير فى حين تم رش حامض السالسيلك فى منتصف يناير ومنتصف فبراير وكذلك التسميد الكيماوي بمعدل١٥٠ كيلو جرام للفدان لكل من سلفات الأمونيوم (٢٠% ن) و سوبر فوسفات الكالسيوم (١٥,٥% فو٢أ٥) ،٥٠ كيلو جرام للفدان سلفات بوتاسيوم (٤٨ % بو٢أ) كجرعة موصى بها وتمت الاضافه بمعدلات ١٠٠ (الكنترول) ،٧٥ ،٥٠،٢٥ % من الجرعة الموصى . السماد الفوسفوري تم إضافته أثناء تجهيز الأرض للزراعة أما السماد النيتروجيني والبوتاسي تم تقسيمه لجزعتين متساويتين الأولى تم إضافتها بعد ٤٥ يوم من الزراعة والجرعة الثانية تم إضافتها بعد شهر من المره الأولى ويمكن تلخيص النتائج المتحصل عليها فى أن المعاملة ب٧٥ % من جرعة السماد الكيماوي +٢٠٠ جزء في المليون من كل من حامضى الاسكوربيك والسالسيلك أعطت أفضل القيم من حيث عدد الأفرع والوزن الطازج والجاف وكذلك محصول الثمار وإنتاجية الزيت العطري والمكون الرئيسي للزيت و كلوروفيل "أ" و"ب" ومحتوى النبات من الكربوهيدرات والفينولات الكلية بينما ارتفاع النبات وأعلا نسبة مئوية للنتروجين والفوسفور والبوتاسيوم نتجت من الجرعة الموصى بها (الكنترول) فى كلا الموسمين ويمكن التوصية بتسميد نباتات الشمربمعدل١/٢ ١١٢ كجم/فدان سلفات أمونيوم، ١/٢ ١١٢ كجم/فدان سوبر فوسفات الكالسيوم ، ١/٢ ٣٧ كجم/فدان سلفات بوتاسيوم + ٢٠٠ جزء فى المليون من كل من حامضى الاسكوربيك والسالسيلك .