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EFFECT OF SOWING DATES, BIO, ORGANIC AND CHEMICAL FERTILIZATION TREATMENTS ON GROWTH AND PRODUCTION OF INDIAN FENNEL UNDER NORTH SINAI CONDITIONS

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By

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ABSTRACT

The present study was carried out at El-Sheikh Zowaid Research Station , Desert Research Center, North Sinai Governorate, during the two successive seasons of 2008/2009 and 2009/2010. The objective of this work was to study the effect of sowing date, applying of chemical, bio and organic fertilizers on the vegetative growth and essential oil productivity of *Foeniculum vulgare* var. *panmorium* Mill .(Indian fennel type). The highest values of vegetative growth measurements were obtained with treatment F5 (100% recommended dose+compost (CM) + biofertilizer) which produced the tallest plants, the heaviest fresh and dry weights of herb/plant as compared to other fertilization treatments. The early sowing date (7^{th} October) proved to be the most effective one for producing the best vegetative growth in comparison with the other sowing dates. In addition, the highest number of umbels /plant, fruit yield/ plant (g) and per feddan (ton) and weight of 1000 fruits (g) were recorded by using the treatment F5 (100% recommended dose+compost (CM) + biofertilizer). The highest oil percentage was due to fertilization treatment F4 (biofertilizer +5 ton compost/fed). Whereas, the highest oil yield/plant was obtained from F5 treatment (100%recommended dose) + compost (CM) + biofertilizer. Delaying planting date from 7^{th} Oct to 7^{th} Nov decreased both oil percentage and oil yield/plant. The highest values belonged to the early sowing date of 7^{th} October. Moreover, the highest leaf N, P and P contents were gained with the treatment of F5 (100%recommended dose) + compost (CM) + biofertilizer in both seasons. The main detected component was trans-anethole which is considered an important constituent, followed descendingly by fenchone then estragole. There are other major components including limonene and ,α-pinene that were found in the tested oil. Delaying sowing date decreased anethol content in the volatile oil. Fenchone percentage in the fennel volatile oil was generally increased with delaying sowing date, and also methyl-chavicol (estragole) was higher in delayed dates, while limonene and ρ-cymene recorded the least value with the late sowing date of 7^{th} November.

A dose of (400kg per fed) ammonium sulphate (20.5%N) + super phosphorus, at the rate of 300 kg calcium super-phosphate (16 % P_2O_5) per feddan +Potassium sulfate, at the rate of 100 kg potassium sulfate (48 % K_2O) per feddan was recommnded.

***Key words**: anethol, estragole, fertilization, foeniculum, Indian fennel, oil constituents, sowing date.*

1. INTRODUCTION

Foeniculum vulgare, Mill. is known as fennel, belongs to family Apiaceae or Umbelliferae. Fennel is a strong aromatic perennial shrublet up to 200 cm high, with feathery leaves and golden yellow flowers. It is native to north Africa, Mediterranean region, southern Europe and Asia. There are two types of oil that are commercially available: bitter fennel oil which is obtained from wild or cultivated *Foeniculum vulgare*, Mill. var. vulgare, and sweet fennel oil from cultivated *Foeniculum vulgare*, Mill. var. dulce. Volatile oil is obtained by steam distillation of the crushed ripe fruits. Formacek and Kubeczka (1982), Boulos (1983),Simon (1990), Lawless (1992) and Bown (1995). reported that the essential oil from fennel seed and plant has flavoring, cosmetic, and pharmaceutical uses as stomachic, tonic, carminative, antispasmodic, diuretic, with the approval of the German Office of Health.

It was mentioned that the main constituents of the essential oil of the most important fennel variety (var. dulce) contains anethole (50 to 80%), limonene (5%), fenchone (5%), estragole (methyl-

chavicol), safrole, α-pinene (0.5%), camphene, β-pinene, β-myrcene and p-cymene. In contrast, the uncultivated form (var. vulgare) contains often more essential oil, but since it is characterized by the bitter fenchone (12 to 22%), it is of little value and its origin is Mediterranean (Leung 1980), Abou Zeid, E.N. (1988), Lawless (1992), Bown (1995) and Chevallier (1996). Egypt cultivates about 11000 feddans of fennel (*Foeniculum vulgare* var. *vulgare*), mostly in Assiut and Qena Governorates. Egyptian type is inferior to the Indian type (*Foeniculum vulgare* var. *panmorium*) in the anethol content which is about 20-35% in the Egyptian variety compared to 60-80% in the Indian types. Further, Egyptian types have another major drawback which is the high content of estragole (methyl chavicol) which reaches 40-50% compared to about 14.7-22.6 % in the Indian types.Abd El-Wahab and Mehasen (2009) on Indian fennel plants, found that delaying sowing date decreased anethole content , while fenchone percentage in the fennel volatile oil increased with delaying sowing date. Methyl-chavicol (estragole) was higher in delayed dates , while limonene and ρ-cymene recorded the least value with late sowing date under upper Egypt conditions. Estragol is among the substances banned for use in infant formulas and drugs. Some countries such as Germany ban the use of Egyptian fennel in drug manufacturing at large. Accordingly, it is empirical for Egypt to introduce a new variety of fennel with lower estaragol content. Market News Service (MNS) Medicinal Plants & Extracts (2006) and (ESHEDA 2007).

2. MATERIALS AND METHODS

The present study was carried out at El- Sheikh Zowaid Research Station, Desert Research Center, North Sinai Governorate during the two successive seasons of 2008/2009 and 2009/2010. The objective of this work was to study the effect of sowing date, applying of chemical, bio and organic fertilizers on the vegetative growth and essential oil productivity of *Foeniculum vulgare* var. *panmorium* (Indian fennel type).

2.1. Plant material and procedure

Seeds of Indian fennel were imported from India by (AERI) Institutional Linkage Project the holder of the U.S. Agency for International Development (USAID)-funded AERI/ILA Cooperative.The Egyptian fennel seeds were obtained from the Egyptian Spices and Herb Export Development Association (ESHEDA).

2.2. Planting dates

Seeds of Indian fennel were sown on 7th Oct., 21st Oct. and 7th Nov. 2008 and 2009 (in the first and second seasons, respectively). Seeds were sown directly in reclaimed sandy soil in the two seasons. The distance between rows was 75cm and 50 cm between hills. The plants were thinned after germination; two plants per hill (22400 plants/fed). Drip irrigation was used with drippers (4 liter / hour /hill) both seasons for only one hour every two days.

The analyses of soil and water are shown in Tables 1 and 2. The chemical properties of soil in ppm (water extract 1:2.5 v/v) were analyzed in the Desert Research Center laboratories according to Chapman and Pratt (1961).

2.3. Fertilizer forms

The fertilization treatments included the following

2.3.1. Chemical fertilizers

1-1-Control with recommended dose of N P K (F1) as (400kg per fed) ammonium sulphate (20.5%N) + phosphorus source at the rate of 300kg calcium super-phosphate (15.5 % P_2O_5) per feddan + potassium source, at the rate of 100 kg potassium sulfate (48% K_2O) per feddan plus compost added before planting 5 ton/fed.

1-2- (75% of the control recommended dose of N P K.(F2) as (300 kg per feddan) ammonium sulphate (20.5%N) + phosphorus, at the rate of 225kg calcium super-phosphate (15.5 % P_2O_5) per feddan + potassium, at the rates of 75 kg potassium sulfate (48% K_2O) per feddan plus compost added before planting 5 ton/fed.

1-3- F3(50% recommended dose)-The chemical fertilizers of N P K (F3) 200 kg per feddan ammonium sulphate (20.5%N) + phosphorus, at the rate of 150kg calcium super-phosphate (15.5 % P_2O_5) per feddan + potassium, at the rate of 50 kg potassium sulfate (48% K_2O) per feddan plus compost added before planting 5 ton/fed.

Fertilization with calcium super phosphate and compost 5 ton /fed. was conducted immediately before planting in each season in only one dose. As for nitrogen and potassium fertilizers they were applied in five equal doses in the both seasons. The first was added 21 days from appearance of the real leaves and then every two week intervals.

2.3.2. Bio-fertilizer

Biofertilizer was added as mixture of 5 strains of bacteria namely: *Azotobacter chroococcum*, *Azospirillum lipoferum*, *Bacillus polymixa*, *B. megatherium* and *Pseudomonas fluorescence* ($1X10^8$ / ml) obtained from Desert Research Center, El-Mataria, Egypt. The biofertilizer (1

Table (1): Mechanical and chemical analyses of the soil.

Physical analysis	Very coarse sand%	Coarse sand %	Medium sand %	Fine sand%	Very fine sand %	Silt and clay %	Type of soil
	0.31	1.93	40.05	53.52	2.44	1.75	Sandy soil

Chemical analysis	pH	E.C. mmhos/cm	O.M. %	Cations meq/L				Anions meq/L			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}
	8.37	0.90	0.52	4.08	0.82	4.50	0.25	-	1.91	3.00	4.74

Table (2): Chemical analysis of the irrigation water.

TDS ppm	pH	Soluble cations (ppm.)					Soluble anions (ppm.)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}		CO^{-3}	HCO^{-3}	SO^{-4}	CL^{-1}
3355	8.1	215.68	128.64	720.00	8.00		20.25	148.23	725.0	1300.0

L mixture of 5 strains of bacteria +20 L of water) was added as a soil drench four times per season at monthly intervals started from sowing the seeds. The addition of biofertilizer was done after one week from the addition of chemical fertilizers.

2.3.3. Organic fertilizer

Compost manure (cm) was used at the rate of (5 ton per feddan) (1m3 = 450-500 kg Compost). The compost manure was obtained from El-obor market- El-obor city. The chemical characteristics of the compost are shown in Table (3). Common cultural practices were used throughout the experiment, including weed control which was similarly done whenever needed. Organic fertilizer was analyzed in the Desert Research Center laboratories.

2.4. The treatments were conducted as follows

F1 Control (100%recommended dose)+ compost(CM).
F2 (75%recommended dose) + compost(CM)
F3 (50%recommended dose) + compost(CM)
F4 Biofertilizer+5ton compost/fed.
F5 (100%recommended dose)+ compost(CM) + biofertilizer
F6 (75%recommended dose) + compost(CM) + biofertilizer
F7 (50%recommended dose) + compost(CM) + biofertilizer

2.5. Harvesting

Plants of fennel were harvested at the mature stage on 30th April for 7th Oct and 7th May for both 21st Oct and 7th Nov in both seasons.

2.6. Data recorded

2.6.1. Vegetative characteristics at beginning of flowering

1.1. Plant height (cm)
1.2. Number of main branches per plant
1.3. Fresh and dry weights of herb (g/plant)

2.6.2. Fruit measurements were recorded at harvesting time

1. Umbels number/plant
2. Fruit yield /plant (g) and per feddan (ton)
3. Weight of 1000 fruits (g)

2.6.3. Determination of essential oil production

1. Essential oil %
2. Essential oil yield per plant (ml) and per fed. (L)

3. Essential oil constituents by GC-Ms analysis:

Volatile oil percentage and content of dry fruits for each sample were determined using Clevenger apparatus according to (British Pharmacopoeia 1963). Also,GC/ Mass analysis of volatile oil of each treatment was performed with specification of the apparatus used according to Robert Adams (1995).

2.6.4. Element Determination (N, P and K) in leaves

Nitrogen percentage was determined by modified micro kjeldahl method as described by A.O. A. C. (1970). For phosphorus determination, the ammonium molybdate method according to Murphy and Riley (1962) was used. As for potassium it was estimated used atomic absorption apparatus according to Cottenie *et al*. (1982).

2.7. Statistical analysis

The layout of the experiment was a complete randomized block design with three replicates (blocks) , each replicate contained 10 plants. Data from all experiments were subjected to analysis of variance using M. statc Statistical Software (1986). Means of all data were compared by L.S.D. method according to (Snedecor and Cochran, 1968).

3. RESULTS AND DISCUSSION

3.1. Vegetative characters

Data in Tables (5&6) indicated the main effect of fertilization treatments on vegetative parameters. The highest values of those parameters were obtained with the application of F5 (100%recommended dose) + compost(CM) + biofertilizer which produced the tallest plants, the highest number of branches/plants, the heaviest fresh and dry weights of herb/plant compared to other fertilization treatments resulting in significant differences in most cases. However, the highest rate of chemical fertilizer F1 Control (100%recommended dose)+ compost(CM) gave the next higher values of vegetative parameters followed by F6 (75%recommended dose) + compost (CM) + biofertilizer). Meanwhile, fertilization treatment F4 (Biofertilizer+5ton compost/fed) produced the lowest growth in the first and second seasons. Also, as sowing date became later up to 7th November the fresh and dry weights showed a parallel significant decrease than in early sowing date (7th October). The interaction between fertilization treatments and sowing dates was insignificant in most cases, however the highest vegetative parameters resulted from fertilization treatment F5 (100 % recommended dose) + compost (CM) + biofertilizer at the early date of 7th October. These results are coincided with those obtained by, Abd El-Latif and Salem (2002) on *Tagetes minuta*, L. and Rashed (2002) on *Anethum graveolens*, *Coriandrum sativum* and *Petroselinum sativum* plants.

Table (3): The chemical properties of compost (CM). used for growing *Foeniculum vulgare* , Mill. plants during 2008 and 2009 seasons.

pH	E.C mmhos	Soluble cations meq/L.				Soluble anions meq/L			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.10	1.10	15.00	45.00	90.00	30.00	-	45.00	10.00	140.50
Humidity		Ash	O.M	N%		P%		K%	
25%		9%	65%	2%		1.5%		1%	

Organic fertilizer was analyzed in the Desert Research Center laboratories.

Table (4): Meteorological data of El-Sheikh Zwaid of North Sinai during 2008/2009 and 2009/2010 seasons.

Month	First season				Second season			
	Temp. C°		Relative Humidity %	Rain mm	Temp. C°		Relative Humidity %	Rain mm
	max.	min.			max.	min.		
October	28.1	15.5	70	5.50	24.2	13.5	70	20.50
November	24.6	12.7	72	15.50	23.2	13.8	71	36.6
December	21.5	10.2	81	19.50	18.2	7.5	73	138.4
January	20.2	9.3	72	32.7	17.1	8.4	75	123.6
February	20.4	8.3	66	23.9	17.7	6.0	70	117.4
March	20.6	9.3	75	28.8	20.7	8.5	70	88.2
April	27.1	13.6	60	0.7	26.2	11.2	64	23.6
May	27.7	15.00	69	0.0	27.7	14.4	71	0.0
June	35.7	22.00	79	0.0	36.1	24.00	84	0.0
July	34.2	23.00	80	0.0	35.5	25.00	82	10.0

*** Meteorological Laboratory, Desert Research Center at El-Sheikh Zowaidd.**

Table (5): Effect of sowing dates and fertilization treatments on plant height (cm) and number of branches/plant of *Foeniculum vulgare* var *panmorium* (Indian fennel type) plants under North Sinai conditions during 2008/2009 and2009/2010 seasons.

First season								
Parameters	**Plant height (cm)**				**No. of branches/plant**			
	Sowing dates				**Sowing Dates**			
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**131.667**	**130.000**	**118.333**	**126.667**	**8.667**	**8.000**	**7.333**	**8.000**
F2	**123.333**	**120.000**	**108.333**	**117.222**	**7.000**	**6.333**	**6.000**	**6.444**
F3	**106.667**	**108.333**	**105.000**	**106.667**	**6.333**	**6.000**	**6.000**	**6.111**
F4	**91.667**	**83.333**	**71.667**	**82.222**	**4.000**	**3.333**	**3.000**	**3.444**
F5	**135.330**	**135.000**	**123.333**	**131.222**	**10.000**	**9.333**	**8.333**	**9.222**
F6	**130.000**	**115.000**	**111.667**	**118.889**	**9.000**	**8.000**	**7.333**	**8.111**
F7	**121.667**	**100.000**	**98.333**	**106.669**	**8.000**	**7.000**	**6.667**	**7.222**
Mean	**120.048**	**113.095**	**105.238**		**7.571**	**6.857**	**6.381**	
L.S.D. at 5% for	**Sowing dates =2.19 Fertilizer =3.35 Interaction =5.81**				**Sowing dates = 0.23 Fertilizer =0.35 Interaction =0.61**			
Second season								
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**130.000**	**128.333**	**116.667**	**125.000**	**8.333**	**7.667**	**7.000**	**7.667**
F2	**121.667**	**120.000**	**106.667**	**116.111**	**6.667**	**6.000**	**5.667**	**6.111**
F3	**103.333**	**106.667**	**103.333**	**104.444**	**6.000**	**5.667**	**5.333**	**5.667**
F4	**90.000**	**81.667**	**70.000**	**80.556**	**4.000**	**3.000**	**3.000**	**3.333**
F5	**133.667**	**133.333**	**121.667**	**129.556**	**9.333**	**9.000**	**8.000**	**8.778**
F6	**128.333**	**113.333**	**110.000**	**117.222**	**8.333**	**7.667**	**7.000**	**7.667**
F7	**120.000**	**101.667**	**96.667**	**106.111**	**7.333**	**6.667**	**6.333**	**6.778**
Mean	**118.143**	**112.143**	**103.571**		**7.143**	**6.524**	**6.048**	
L.S.D. at 5% for	**Sowing dates =1.98 Fertilizer =3.14 Interaction =5.26**				**Sowing dates =0.21 Fertilizer =0.32 Interaction =0.57**			

F1 Control (100%recommended dose)+ Compost
F2 (75%recommended dose) + compost
F3 (50%recommended dose) + compost
F4 Biofertilizer+5ton compost/fed.
F5 (100%recommended dose)+ compost+ biofertilizer
F6 .(75%recommended dose) + compost+ biofertilizer
F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P_2O_5) + 100 kg potassium sulfate (48% K_2O) plus compost = 5 ton/fed.

Table (6): Effect of sowing date and fertilization treatments on Fresh and dry weights of herb (g/plant) of *Foeniculum vulgare var panmorium* **(Indian fennel type) plants under north Sinai conditions during 2008/2009 and2009/2010 seasons.**

First season								
Parameters	**Fresh weight of herb (g/plant)**				**Dry weight of herb (g/plant)**			
	Sowing Dates				**Sowing Dates**			
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**723.333**	**700.000**	**616.667**	**680.000**	**122.357**	**117.610**	**109.797**	**116.588**
F2	**636.667**	**606.667**	**575.000**	**606.111**	**114.697**	**111.540**	**104.267**	**110.168**
F3	**553.333**	**510.00**	**500.00**	**521.111**	**96.397**	**91.123**	**92.133**	**93.218**
F4	**233.333**	**150.000**	**133.333**	**172.221**	**42.890**	**31.333**	**31.133**	**35.119**
F5	**833.333**	**800.000**	**733.333**	**788.889**	**144.463**	**138.000**	**128.800**	**137.088**
F6	**775.000**	**718.333**	**666.667**	**720.000**	**135.223**	**129.00**	**124.533**	**129.586**
F7	**593.333**	**540.000**	**433.333**	**522.222**	**120.717**	**93.587**	**74.000**	**96.101**
Mean	**621.190**	**575.000**	**522.619**		**110.963**	**101.742**	**94.952**	
L.S.D. at 5% for	**Sowing dates=15.42 Fertilizer =23.56 Interaction =40.81**				**Sowing dates =1.63 Fertilizer =2.49 Interaction =4.32**			
Second season								
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**713.333**	**683.333**	**600.000**	**665.556**	**115.673**	**114.300**	**103.133**	**111.036**
F2	**600.000**	**600.000**	**551.667**	**583.889**	**108.033**	**107.533**	**100.933**	**105.500**
F3	**516.667**	**500.000**	**500.000**	**505.556**	**91.067**	**87.800**	**83.800**	**87.556**
F4	**216.667**	**131.667**	**116.667**	**155.000**	**39.567**	**26.000**	**28.800**	**31.456**
F5	**816.667**	**783.333**	**703.333**	**767.778**	**136.467**	**124.667**	**122.133**	**127.756**
F6	**741.667**	**700.000**	**636.667**	**692.778**	**130.900**	**124.000**	**107.867**	**120.922**
F7	**576.667**	**516.667**	**416.667**	**503.333**	**114.700**	**88.600**	**69.000**	**90.767**
Mean	**597.381**	**559.286**	**503.571**		**105.201**	**96.129**	**87.952**	
L.S.D. at 5% for	**Sowing dates =14.13 Fertilizer =21.42 Interaction =36.67**				**Sowing dates = 1.29 Fertilizer =2.23 Interaction =3.93**			

F1 Control (100%recommended dose)+ Compost
F2 (75%recommended dose) + compost
F3 (50%recommended dose) + compost F4 Biofertilizer+5ton compost/fed.
F5 (100%recommended dose)+ compost+ biofertilizer
F6 .(75%recommended dose) + compost+ biofertilizer
F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P2O5) + 100 kg potassium sulfate (48% K2O) plus compost = 5 ton/fed.

3.2. Fruit production

3.2.1. Number of umbels/plant

Data in Table (7) showed that the highest number of umbels/plant was obtained from fertilization treatment F5 fertilizer (100%recommended dose) + compost (CM) + (100%recommended dose) + compost (CM) + biofertilizer, while F1 Control (100 % recommended dose) + compost(CM) and F6 (75%recommended dose) + compost(CM) + biofertilizer resulted in significantly less number of umbels. The least significant number of umbels was obtained from fertilization treatment of F4 (Biofertilizer + 5ton compost/fed) which produced (15.33 and 16.00 umbels per plant) in the first and second seasons, respectively. Also delaying planting date to 7th November caused a significant decrease in umbel number/plant. These results are coincided with those obtained by Ibrahem (2000) on *Ammi visnaga* L. and *Foeniculum vulgare* Mill. and Shalan *et al*. (2001) on roselle and Ayub *et al*. (2008) on fennel.

3.2.2. Seed index (weight of 1000 seeds (g))

Data in Table (7) show that the highest average of seed index (1000 seed weight) belonged to fertilization treatment F5, while the least average belonged to fertilization treatment F4 (Biofertilizer + 5ton compost/fed). Delaying sowing date to 7th November resulted in a significant decrease in 1000 seed weight. The interaction between fertilization and sowing date was significant, however the highest 1000 seed weight belonged to fertilization treatment F5 (100%recommended dose) + compost (CM) + biofertilizer) planted at the early date of 7th October. Similar results were obtained by Osman (2000) on coriander and Gad (2001) on *Foeniculum vulgare* Mill and *Anethum graveolens* L.

3.2.3. Fruit yield per plant and per feddan

Data concerning the effect of different fertilization treatments on fruit yield per plant are presented in Table (8).These data cleared that the treatment of F5 fertilizer (100%recommended dose)+ compost (CM) + biofertilizer resulted in the highest fruit yield per plant. The other treatments significantly resulted in less fruit yield/plant being the least at F4 (Biofertilizer+5 ton compost/fed.). Also, delaying sowing date to 7th November resulted in the least significant yield of fruits/plant. The interaction between fertilizers and sowing date proved that the highest yield of fruits/plant was belonging to sown Indian fennel plants on 7th of Oct. and fertilized with F5 ,while the lowest fruit yield /plant was obtained by treating the plants with F4 and planted in the7th of Nov. in both seasons.

Fruit yield per feddan in Table (8) shows a similar trend of fruit yield/plant where the highest yield/feddan was generally obtained by F5 with early sowing date of 7th October, whereas the least yield was obtained by F4 at the delayed sowing date of 7th November. Similar results were obtained by Badawi (2000) on roselle and Osman (2000) on coriander and Mahfouz and Sharaf-Eldin (2007) on fennel plants.

3.3. Essential oil production

3.3.1. Oil percentage and oil yield/plant and/ feddan

Data in Table (9) show that the differences between fertilization treatments were significant, where the highest oil percentage belonged to fertilization treatment F4 (Biofertilizer + 5ton compost/fed). However, the highest oil yield/plant and /fed was obtained from F5 fertilizer (100%recommended dose) + compost(CM) + biofertilizer), whereas the least oil yield/plant and /fed was obtained from fertilization treatment F4. Also, delaying planting decreased both oil percentage and oil yield/plant and /fed . The highest values belonged to the early sowing date of 7th October.

The interaction effects between fertilization treatments and sowing dates on oil percentage and oil yield were significant. The highest oil percentage in fruits were produced in the earliest date (7th of Oct.) when the plants treated with F4 treatment. This may be due to the shortage of nutrition rates was sufficient to direct plants towards building up secondary metabolites including volatile oil.

The highest oil yield/plant and /fed belonged to F5 fertilizer, which planted in the7th of Oct. On the reverse, the least oil yield per plant and /fed produced from plants planted in the 7th of Nov and treated with F4 treatment.

The increase in oil yield per plant may be due to the beneficial effects of these fertilizers on the synthesis of carbohydrates in plant tissues, consequently used for oil production. These results are in harmony with those found by Al-Humaid (2004) on fennel plants.

3.3.2. Essential Oil constituents

Analyzing the volatile oil of Indian fennel using G-C Mass spectrometry picnics revealed there were differences in the main components of the oil, according to sowing dates used in this investigation, as shown in Table (10) and chromatography Fig (1,2 and 3).

In the early date (7th of Oct.) as shown in (Fig.1)

Table (7): Effect of sowing date and fertilization treatments on umbel number per plant (g/ plant) and weight of 1000 fruits (g) of *Foeniculum vulgare* var *panmorium* (Indian fennel type) plants under north Sinai conditions during 2008/2009 and2009/2010 seasons.

First season								
Parameters	**Umbel number/ plant**				**Weight of 1000 fruits (g)**			
	Sowing Dates				**Sowing Dates**			
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**40.333**	**37.667**	**31.667**	**36.556**	**5.117**	**5.017**	**5.003**	**5.046**
F2	**34.000**	**31.667**	**28.333**	**31.333**	**5.000**	**4.930**	**4.900**	**4.943**
F3	**29.667**	**25.667**	**20.000**	**25.111**	**4.173**	**4.020**	**4.053**	**4.082**
F4	**22.000**	**20.00**	**15.333**	**19.111**	**3.057**	**2.893**	**2.803**	**2.918**
F5	**46.000**	**42.667**	**36.667**	**41.778**	**5.680**	**5.360**	**5.070**	**5.370**
F6	**41.000**	**39.333**	**35.667**	**38.667**	**5.060**	**4.950**	**4.940**	**4.983**
F7	**34.000**	**31.333**	**29.667**	**31.667**	**4.257**	**4.070**	**4.043**	**4.123**
Mean	**35.286**	**32.619**	**28.190**		**4.620**	**4.463**	**4.402**	
L.S.D. at 5% for	**Sowing dates =1.10 Fertilizer =1.55Interaction =2.69**				**Sowing dates = 0.11 Fertilizer =0.17Interaction=0.29**			
Second season								
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**38.333**	**36.000**	**30.667**	**35.000**	**5.100**	**4.673**	**5.017**	**4.930**
F2	**31.667**	**30.333**	**27.000**	**29.667**	**5.000**	**4.933**	**4.900**	**4.944**
F3	**27.667**	**25.000**	**19.333**	**24.000**	**4.167**	**4.007**	**4.067**	**4.080**
F4	**20.333**	**18.333**	**16.000**	**18.222**	**3.067**	**2.900**	**2.800**	**2.922**
F5	**42.667**	**40.333**	**35.000**	**39.333**	**5.700**	**5.433**	**5.100**	**5.411**
F6	**39.000**	**36.667**	**31.333**	**35.667**	**5.040**	**4.933**	**4.933**	**4.969**
F7	**30.667**	**30.000**	**27.333**	**29.333**	**4.233**	**4.043**	**4.033**	**4.103**
Mean	**32.905**	**30.952**	**26.667**		**4.615**	**4.418**	**4.407**	
L.S.D. at 5% for	**Sowing dates =1.04 Fertilizer =1.44 nteraction =2.40**				**Sowing dates =0.12 Fertilizer =0.19Interaction =0.31**			

F1 Control (100%recommended dose)+ Compost
F2 (75%recommended dose) + compost
F3 (50%recommended dose) + compost F4 Biofertilizer+5ton compost/fed.
F5 (100%recommended dose)+ compost+ biofertilizer
F6 .(75%recommended dose) + compost+ biofertilizer
F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P_2O_5) + 100 kg potassium sulfate (48% K_2O) plus compost = 5 ton/fed.

Table (8): Effect of sowing date and fertilization treatments on fruit yield/plant (g) and fruit yield/feddan (ton) of *Foeniculum vulgare* subsp. *Panmorium* (Indian fennel type) plants under north Sinai conditions during 2008/2009 and2009/2010 seasons.

First season								
Parameters	**Fruit yield / plant (g)**				**Fruit yield per feddan (ton)**			
	Sowing Dates				**Sowing Dates**			
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**66.149**	**63.149**	**59.149**	**62.816**	**1.482**	**1.415**	**1.325**	**1.407**
F2	**60.179**	**55.519**	**52.519**	**56.072**	**1.348**	**1.244**	**1.176**	**1.256**
F3	**51.179**	**49.519**	**27.509**	**42.736**	**1.146**	**1.109**	**0.616**	**0.957**
F4	**8.519**	**7.179**	**5.509**	**7.069**	**0.191**	**0.161**	**0.123**	**0.158**
F5	**75.519**	**72.519**	**70.149**	**72.729**	**1.692**	**1.624**	**1.571**	**1.629**
F6	**67.509**	**62.149**	**60.519**	**63.392**	**1.512**	**1.392**	**1.356**	**1.420**
F7	**31.179**	**30.509**	**23.519**	**28.402**	**0.698**	**0.683**	**0.527**	**0.636**
Mean	**51.462**	**48.649**	**42.696**		**1.153**	**1.090**	**0.956**	
L.S.D. at 5% for	**sowing dates =4.87 fertilizer =7.50 interaction=14.18**				**Values calculated**			
Second season								
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**64.62**	**61.64**	**57.66**	**61.31**	**1.45**	**1.38**	**1.29**	**1.37**
F2	**58.65**	**54.06**	**51.29**	**54.67**	**1.310**	**1.210**	**1.150**	**1.220**
F3	**49.65**	**48.05**	**26.38**	**41.36**	**1.110**	**1.080**	**0.590**	**0.930**
F4	**7.39**	**5.65**	**4.28**	**5.78**	**0.170**	**0.130**	**0.100**	**0.130**
F5	**74.09**	**71.29**	**68.62**	**71.34**	**1.660**	**1.600**	**1.540**	**1.600**
F6	**66.03**	**60.62**	**59.39**	**62.02**	**1.480**	**1.360**	**1.330**	**1.390**
F7	**29.65**	**29.08**	**22.19**	**26.98**	**0.660**	**0.650**	**0.500**	**0.600**
Mean	**50.02**	**47.20**	**41.41**		**1.120**	**1.060**	**0.930**	
L.S.D. at 5% for	**sowing dates =4.16 fertilizer =7.82 interaction =13.96**				**Values calculated**			

F1 Control (100%recommended dose)+ compost
F2 (75%recommended dose) + compost
F3 (50%recommended dose) + compost
F4 Biofertilizer+5ton compost/fed.
F5 (100%recommended dose)+ compost+ biofertilizer
F6 .(75%recommended dose) + compost+ biofertilizer
F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P_2O_5) + 100 kg potassium sulfate (48% K_2O) plus compost = 5 ton/fed.

Table (9): Effect of sowing date and fertilization treatments on essential oil percentage ,oil yield per plant (ml/ plant) and oil yield / feddan (liter) of *Foeniculum vulgare var panmorium* **(Indian fennel type) plants under north Sinai conditions during 2008/2009 and2009/2010 seasons.**

First season												
Parameters	**Essential oil percentage**				**Oil yield / plant (ml.)**				**Oil yield / feddan (liter)**			
Fertilizer	**Sowing Dates**				**Sowing Dates**				**Sowing Dates**			
	7th Oct.	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 cont.	**2.130**	**2.113**	**2.100**	**2.114**	**1.409**	**1.334**	**1.242**	**1.328**	**31.562**	**29.882**	**27.821**	**29.747**
F2	**2.127**	**2.107**	**2.097**	**2.110**	**1.280**	**1.170**	**1.101**	**1.183**	**28.672**	**26.208**	**24.662**	**26.499**
F3	**2.133**	**2.103**	**2.107**	**2.114**	**1.092**	**1.041**	**0.580**	**0.903**	**24.461**	**23.318**	**12.992**	**20.227**
F4	**2.270**	**2.250**	**2.237**	**2.252**	**0.193**	**0.161**	**0.123**	**0.159**	**4.323**	**3.606**	**2.755**	**3.562**
F5	**2.127**	**2.117**	**2.067**	**2.103**	**1.606**	**1.535**	**1.450**	**1.529**	**35.974**	**34.384**	**32.480**	**34.250**
F6	**2.140**	**2.123**	**2.100**	**2.121**	**1.445**	**1.319**	**1.271**	**1.344**	**32.368**	**29.546**	**28.470**	**30.106**
F7	**2.110**	**2.100**	**2.090**	**2.100**	**0.658**	**0.641**	**0.491**	**0.596**	**14.739**	**14.358**	**10.998**	**13.350**
Mean	**2.148**	**2.130**	**2.114**		**1.105**	**1.036**	**0.902**		**24.752**	**23.206**	**20.205**	
L.S.D. at 5% for	**Sowing dates =0.019** **Fertilizer =0.028** **Interaction =0.049**				**Sowing dates =0.048** **Fertilizer =0.074** **Interaction =0.128**				**Values calculated**			
Second season												
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1Cont.	**2.133**	**2.113**	**2.100**	**2.116**	**1.378**	**1.302**	**1.211**	**1.297**	**30.867**	**29.165**	**27.126**	**29.053**
F2	**2.133**	**2.107**	**2.103**	**2.114**	**1.251**	**1.139**	**1.079**	**1.156**	**28.022**	**25.514**	**24.170**	**25.894**
F3	**2.140**	**2.103**	**2.113**	**2.119**	**1.062**	**1.010**	**0.557**	**0.876**	**23.789**	**22.624**	**12.477**	**19.622**
F4	**2.263**	**2.253**	**2.233**	**2.250**	**0.167**	**0.127**	**0.095**	**0.130**	**3.741**	**2.845**	**2.128**	**2.912**
F5	**2.133**	**2.103**	**2.090**	**2.109**	**1.580**	**1.499**	**1.434**	**1.505**	**35.392**	**33.578**	**32.122**	**33.712**
F6	**2.140**	**2.123**	**2.100**	**2.121**	**1.413**	**1.287**	**1.247**	**1.315**	**31.651**	**28.829**	**27.933**	**29.456**
F7	**2.110**	**2.100**	**2.103**	**2.104**	**0.626**	**0.611**	**0.467**	**0.568**	**14.022**	**13.686**	**10.461**	**12.723**
Mean	**2.150**	**2.129**	**2.120**		**1.075**	**1.005**	**0.878**		**24.080**	**22.512**	**19.667**	
L.S.D. at 5% for	**Sowing dates =0.018** **Fertilizer =0.027** **Interaction =0.048**				**L.S.D. at 5% for**	**Sowing dates =0.051** **Fertilizer =0.077** **Interaction =0.131**			**L.S.D. at 5% for**	**Values calculated**		

F1 Control (100%recommended dose)+ Compost

F2 (75%recommended dose) + compost F3 (50%recommended dose) + compost

F4 Biofertilizer+5ton compost/fed. F5 (100%recommended dose)+ compost+ biofertilizer

F6 .(75%recommended dose) + compost+ biofertilizer F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P_2O_5) + 100 kg potassium sulfate (48% K_2O) plus compost = 5 ton/fed.

1) the main component detected was trans-anethole (54.15%) which is considered the important constituent, followed by fenchone (14.88%) then estragole (14.72%). There are other major components such as limonene (8.81%) and ,α-pinene (2.14%) found in the volatile oil.

Referring to the oil of the fruits sown in the middle date 21st of Oct. illustrated in Table (10) and chromatography (Fig 2), it contained trans-anethole as the main component (52.31%). This value was less than that of the first date (7th of Oct.) followed descendingly by estragole (17.84%) then fenchone (14.91%). Moreover, there are some components in small quantities such as limonene (8.11%) and α-pinene (2.18%) which are considered important constituents.

Concerning the main component in the fruits of the plants planted in the 7thof Nov and illustrated in Table (10) and Fig (3) it was trans-anethole. Its percentage was less (46.11%) followed descendingly by estragole (22.64%) followed descendingly by fenchone (15.21%) then limonene (8.14%) and α-pinene (2.21%).

sowing date. Methyl-chavicol (estragole) was high in delayed dates, while limonene and ρ-cymene recorded the least values with late sowing date of 21 November. Razan (2010) sowed anise seeds on three dates (15th Nov., 1st Jan., 15th Feb.). He found that the best sowing date for anethole percentage was on 15th Nov. which gave (91.83 %). Naguib *et al*. (2007) on *Ruta graveolens* L. showed that coumarin and rutin contents were higher with delaying sowing dates.

3.3.3. Chemical composition (NPK)

Data presented in Table (11) showed that, fertilized Indian fennel plants with F5 treatment showed its superiority for increasing nitrogen, phosphorus and potassium percentages in their tissues, followed descendingly by using F1 control. The positive effect of NPK fertilization on nitrogen percentage in Indian fennel might be due to more absorption and accumulation of nitrogen.

Concerning the specific effect of sowing dates on nitrogen, phosphorus and potassium (%), the results recorded in Table (11) indicate that, the percentages of nitrogen, phosphorus and

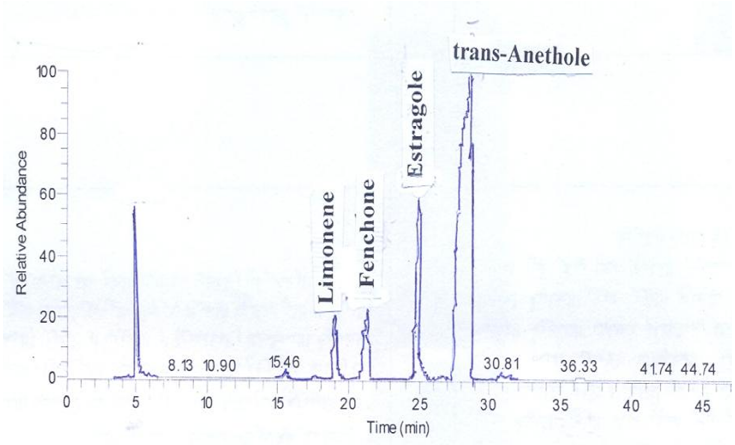
Table (10): Effect of sowing date on essential oil constituents of *Foeniculum vulgare* subsp. *panmorium* (Indian fennel type) under North Sinai conditions.

Name of compound	Retention time	Area %		
		7th Oct.	21th Oct.	7th Nov.
1.α-Pinene	15.06	2.14	2.18	2.21
2.Camphene	15.37	0.63	0.65	0.66
3.Sabinene	16.93	0.21	0.20	0.18
4.β-Pinene	17.65	0.10	0.11	0.13
5.Myrcene	17.90	0.07	0.1	0.12
6.Phellandrene	18.03	0.20	0.20	0.25
7.Limonene	18.92	8.81	8.11	8.14
8.Fenchone	21.14	14.88	14.91	15.21
9.Camphor	22.60	0.05	0.06	0.06
10.Estragole	24.51	14.72	17.84	22.64
11.Fenchyl acetate	26.05	0.30	0.29	0.31
12.Trans-anethole	27.76	54.15	52.31	46.11
Other components		3.74	3.04	3.78

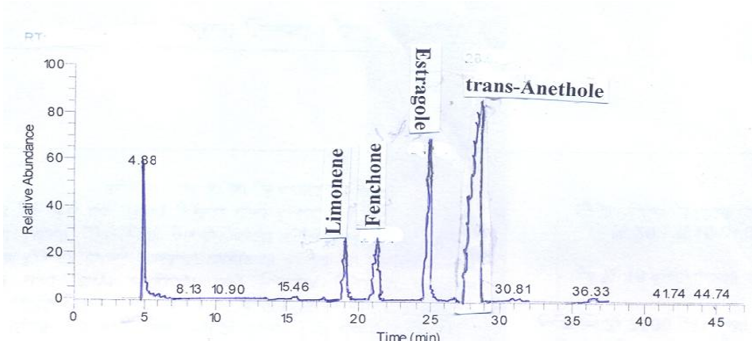
These results coincided with those obtained by Jacoub (1995) on sweet basil (*Ocimum basilicum*) plants. He found that, chemical fertilizers with different rates caused insignificant effect on oil percentage, whereas, oil yield/plant and linalool content were increased., while methyl chavicol percentage was decreased. Abd El- Wahab and Mehasen (2009) on fennel found that delaying sowing date decreased anethol content in the volatile oil. Fenchone percentage in the fennel volatile oil was generally increased with delaying

potassium in the leaves generally decreased by delaying the planting date from 7th of Oct to7thof Nov in both seasons.

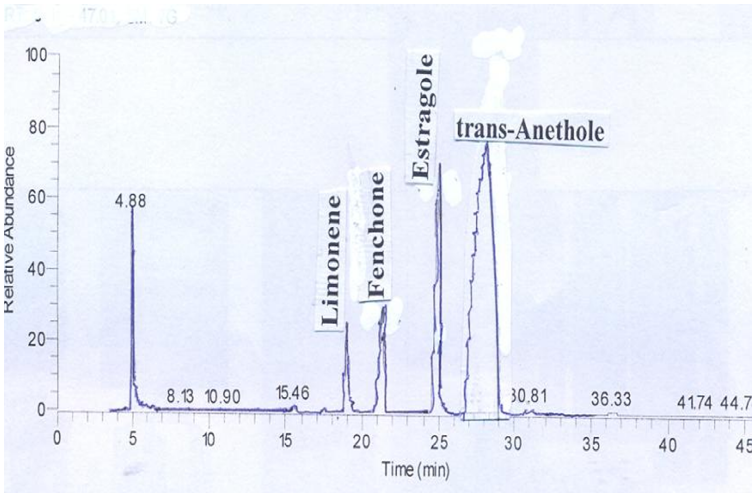
Referring to the interaction effect between fertilizers and sowing date data presented in Table (11) cleared that, the highest values of nitrogen, phosphorus and potassium percentages were recorded with the planting dates of 7th of Oct, 21stof Oct and the 7th of Nov respectively when the plants of Indian fennel were treated with F5 in both seasons. This increment may be due to the



(Fig. 1): Effect of sowing date 7th Oct. on Essential oil constituents of *Foeniculum vulgare* var. *panmorium* (Indian fennel type) plants under north Sinai conditions.



(Fig. 2): Effect of sowing date 21st Oct. on Essential oil constituents of *Foeniculum vulgare* vat. *panmorium* (Indian fennel type) plants under north Sinai conditions.



(Fig. 3): Effect of sowing date 7th Nov. on Essential oil constituents of *Foeniculum vulgare var. panmorium* (Indian fennel type) plants under north Sinai conditions.

Table (11): Effect of sowing date and fertilization treatments on nitrogen , phosphorus and potassium percentages of *Foeniculum vulgare* var. *panmorium* (Indian fennel type) plants under North Sinai conditions during 2008/2009 and2009/2010 seasons.

First season												
Parameters	**Nitrogen %**				**Phosphorus %**				**Potassium %**			
Fertilizer	**Sowing Dates**				**Sowing Dates**				**Sowing Dates**			
	7th Oct.	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**1.560**	**1.540**	**1.500**	**1.533**	**0.360**	**0.340**	**0.310**	**0.337**	**3.360**	**3.340**	**3.320**	**3.340**
F2	**1.440**	**1.450**	**1.390**	**1.427**	**0.340**	**0.330**	**0.300**	**0.328**	**3.240**	**3.250**	**3.220**	**3.237**
F3	**1.310**	**1.290**	**1.270**	**1.290**	**0.310**	**0.290**	**0.270**	**0.290**	**3.220**	**3.210**	**3.200**	**3.210**
F4	**1.210**	**1.230**	**1.190**	**1.210**	**0.290**	**0.270**	**0.290**	**0.283**	**3.110**	**3.130**	**3.120**	**3.120**
F5	**1.640**	**1.630**	**1.580**	**1.617**	**0.440**	**0.380**	**0.360**	**0.393**	**3.540**	**3.530**	**3.480**	**3.517**
F6	**1.510**	**1.540**	**1.470**	**1.507**	**0.330**	**0.340**	**0.320**	**0.330**	**3.330**	**3.340**	**3.310**	**3.327**
F7	**1.340**	**1.320**	**1.290**	**1.317**	**0.300**	**0.320**	**0.290**	**0.303**	**3.140**	**3.120**	**3.120**	**3.127**
Mean	**1.430**	**1.429**	**1.384**		**0.339**	**0.324**	**0.306**		**3.277**	**3.274**	**3.253**	
L.S.D. at 5% for	**Sowing dates = 0.011 Fertilizer =0. 25 Interaction =0.148**				**Sowing dates = 0.021 Fertilizer =0.089 Interaction=0.121**				**Sowing dates = 0.014 Fertilizer =0.221 Interaction=0.213**			
Second season												
Fertilizer	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**mean**	**7th Oct.**	**21st Oct.**	**7th Nov.**	**Mean**
F1 Control	**1.580**	**1.560**	**1.490**	**1.543**	**0.360**	**0.330**	**0.310**	**0.333**	**3.380**	**3.360**	**3.350**	**3.363**
F2	**1.420**	**1.420**	**1.360**	**1.400**	**0.330**	**0.320**	**0.300**	**0.317**	**3.340**	**3.320**	**3.290**	**3.317**
F3	**1.340**	**1.310**	**1.290**	**1.313**	**0.320**	**0.300**	**0.280**	**0.300**	**3.260**	**3.250**	**3.260**	**3.257**
F4	**1.230**	**1.220**	**1.200**	**1.217**	**0.300**	**0.260**	**0.290**	**0.283**	**3.210**	**3.190**	**3.180**	**3.193**
F5	**1.630**	**1.580**	**1.530**	**1.580**	**0.420**	**0.370**	**0.350**	**0.380**	**3.510**	**3.510**	**3.490**	**3.503**
F6	**1.490**	**1.520**	**1.480**	**1.497**	**0.310**	**0.340**	**0.310**	**0.320**	**3.310**	**3.320**	**3.290**	**3.307**
F7	**1.320**	**1.300**	**1.300**	**1.307**	**0.300**	**0.310**	**0.290**	**0.300**	**3.230**	**3.200**	**3.190**	**3.207**
Mean	**1.430**	**1.416**	**1.379**		**0.334**	**0.319**	**0.304**		**3.320**	**3.307**	**3.293**	
L.S.D. at 5% for	**Sowing dates = 0.013 Fertilizer =0.26 Interaction =0.151**				**Sowing dates = 0.022 Fertilizer =0.091 Interaction =0.126**				**Sowing dates = 0.16 Fertilizer =0.235 Interaction =0.261**			

F1 Control (100%recommended dose)+ Compost F2 (75%recommended dose) + compost

F3 (50%recommended dose) + compost F4 Biofertilizer+5ton compost/fed.

F5 (100%recommended dose) + compost+ biofertilizer F6 .(75%recommended dose) + compost+ biofertilizer

F7 (50%recommended dose) + compost+ biofertilizer

Recommended dose/fed (400kg ammonium sulphate (20.5%N) + 300kg calcium super-phosphate (15.5 % P_2O_5) + 100 kg potassium sulfate (48% K_2O) plus compost = 5 ton/fed.

availability of nitrogen for plant absorption.

These results are in harmony with those reported by Badawi (2000) on roselle who found that, the highest increases of nitrogen, phosphorus and potassium in the leaves, seeds and sepals were recorded for the treatment of (300 kg N + 200 kg P + 100 kg K + biofertilizers). Hamed (2004) on chamomile plants, mentioned that the highest values of nitrogen, phosphorus and potassium in the herb were recorded with the treatment of biofertilizer plus full dose of N and P than the other treatments and control. Abd El-Latif (2006) on *Salvia officinalis*, found that using poultry manure (PM) at 20 m^3/fed. increased nitrogen, phosphorus and potassium percentages in most cuts. Bishr *et al*., (2006) on borage (*Borago officinalis*), cleared that the treatment of chicken manure (10 m^3/fed.), Mn (100 ppm) and their combination recorded the highest values in nitrogen, phosphorus and potassium /plant. These results are in harmony with those found by El-Ghadban *et al*. (2008) on lavander (*Lavendula multifida* L.), who concluded that the effect of organic fertilizer (compost) at the rate of 25, 50 and 75 g/pot on chemical composition. The results revealed that increasing in N, P and K percentages.

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تأثير مواعيد الزراعه ومعاملات التسميد الحيوى والعضوى والكيماوى
على النمو والانتاج لنبات الشمر الهندى تحت ظروف شمال سيناء

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ملخص

تمت هذه الدراسة في محطة بحوث الشيخ زويد التابعة لمركز بحوث الصحراء – محافظة شمال سيناء في موسمين متتالين ٢٠٠٨–٢٠٠٩ و ٢٠٠٩/٢٠١٠ بهدف دراسة تأثيرمواعيد الزراعة ودور التسميد الكيماوى والعضوى و الحيوي على النمو وإنتاجية الزيت لنباتات الشمر الهندى. أدى التسميد بالمعامله F5 إلى الحصول على أعلى القيم للقياسات الخضريه (ارتفاع النبات والوزن الطازج والجاف للعشب مقارنا بالمعاملات السماديه الآخرى و أدت الزراعه المبكره فى (السابع من أكتوبر) والتسميد بالمعامله F5 الى زياده معنويه فى النمو الخضرى مقارنا بالمواعيد الآخرى بالإضافه الى إنتاج أعلى عدد من النورات و محصول الثمار للنبات والفدان ووزن الألف بذره .أدى التسميد بالمعامله F4 الى زياده معنويه فى نسبة الزيت بينما تم الحصول علي أعلى محصول للزيت باستخدام المعامله السماديه F5. أدي تأخير ميعاد الزراعه الى تناقص فى كل من نسبة ومحصول الزيت للنبات بينما أدت الزراعه فى الميعاد المبكر(السابع من أكتوبر) الى زياده فى نسبْة الزيت ومحصول الزيت. أدى تأخير موعد الزراعة الى تناقص محتوى الزيت من الانيثول، وزادت نسبة الفينشون في زيت الشمر بشكل عام مع زيادة تأخير موعد الزراعة كما كانت نسبة مثيل شافيكول (الاستراجول) أعلى عند التأخر في المواعيد اما نسبة الليمونين و باراسيمين فقد سجلتا أقل قيمة مع التأخر فى الزراعة في ٧ نوفمبر. اعطى الشمر الهندى اعلى معدل من محتوى الانيثول واقل معدل من مثيل شافيكول(الاستراجول) مقارنة بالمعدلات المتعارف عليها بالشمر المزروع محليا. زادت النسبة المئويه لعناصر (النتروجين والفوسفور والبوتاسيوم) فى أوراق النباتات المعامله ب F5 فى كلا الموسمين .

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