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Effect of plant density on vegetative growth, fruits yield, essential oil and chemical constituents of Dutch Fennelunder Sinai conditions

Research article

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Abstract

The current research consists of two field trials carried out during 2014/2015 and 2015/2016 seasons at the El-Maghara Research Station-DesertResearch Center., to study the effect of sowing dates and spacing on the growth, and productivity of Dutch fennel under Sinai condition.The experiment was designed in a split-plot design of six treatments with three replications for each treatment, as the sowing space in the main plot with three sown spacing at 30, 50 and 70 cm, and the number of plants/hills came in the subplots in two levels as one or two plants/hill.The results showed that, application sown spacing at 50 cm between plants with planting density one plant per hill recorded the highest values of fresh and dry weights/plant, number of umbels/plant, fruit yield /plant, oil yield/plant and also chemical constituents including chlorophyll a, b, total chlorophyll, carotenoids, N, P, K and total carbohydrates percentage in both seasons. Meantime. The highest values of plant height, the weight of 1000 fruits and essential oil percentage were obtained with sown spacing at 30 cm between plants with planting density one plant/hill for both seasons. While the sown spacing at 30 cm between plants with planting density two plants/hill for both seasons recorded the highest of fruit yield /feddan (ton) and oil yield/feddan.

Keywords

Foeniculum vulgare; spacing, density; growth; yield

Introduction

Foeniculum vulgare is a herbaceous plant or a mullet. It is a branch of a branch. Its height ranges from 75-175 cm. The leaves are divided into thin floral pieces. Yellow flowers are collected in the form of a tent, which turns after maturity to greenish-yellow fruits and aromatic aroma. The fruit is used as oil of pilot as a dwelling for colic and chasing gases in children's medicines, treatment of thinness, rheumatism, liver and stomach diseases NHB (2013).

Despite the fact that Egypt is one of the most important producers and exporters of fennel in the world, the Egyptian fennel strain finds obstacles in increasing its source to international markets due to the increase of astragol, which reaches 53-61% in pilot oil, while the percentage of menthol, To 1-12%. This leads to the rejection of the introduction of the Egyptian variety in the pharmaceutical factories abroad, in addition to the decrease in the percentage of oil in general due to the lack of genetic improvement of cultured varieties.

New strains of sweet fennel have been introduced with a high percentage of anethol to more than 50% and less than 10% of the astragal and less than 1.5% of the pilot oil. The most important varieties were *Foeniculum vulgare spp. vulgare*, a new breed of fennel SEKEM imported its seeds from the Netherlands (Euro Herb) and the introduction of cultivation in recent years in many areas in the Arab Republic of Egypt in cooperation with the National Research Center and was distinguished by its superiority in the fruit crop and oil yield and chemical components from the rest of the other breeds, The average percentage of anethol in aromatic oil of fruits (75.93%) while the percentage of astragol is the lowest (4.22%). The average productivity of the fruit yield is 1000-1250 kg / fed.

Plant density is one of the most important studies and an important agricultural factor that influences the growth and quality of the crop (Caliskan et al., 2007). Many investigators studied the effect of plant density on fennel (F. vulgare) plants. In this respect, (Adava and Khurana) and (Yadav and Khurana) 2000 ; (Masood et al.) and (Abdou et al. (2004 ;(Amin et al.) 2005; (Menariaand Maliwal) 2006 ; (Tank et al.) 2006; (Menaria and Maliwal and (Badran et al.) 2007; (Khorshid et al.) 2009; (Lebaschy et al.) 2010; (Mehta et al.) 2011; (Nakhaei et al.) 2012; (Avc and (Selim et al.) 2013; (Moosavi et al.) 2014 and Moosavi et al. (2015) [1-17] on fennel plants they noted that the sowing date and planting density has positive effect on plant height, fresh and dry weights of herb per plant, number of umbels per plant as well as weight of 1000 fruits and fruit yield per plant and feddan .

On the other hand, Khorshidi et al., [18]; (Avc) and Selim et al., [15] on fennel plants they found that significantly effect on essential oil percentage, oil yield, the major content of oil (anethole, estragole, fenchone) and photosynthetic pigment compared all treatments. However,Ibrahem [19]; Abdou et al., [20] ; Badran et al. 2007 and Menaria and Maliwal, 2007 [10] showed that the expressively effect on chemical constituents in herb indicated that, Minimize the density planting with one plant per hill increased all aforementioned studies. indicated that, Minimize the density planting with one plant per hill increased all parameter studies.

Therefore, the study justified the publication and introduction of the cultivation of a new strain of fennel plant (Dutch fennel strain) in the new reclamation lands and in particular the Sinai and its production under Sinai. Access to the highest plant density suitable for feddan to produce the highest yield of the fruit and oil pilot of the Dutch fennel plant under the conditions of central Sinai.

Material and Methods

The present investigation was carried out at the Experimental Farm El Maghara south El-Arish city, North Sinai Governorate Research Station, Desert Research Center stationduring the two successive seasons of 2014-2015 & 2015-2016 .aimed to investigate study the effect of sowing dates and spacing on the growth, and productivity of Dutch fennel under Sinai condition.

Dutch fennel seeds were obtained from the Medicinal and Aromatic Plants Experimental Station of Sekem Company. Seeds were sown on the 18th of October in the first season and 21st of October in the second season. The irrigation water through drip irrigation and the plant received normal agriculture practices whenever they were needed. The mechanical and chemical properties of the used soil are shown in Table 1 according to Chapman and Pratt (1980).

The experimental design was split-plot including 6 treatments with three replications; sown spacing in the main plot, while plant density in the subplot.

Treatment of plant density included two levels, the first level contained three sown spacing at 30, 50 and 70 cm between plants. The second level of density consists of planting density/hill as one or two plants/hill.

In this experiment plants received fertilization as the recommended dose of **Ali, (2002)** as (85, 32 and 48 NPK Kg/feddan), calcium superphosphate fertilizer was added during land preparation. The nitrogen, as well as potassium fertilizer, were added in three equal doses, nitrogen and potassium fertilizers were applied in three equal doses at 30, 60 and 90 days.

Data recorded

I. Vegetative growth characters:

1. Plant height (cm/plant)

Table 1: The mechanical analysis of the experimental soil area.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
0-30	95.00	4.00	1.00	Sandy

2. Fresh and dry weights per plant (gm).
3. Number of umbels
4. Weight of 1000 fruits (g)
5. Fruit yield per plant (g) and feddan (ton)

II. Oil production:

1- Essential oil percentage

2- Oil yield per plant (ml) and per feddan (L)

III. Chemical constituents

1- Pigment content (mg/g F.W.) Chlorophyll a, b and carotene

2- Nutrient element percentage N, P, and K

3- Total carbohydrates

Pigment content (mg/g F.W.) determination such as chlorophyll a, b and carotene were determined in leaf fresh samples (mg/g F. W.) as described by Saric, (1967); nutrient element percentagessuch as N, P and K elements. The chemical analysis was carried out on dried leaves samples obtained from the different treatments. The dry leaves were ground to a fine powder for the determination of Nitrogen content was determined by the modified micro Kjeldahl method as described by A. O. A. C. (1970). Phosphorus was calorimetricallydetermined using the method described by Murphy and Riley (1962) using a spectrophotometer at 882 µv. As for potassium, it was estimated using flame photometry according to Cottenie*et al*., (1982). And total carbohydrates percentage in dried leaves was determined according to Herbert *et al.*, (1971)

Statistical Analysis:

Results were statistically analyzed in a split-plot design according to Means were compared using LSD test at 0.05 level according to Snedecor and Cochran, (1967), by using MSTATC program Bricker, (1991).

Results

Effect of plant spacing

Effect of plant spacing on the growth of *FoeniculumVulgare*is presented in tablet(1) results showed that the vegetative growth parameter is significantly affected from Sawing seeds on 30cm spacing giving the highest value for plant height (93.11 and 96.17cm) and weight of 1000 fruits (14.68 and 14.85 g) in both seasons respectively . while the highest values of fresh weight per plant when sowing seeds on 50cm between plants as (553.80 and 956.10g) g dry weight per plant (267.70 and 268.60 g), number of umbels (93.06 and 94.61 g) and fruit weight per plant (71.22 and 72.33 g) in the first and second seasons, respectively.

It was also observed that there was adirect relationship between growth and yield Productivity determination at fennel plants, that some sowing space in table 2 gave the highest values for fruit weights Per feddan was recordedby sowing spacing 30cm between plants as (l.42 and 1.44 ton), essential oil percentage (2.03 and 2.03%), while the highestvalues for oil yield per plantwas recorded by sawing spacing (1.32 and 1.35 ml).Meanwhile,the oil yield per feddanwas recorded when sonny spacing 30cm between plants (28.60 and 29.09 L) in both seasons, respectively.

Furthermore, the presented data in table (2) demonstrate that, sown seeds in plantings spacing 50cm between plant gave the highest values for pigments content of *Foeniculum vulgare* plant such as chlorophyll-a (0.895 and 0.903 mg/g), chlorophyll b (0.287 and 0.295 mg/g), total chlorophyll (1.182 and 1.198 mg/g) and carotenoids (0.143 and 0.203 mg/g)in both seasons respectively.

on the other hand, data presented in table 3 indicate that planting seeds in 50cm spacing between plants gave the highest values of chemical components such as nitrogen percentage (1.24 and 1.29%), phosphorus percentage (0.33 and 0.36%), potassium percentage (3.50 and 3.51%) respectively, in both seasons.

Moreover, the data presented in table 2 dissect that, the planting seeds in 70cm between plants gave the lowest values of growth parameters such as plant height(80.89 and 83.72cm), fresh weight per plant (491.90 and 493.60g), dry weight per plant (233.60 and 235.40g), number of umbels (74.22 and 75.50), weight of 1000 fruits (12.77 and 13.77g) and fruit per plant (54.00 and 55.I7g).

The data in table 1 revealed that the seeds sown in 70cm between plants led to decrease the yield productivity such as fruits yield per feddan (0.64 and 0.69 ton), essential oil percentage (1.76 and 1.77%), at yield per plant (0.99 and 0. 98ml) and oil yield per feddan (11.09 and 11.36l)

According to data in table 2 showed that pigments contents of fennel plant such as chlorophyll-a (0.660 and 0.661 mg/g)and carotenoids (0.117 and 0.128 mg/g) recorded the Lowest values when planting seeds at 70cm between plants, while the lowestvalues in chlorophyll b

Table 2: Effect of plant spacing on vegetative growth characters and oil production of *FoeniculumVulgare* plant during the two seasons of 2014/2015 and 2015/2016.

Spacing	Plant height (cm)	Fresh weight (g)	Dry weight (g)	Number of umbels	Weight of 1000 fruits(g)	Fruit yield/ plant(g)	Fruit yield/ feddan (ton)	Essential oil %	Oil yield/plant (ml)	Oil yield/ feddan (l)
	First season									
30 cm	93.11	530.80	254.70	74.28	14.68	54.39	1.42	2.03	1.11	28.60
50 cm	85.78	553.80	267.70	93.06	13.25	71.22	1.18	1.85	1.32	21.72
70 cm	80.89	491.90	233.60	74.22	12.77	54.00	0.64	1.76	0.95	11.05
LSD at p<0.05	10.57	15.54	12.46	8.24	0.05	1.70	0.02	0.09	0.07	0.87
	Second season									
30 cm	96.17	530.60	254.20	75.44	14.85	55.28	1.44	2.03	1.13	29.09
50 cm	88.55	556.10	268.80	94.61	13.37	72.33	1.20	1.86	1.35	22.16
70 cm	83.72	493.60	235.40	75.50	13.17	55.17	0.65	1.77	0.98	11.36
LSD at p<0.05	10.88	12.69	13.43	12.27	0.22	7.38	0.12	0.09	0.16	2.64

Table 3: Effect of plant spacing on Chemical constituentsof *Foeniculumvulgare* plant during the two seasons of 2014/2015 and 2015/2016.

Spacing	Chl. a (mg/g)	Chl. b (mg/g)	Total chl. (mg/g)	Carotenoids (mg/g)	% N	% P	% K	Total Carbohydrates
	First season							
30 cm	0.660	0.212	0.875	0.133	1.15	0.26	3.15	22.31
50 cm	0.895	0.287	1.182	0.193	1.24	0.33	3.50	25.90
70 cm	0.693	0.215	0.905	0.117	1.09	0.24	3.11	21.21
LSD at p<0.05	0.088	0.051	0.101	0.051	0.09	0.02	0.31	0.46
	Second season							
30 cm	0.662	0.218	0.880	0.137	1.15	0.26	3.17	22.65
50 cm	0.903	0.295	1.198	0.203	1.25	0.34	3.51	25.95
70 cm	0.705	0.230	0.935	0.128	1.11	0.25	3.13	21.35
LSD at p<0.05	0.168	0.072	0.215	0.051	0.11	0.05	0.24	0.46

Table 4: Effect of planting density on vegetative growth characters and oil production of *Foeniculum vulgare*plant during the two seasons of 2014/2015 and 2015/2016.

Density	Plant height (cm)	Fresh weight (g)	Dry weight (g)	Number of umbels	Weight of 1000 fruits(g)	Fruit yield/ plant(g)	Fruit yield/ feddan (ton)	Essential oil percentage	Oil yield/plant (ml)	Oil yield/ feddan (l)
	First season									
One plant	85.08	561.50	270.80	87.19	13.38	65.56	0.84	1.95	1.28	16.68
Two plants	88.11	489.60	233.20	73.85	13.76	54.19	1.32	1.80	0.97	24.23
LSD at p<0.05	2.67	19.39	9.95	4.32	0.25	1.87	0.01	0.08	0.05	0.81
	Second season									
One plant	88.33	563.60	272.70	88.52	13.70	66.96	0.85	1.96	1.31	17.08
Two plants	90.63	489.90	233.00	75.19	13.89	54.89	1.34	1.82	0.99	24.66
LSD at p<0.05	1.680	21.07	10.20	5.76	0.18	3.75	0.10	0.07	0.04	1.40

Table 5: Effect of planting density on Chemical constituents of *Foeniculum vulgare*plant during the two seasons of 2014/2015 and 2015/2016.

Density	Chl. a (mg/g)	Chl. b (mg/g)	Total chl. (mg/g)	Carotenoids (mg/g)	% N	% P	% K	Total carbohydrates
	First season							
One plant	0.784	0.259	1.043	0.160	1.23	0.31	3.38	23.94
Two plants	0.714	0.217	0.931	0.136	1.09	0.24	3.13	22.34
LSD at p<0.05	0.052	0.036	0.052	0.036	0.01	0.04	0.16	0.48
	Second season							
One plant	0.797	0.268	1.064	0.171	1.25	0.32	3.40	23.98
Two plants	0.717	0.223	0.944	0.141	1.09	0.25	3.14	22.65
LSD at p<0.05	0.109	0.052	0.121	0.036	0.04	0.05	0.20	0.38

Table 6: Effect of interaction between plant spacing and planting density on vegetative growth characters and oil production of *Foeniculum vulgare* plant during the two seasons of 2014/2015 and 2015/2016.

Interaction		Plant height (cm)	Fresh weight (g)	Dry weight (g)	Weight of 1000 fruits(g)	Number of umbels	Fruit yield/ plant(g)	Fruit yield/ feddan (ton)	Essential oil %	Oil yield/ plant (ml)	Oil yield/ feddan (l)
		First season									
30 cm	One plant	95.89	551.00	266.60	14.90	83.33	65.22	1.22	2.13	1.39	25.87
	Two plants	90.33	510.70	242.90	14.47	65.22	43.56	1.63	1.93	0.84	31.33
50 cm	One plant	82.45	619.90	300.60	13.43	100.10	74.11	0.83	1.89	1.40	15.67
	Two plants	89.11	487.80	234.90	13.07	86.00	68.33	1.53	1.81	1.24	27.77
70 cm	One plant	76.89	513.60	245.30	11.80	78.11	57.34	0.46	1.85	1.06	8.50
	Two plants	84.89	470.20	221.80	13.73	70.34	50.67	0.81	1.67	0.85	13.60
LSD at p<0.05		4.63	33.58	17.24	0.43	7.49	3.24	0.02	0.14	0.09	1.41
		Second season									
30 cm	One plant	99.78	553.30	269.00	14.97	84.22	66.55	1.24	2.12	1.41	26.36
	Two plants	92.56	507.90	239.30	14.73	66.67	44.00	1.64	1.94	0.85	31.83
50 cm	One plant	85.55	622.70	301.30	13.57	102.00	75.67	0.85	1.90	1.44	16.14
	Two plants	91.55	489.60	236.30	13.17	87.22	69.00	1.55	1.82	1.26	28.18
70 cm	One plant	79.67	514.90	247.7 0	12.57	79.33	58.67	0.47	1.86	1.09	8.74
	Two plants	87.78	472.20	223.20	13.77	71.67	51.67	0.83	1.69	0.87	13.97
LSD at p<0.05		2.91	36.50	17.66	0.31	9.97	6.49	0.18	0.13	0.06	2.43

(0.879 and 0.880 mg/g) and total chlorophyll (0.212 and 0.218 mg/g)was recorded with planting spacing at 30cm between plants.

The lowest values of chemical components such as nitrogen percentage (1.09 and 1.11%), phosphorous percentage (0.24 and0.25%),potassium percentage (3.11 and 3.13%) and total carbohydrate percentage (21.21 and 21.35%) due to sown spacing 70cm between plants in the first and second seasons, respectively.

Effectof plant density

Data presented in table 4 illustrate the effect of planting density on Dutch fennel showed that, The significantly tallest Plants when planting two plants Per hill as (88.11 and 90.63cm) while The lowest Values of plant highest when planting one plant Per hill as (85.08 and 88.33cm) in the first and second seasons, respectively

The largest amount of fresh and dry weights per plant was positively increasing due to density planting one plant per hill as (561.50 and 270.80g) inthe first season and (563.60 and 272.70g) in the second season, respectively. Onthe other hand,the application of plant density two plants per hill as (489.60 and 233.20g) in the first

Table 7: Effect of plant spacing on Chemical constituentsof *Foeniculum vulgare*plant during the two seasons of 2014/2015 and 2015/2016.

Interaction		Chl. a (mg/g)	Chl. B (mg/g)	Total chl. (mg/g)	Carotenoids (mg/g)	% N	% P	% K	Total Carbohydrates
		First season							
30 cm	One plant	0.717	0.240	0.957	0.150	1.23	0.30	3.31	23.99
	Two plants	0.603	0.190	0.793	0.113	1.06	0.21	3.00	20.62
50 cm	One plant	0.933	0.310	1.243	0.210	1.36	0.38	3.67	26.03
	Two plants	0.857	0.263	1.120	0.177	1.12	0.28	3.32	25.78
70 cm	One plant	0.703	0.227	0.930	0.120	1.11	0.26	3.16	21.80
	Two plants	0.683	0.197	0.880	0.117	1.08	0.23	3.05	20.62
LSD at p<0.05		0.089	0.063	0.089	0.063	0.02	0.06	0.27	0.826
		Second season							
30 cm	One plant	0.733	0.245	0.980	0.157	1.24	0.31	3.33	23.91
	Two plants	0.590	0.190	0.780	0.117	1.05	0.21	3.02	20.70
50 cm	One plant	0.943	0.317	1.260	0.220	1.38	0.39	3.68	26.05
	Two plants	0.863	0.273	1.137	0.187	1.11	0.29	3.34	25.84
70 cm	One plant	0.713	0.240	0.953	0.137	1.12	0.27	3.18	22.00
	Two plants	0.697	0.220	0.917	0.120	1.10	0.24	3.07	21.39
LSD at p<0.05		0.189	0.089	0.209	0.063	0.06	0.09	0.35	0.67

season and (489.90 and 233.00g) in the second season, respectively.

Data in table 4 showed that the effect of planting density one plant per plant on the number of umbels gave the highest values (87.19 and 88.52) while, the lowest values (73.85 and 75.19)in both seasons, respectively.

Results show that fruit yield per plant took the same direction ofmemories umbels as planting density one plant per hill as (65.56 and 66.96g). Moreover, the minimum values obtained with two plants per hill as (54.19 and 54.899) in both seasons respectively.

Results in table 4 indicated that the highest fruit yield per feddan was recorded by planting density of two plants per hill as (1.32 and 1.34 ton). Meanwhile, the lowest valves were recorded by one plant per hill as (0.84 and 0.85 ton) in both seasons respectively.

Itis clear from data in table 4 that the planting density one plant per hill had a significant increase in essential oil percentage as(1.95 and 1.96%). However, the two plants per hill produced the minimum values as(1.80 and 1.82%) in both seasons respectively.

Itis clear from the data of table 4there were significant differences between the treatments. also. yield per plant was given the maximum values as (1.28 and 1.31 ml) with one plant per hill. While theyield per feddan gave the highest values with two plants per hill as (24.23 and 26.66 L) in both seasons respectively. However, the oil yield per plant was recorded the minimum valves with one plant per hill (0.97 and 0.99ml). While the lowest values were recorded with planting one plant per hill as (16.88 and 17.08 L).

The data in table 5 showed that, the highest values for pigments content of *Foeniculum vulgare* plant such as chlorophyll-a (0.784 and 0.796 mg/g), chlorophyll b (0.259 and 0.268 mg/g), total chlorophyll (1.043 and 1.064 mg/g) and carotenoids (0.160 and 0.171 mg/g) when planting density one plant per hill in first and second seasons, respectively.

Meantime, the lowest valves obtained with two plants per hill for chlorophyll a (0.714 and 0.717 mg/g), chlorophyll b (0.217 and 0.223 mg/g), total chlorophyll (0.931 and 0.944 mg/g) and carotenoids (0.136 and 0.141 mg/g) in the first and second seasons, respectively.

The results in table 5 recorded that, the chemical composition of Dutch fennelsuch as nitrogen percentage (1.23 and 1.25%),phosphorus percentage (0.31 and 0.32%), Potassium Percentage (3.38 and 3.40%) and total carbohydrates (23.94 and 23.98%) as results of using a plant per hill in first and second seasons,

respectively. However, the lowest values were recorded with planting two plants per hill for nitrogen percentage (1.09 and 1.09%), phosphorus percentage (0.24 and 0.25%), potassium percentage (3.13 and 3.14%) and total carbohydrates (22.34 and 22.65%) in the first and second seasons, respectively.

Effectof interaction

Data presented in table 6 shows that the growth parameters, yield productivity, pigments and chemical constituents of Dutch fennel were significantly in flounced by the interaction between planting spacing and planting plant density in 2014/ 2015 and 2015/2016 seasons.

The interaction between 30cm spacing and one Plant per hill affected significantly on the highest values of plant height (95.89 and 99.78cm) while the lowest Values recorded from planting spacing 70cm and signal plant per hill as (76.89 and 79.67cm) in both seasons, respectively.

Meanwhile, themaximumvalue of fresh weight per plant (619.90 and 622.70g) in both seasons, respectively were recorded with sown spacing 50cm and one plant per hill. However, theminimum values were recorded with sown spacing 70cm and two plants per hill as (470.90 and 472.20g) in both seasons, respectively.

Onthe other hand, themaximum Value of dry weight per plant (300.60 and 301.30g) in both seasons, respectively were recorded with sown spacing 50cm and one plant per hill. However, the minimum values were recorded with sown spacing 70cm and two plants per hill as (221.80 and 223.20g) in both seasons, respectively.Table (5)

On the other hand, the highest Values of the number of umbels (l00.10 and 102.00) in the first and second seasons, respectively, were recorded with sown planting 50cm and one plant per hill. Table (5). Moreover, the lowest values (65.22 and 66.67) in both seasons, respectively were recorded by sown spacing 30cm and two plants per hill. Table (5).

According to data presented in table (5) observed that The treatment is planting spacing 30cm and one plant per hill gave the highest values for weight of 1000 fruits as (14.90 and 14.97g) but the treatment is planting spacing 70cm and one plant per hill gave the lowest values as (11.80 and 12.57g) in both seasons, respectively.

Data on table (5) indicated that the highest values of fruit yield per plant were recorded with sown spacing 50cm and one plant per hill as (74.11 and 75.67g), while the lowest Values were recorded with sown spacing 30cm and one plant per hill as (43.56 and 44.00g) in both seasons, respectively.

concerning interaction between sowing spacing and planting density, sowing spacing 30cm with two plants per hill led to the highest values of fruit yield per feddan as (1.63 and 1.64 ton) but the lowest values recorded by sown planting 70cm with one plant per hill as (0.46 and 0.47 ton) in both seasons, respectively. Table (5).

However, the data tabulated in table (5) observed that sowing spacing 30cm with one plant per hill gave the highest values of essential oil percentage (2.13 and 2.13 %), but the lowest values as (1.67 and 1.69%) were recorded by sown spacing 70cm with two plants per hill in both seasons, respectively. On the other hand, data in table (5) show that sowing spacing 50cm with one plant per hill led to the highest values of oil yield per plant as (1.40 and 1.44ml). Meanwhile, the lowest values as (0.84 and 0.85ml) were recorded to sown spacing 30cm with two plants per hill.

Data in table 6 illustrated that plants which sown spacing 30cm with two plants per hill were recorded the maximum values as (31.33 and 31.83l). However, the minimum values as (8.50 and 8.74l) in the first and second seasons, respectively were recorded by sown spacing at 70cm with a single plant per hill.

Concerning the interaction between planting spacing and planting density, the highest values of pigments content such as chlorophyll-a (0.933 and 0.943mg/g), chlorophyll b (0.310 and 0.317mg/g), total chlorophyll (1.243 and 1.260mg/g) and carotenoids (0.210 and 0.220mg/g) were obtained by sown spacing 50cm between plant with one plant per hill. But the lowest values of pigments content chlorophyll a (0.603 and 0.590mg/g), chlorophyll b (0.190 and 0.190mg/g), total chlorophyll (0.793 and 0.78mg/g) and carotenoids (0.113 and 1.117mg/g) were obtained by sown spacing 30cm between plant with one plant per hill for first and second seasons, respectively as shown in table 7.

Combining between sown spacing and planting density as data in table 7 use sown spacing 50cm between plants with planting density on one plant per hill led to maximum values of chemical components such as nitrogen percentage (1.36 and 1.38%), phosphorus percentage (0.38 and 0.39%), potassium percentage (3.67 and 3.68%)

and total carbohydrates percentage (26.03 and 26.05%). However, the minimum values were recorded with sown spacing 30cm with two plants per hill as nitrogen percentage (1.06 and 1.05%), phosphorus percentage (0.21 and 0.21%), potassium percentage (3.00 and 3.02%) and total carbohydrates percentage (20.62 and 22.70%) in both seasons, respectively.

Discussion

The results can be discussed as follows: Cultivation of plants at a distance of 30 cm with the cultivation of one plant in a single way to the spacing of plants between some of them, which allowed the plants to grow better and thus increase the growth of urban total while planting plants at a distance of 50 cm with a plant This is due to the increased ventilation between the plants, which led to an increase in the spread of the root mass and the lack of competition between plants on food and water, as confirmed according to Ibrahem [19] and Ali, [21] on fennel plant, where they found that reducing the distances of agriculture to increase the height of the plant while increasing the distances of agriculture led to an increase in fresh and dry weight, provided that there is one plant per hill.

The number of umbels/plant increased by 50 cm between plants with one plant in each cult due to the lack of competition between plants on plant nutrients and environmental conditions. The increase in the number of plants in the hill has led to competition between plants for light and ventilation and absorption of nutrients and water, which led to a lack of production of plants and therefore the number of umbels/plant and the amount of fruits/ plant table (2). But we note that when cultivating plants on 30 cm with the presence of two plants per hill valley to a significant increase in fruit productivity per feddan in both seasons and this is due to the increase in the number of plants in the unit area and these results agreed with on fennel. They found that growing plants at large distances led to an increase in the number of crops and fruit/plant yield while planting plants at higher distances resulted in increased fruit productivity per feddan compare with other treatments.

The results showed an increase in the percentage of oil due to the reduction of the distance between plants and plant growing to 30 cmthis is due to an increase in productivity of fruits / feddan due to an increase in the number of plants per feddan. This was agreed with Jalal et al., [22] on fennel, who found increased quantity of oil while reducing the distances of cultivation but obtained the highest amount of essential oil per plant and per feddan when growing plants at a distance of planting 50 cm with one plant per hill, which is due to the large distances between plantsIbrahem(2000) on fennel, which explained that planting plants at a distance of 50 cm gave the highest values of oil production per feddan and obtained the highest amount of yield Oil when planting plants on 30 cm with the presence of two plants per hill due to an increase in the number of plants in the unit area and this was agreed withHussein et al., (2006) on dragonhead, Ibrahim, (2000); Selim et al. (2013) and Ali, (2006) on fennel,Where they found that increase the distances of agriculture led to increasing the proportion of oil with an increase in oil production per plant and feddan. While reducing the distance to the valley gave an increase in the number of branches and fruits per plant and feddan in both seasons and this is what we observe in the significant difference between the treatments.

The data showed an increase in both seasons (chemical composition such as nitrogen, phosphorus, potassium, and total carbohydrates percentage and pigments content such as chlorophyll a, b, total chlorophyll and carotenoids) as a result of growing the plants at a distance of 50 cm with one plant in each case and agreed with Hussein (2006) on dragonhead, Selim et al. (2013) on fennel, which showed an increase in (chemical composition such as nitrogen, phosphorus, potassium, and total carbohydrates percentage and pigments content such as chlorophyll a, b, total chlorophyll and carotenoids) when growing plants at spaced distances. This is due to the intense competition between plants for ventilation, light, water absorption and nutrients. These results were in harmony with those reported by Ibrahem, (2000), Selim et al. (2013) on fennel and Hussein, (2006) on *Dracocephalummoldavica* L. plant.

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