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EFFECT OF SOWING DATE ON THE GROWTH , YIELD AND VOLATILE OIL OF *CARUM CARVI* L. PLANTS

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Abstract

In a study conducted at the farm of Seds experimental station, Beni Sweif Governorate, Hortcultural Institute, Egypt, caraway (*Carum carvi L.*) seeds were sown in five dates 5th and 26th October, 16th November and 2nd and 27th December) in two successive seasons of 1990 and 1991 . Early sowing date (26th October) gave higher values for plant height, number of main branches / plant and number of umbels/plant, fruit yield and volatile oil content during both the two seasons of growth. A suitable physiological changes were obtained by using the early sowing date. Gas liquid chromatography analysis indicated that, early sowing date (26th Oct.) resulted in higher content of carvone and lower content of d-limonene and the opposite result was true for the oil obtained in the late sowing date (December 27th) . Consequentiy , Sowing Caraway Seeds at the last week of October could be recommended as the optimal date of sowing under the environmental conditions of Seds region.

INTRODUCTION

Great attention has been paid for the cultivation of aromatic fruits, regarding to their importance for both local and foreign markets. Among these aromatic's is caraway fruits which consists of the dried ripe fruits of *Carum carvi L.* The plant is an annual to biennial herbanceous plant about 1m. high. It grows both wild and culti-

vated in central and northern Europe, Morocco and China. Caraway fruits were known to the Arabian physicians and came into use in the thirteen century. Caraway contains 3-7% volatile oil , 8-10% fixed oil, proteins, calcium oxalate colouring matter and resin. The volatile oil consists of the ketone carvone and the terpene limonene with small quantities of dihydrocarvone. Large quantilties of caraway fruits are used for culinary purposes as a flavouring agent (Trease and Evans (1983)) . Medicinally, the fruits and oil are used as antispasmodic, carminative, mild stomachic, antirheumatic and lactagoge. Schavenberg and Paris (1997) mentioned that, Caraway fruits are used to treat rheumatism and pleurisy, and the plants are used in the manufacture of some spirits.

Putievsky (1978) and Fleisher and Fleisher (1988) on (caraway) Sharma and Prasal (1990) on (*Coriandrum sativum* L., *Anethum sowa* L. and *Foeniculum vulgare* L.) and Cupta and Yadova (1989) on (cumin) , stated that the highest yield and oil content resulted with the earliest sowing date than on later ones.

The aim of this investigation is to study the effect of five sowing dates on the growth , yield , and volatile oil content of caraway plants .

MATERIALS AND METHODS

This investigation was conducted in Seds Experimental station, Beni Sweif Governorate, Hort. Institute during the two successive seasons of 1990 and 1991.

In this concern caraway seeds were sown on five dates, October 5th and 26th, November 16th and December 6th and 27th.

The inital stock of fresh seeds used in the experiment were obtained from the same farm. The seeds were sown in plots 1.8x2m $(3.6m)^2$ containing 3 rows 60cm apart . The spaces between plants were 25cm, so each plot contains 21 plants. The complete randomized blocks design was used with 3 replicates.

The nitrogen , phosphorous and potassium fertilizers were added in two equal doses the first after 45 days from sowing , while the second one was at flowering stage. The total amounts of fertilizers were : 300kg, ammonium sulphate 20.5% , 200kg. calcium super phosphate 15.5% and 50kg. potassium sulphate 48%k_{20} Per Feddan. Irrigation, weed control and also pests and diseases control as well other agricultural practices were done whenever required.

During the two seasons, germination , flowering , fruit setting and fruit ripening dates were recorded.

At harvesting dates, 10plants of each plot were taken for recording the following data " Plant height, number of main branches, number of umbels as well as fruit yield per plant and plot. Meanwhile representative samples of dried fruits from each plot were subjected for essential oil determination using Clevenger apparatus according to Guenther (1962). Statistical analysis was carried out according to Snedecor (1966) . The oil distilled from the three replicates of each treatment was collected and dried over anhydrous sodium sulphate. The oil samples were evaluated using gas liquid chromatography (G.L.C.). The G.L.C. analysis was carried out in the central lab of National Research Centre. Philips , 4500 Gas chromatography instrument was used with stainless steel column packed by 10% SE 30 an chromosorb 100/720 mest . The operating condition were initial temperature 70°C increasing by 4°C/mm , injection temp. 28°C, detected 300°C. sample size 0.1 ui 20, H_2 = 20 and Air =200.

RESULTS AND DISCUSSION

1. Physiological Changes

For the physiological changes in caraway plant due to the date of sowing, the results inTable 2, show that, the number of days required for germination increased (14 days) by sowing caraway seeds in the late date (27 December) compared to the First (5 October) and Second (26 October) dates which needed 9 days for germination. Similar results were obtained in both seasons of growth . The decrease in the number of days required for germination of seeds in the early dates of sowing , may be due to the higher temperature during that time of the year (Table 1) which increases the water uptake and consequently higher rate of germination.

The observation of number of days required to flowering (Table 2) indicated that, the earliest sowing date (5 October) required the shortest period (64 days), while the late date increased the periods required for flowering except in the last date (27 December) which required 78 days only. Consequently similar results were noticed in the required periods for fruit setting. These results were the same during both seasons of growth .

Street and Helgi Opic (1984) revealed that, appropriate conditions of temper-

Table 1. Metrological Data for Beni-Sweif Region (The temperature on 2m).

Date	Max. °C	Min. °C	Day °C	Night °C
1989				
October	29.9	14.5	25.9	20.6
November	24.9	13.0	21.3	16.1
December	21.2	9.7	17.3	12.3
1990				
January	18.7	8.0	14.3	11.3
February	20.0	8.2	16.4	11.8
March	23.0	10.9	19.3	14.2
April	29.0	15.0	23.9	18.7
May	31.9	18.0	25.7	20.9
June	34.1	20.8	28.1	23.9
October	30.9	18.7	26.8	21.3
November	25.7	13.6	21.6	17.4
December	22.6	9.7	18.7	14.5
1991				
January	19.3	8.0	15.3	11.2
February	21.4	8.9	17.4	12.6
March	25.2	13.0	21.3	16.4
April	29.6	16.0	24.5	20.0
May	31.9	18.8	26.6	21.9
June	34.4	20.9	28.6	24.3

Table 2.Effect of sowing Date on The Physiological changes of *Carum carvi* L. Plant during (1990 - 1991) seasons.

Treatments	1990 season				1991 season			
	Number of days from sowing to				Number of days from sowing to			
Sowing date	Germin -ation	Flower -ing	Fruit setting	Fruit ripining	Germin -ation	Flower -ing	Fruit setting	Fruit ripining
1st date	9	64	102	187	8	71	100	192
2nd date	9	78	117	182	9	84	122	178
3rd date	10	89	120	176	10	85	120	165
4th date	11	90	117	166	11	91	113	158
5th date	14	78	108	154	13	83	110	158

ature and/or day length are essential for flowering or can greatly hasten or delay the onset and abundance of this process. Often the speed of flowering and the number of flowers formed increase as the number of consecutive inductive photoperiods increase.

Concerning fruit ripening reverse trend was obtained, the earliest sowing date, the longest period (187 days) required for fruit ripening, while the last date required the shortest period (154 days) to reach the ripening. The decrease in the number of days required for the fruit ripening in the late sowing date may be attributed to the speed of flowering as well as the high temperature during the period of maturity (Table 1).

II. Growth characters

The recorded data of caraway plants (Table3) sown at the different dates deal with the growth character (Plant height, number of main branches, and number of umbels /plant).

Concerning plant height the listed data indicated insignificant differences of plant heights among the treatments. However, the second sowing date (26 Oct.)showed a higher value of plant height and the least value was that of the late sowing dates in both seasons.

Regarding the number of main branches, the results showed nearly consistent values in the 1st and 2nd dates, whereas significant decrements were obtained starting from the third date (16 Nov.) till the fourth one, the significancy was clearly shown in the differences among the second, third and fourth sowing dates. The differences were insignificant between the 4th and 5th (the lastest) sowing dates.

Number of umbels/ plant followed a similar trend, as that of the number of main branches . The highest values could be observed in case of the second sowing date, while the least one was noticed in the late sowing date in both seasons. The increase or decrease reached the significance level in most cases (except between the 3rd and 4th sowing dates at the second season of growth). These results are in agreement with those obtained by Baswana *et al.* (1990) on coriander where they found that, the highest values for plant height, number of primary branches /plant and number of umbels/plant were obtained with sowing during October.

From the previous reuslts, it is clearly shown that sowing dates resulted in

Table 3. Effect of sowing Date on Some Growth characters of *Carum carvi* plant during (1990 -1991).

Treatments	1990 season			1991 season		
Sowing date	Plant heighr in cms	No. of main branches /plant	No. of umbels /plant	Plant height in cms	No. of main branches /plant	No. of umbels /plant
1st date	94.00	2.60	30.80	96.00	2.90	35.67
2nd date	97.20	2.63	36.10	99.23	2.90	42.00
3rd date	96.67	1.70	23.60	97.13	1.87	26.90
4th date	91.13	1.10	15.00	94.13	1.20	23.57
5th date	91.47	1.00	11.75	93.00	1.00	16.23
:L.S.D. at 5%	N.S	0.31	3.04		0.58	4.20

Table 4. Effect of sowing Date on The dry Fruit Yield of carum carvia plant during (1990 -1991).

Treatments	1990 season			1991 season		
	The weight of:			The weight of:		
Sowing date	100 seeds in gms	Fruits plant in gms	Fruits/ plot in gms	100 seeds in gms	Fruits plant in gms	Fruits/ plot in gms
1st date	0.797	25.00	705.00	0.893	28.50	803.33
2nd date	0.893	30.70	838.33	1.035	33.12	948.33
3rd date	0.571	21.80	615.00	0.656	20.50	620.00
4th date	0.434	14.20	405.00	0.514	12.05	381.67
5th date	0.296	2.150	68.33	0.373	3.20	92.67
:L.S.D. at 5%	0.047	1.860	29.37	0.070	6.12	46.48

different effects. The earlier dates led to obtain the best results , while those of the late ones had adverse effects on the growth characters designated as plant height, number of main branches and number of umbles/plant. The decreased values of the growth characters may be attributed to the uncovenient enviromental conditions in particularly the low temperature and /or the day length throughout the vegetative growth stage which in turn affect the reproductive growth (i.e. flowering and fruit setting).

Concerning , the yield of fruits and the weight of seeds as affected by different sowing dates, the data presented in Table 4 indicated that, the highest yield of 100 seeds resulted by the early dates particulary the second one, while the latest date yielded the lowest value.

The superior production of fruit weight /plant was obtained by sowing on the 2nd date compared with the different dates of sowing especially the late ones (5th date) which produced the lowest weight of fruits /plant. Consequently similar trend was observed as that of the weight of fruits yield /plot , in this concern the highest value noticed in the second date while the lowest one was regarded in the late sowing date, The increases or decreases reached the highly significant levels in most cases during both seasons of growth . A similar trend was obtained by Putievsky (1978) on caraway; when they found the optimal date to produce a best yield of 2000k/ha was when sowing in the early winter (November). Sharma and Prasad (1990) reached the same conclusion and they mentioned that, all species (*Coriandrum sativa* L., *Anethur Sowai L., and foeniculum vulgare L. gave the highest* yield when sown on the earliest date. Baswana (1989) on coriander reported that, the highest seed yield obtained with sowing on 30 Oct. and the yield decreased when sowing after this date.

The results obtained exhibited that the early date (26 Oct.) resulted in the highest values for the weight of 100 seeds and the yield of fruits. This may be attributed to the optimal environmental conditions for increasing photosynthesis and decreasing the respiration, to increase the profusion of flowering and fruiting , so that the seeds could reach full maturity. The reverse trend was obtained in the last date (27 Dec.) , which gave the lowest values of seed weight and fruit yield . In this concern the reduction of weights. This may be due to the high temperature during the fruit period of ripening . This leads to more respiration than photosynthesis and consequently the fruits could become dry before reaching the full maturity and thus decrease the weight (Yield) of the fruits.

Volatile oil contents

Data presented in Table 5 show no significant differences of volatile oil percentage among the treatments in most cases. The second date exhibited a higher value in comparison with the other treatments. However , the least value was observed in the late sowing date in both seasons.

Concerning the effect of sowing dates on the volatile oil yield per plant or plot (Table 5) , there is a similar trend to that of the volatile oil percentage. The highest oil yield was found in the plants sown at the second date and the least oil yield was recorded in the late date of December. The differences among the treatments were highly significant in most cases. The mentioned results are in accordance with those obtained by Mawrya (1990) on coriander where he found that, the essential oil content of fruits was greatest when harvesting after 120 days from sowing .

Gas liquid chromatography of volatile oil

Two volatile oil samples represent the highest and least treatments , the samples of the second and fifth dates were used in the evaluated using G.L.C. analysis , thus will help to compare between both treatments in this concern.

The results shown in Table 6 and illustrated in Fig. 1 demonstrate that G.L. chromatograms of the 2nd and 5th sowing dates revealed the presence of 13 components from which 11 compounds were identified. These are cryophyllene, 1, 8 cineol, limonene, linalool, citronellal , borneol , menthol, piperitone, carvone, citronellol and carvacrol. In both samples, the reltative percentage areas of the identified peaks indicated that two compounds (i.e.limonene and carvone) are of higher amounts while those of the other peaks exhibited lowest values. It could be observed in both samples that, the same components were occurred , but the peaks areas were reversed. So, an inversed relationship could be observed between the limonene (terpene hydrocarbon) and carvone (oxygenated terpene) contents. The increase of carvone was associated by the decrease in limonene contents in the second sample and vise versa in the fifth one. Concequently, it could be concluded that the increase of exygenated compounds resulted at the expense of the hydrocarbon ones. These results are in agreement with that is mentioned in Guenther (1962) who reported that the major constituents of caraway oil are limonene and carvone and that caraway plants converts more than 50 % of limonene into carvone and also Trease and Evans (1983) mentioned that , ca-raway oil contains carvone (50-60%) and limonene (20%).

Table 5. Effect of sowing date on the volatile oil content of *Carum carvi* plant during (1990 -1991).

Treatments	1990 season			1991 season		
	Oil%	Oil yield in cc.		Oil%	Oil yield in cc.	
Sowing date		Plant	Plot		Plant	Plot
1st date	2.15	0.538	15.16	2.20	0.627	17.67
2nd date	2.17	0.666	18.19	2.20	0.729	20.86
3rd date	2.15	0.469	13.22	2.15	0.441	13.33
4th date	1.90	0.269	7.702	1.94	0.234	7.40
5th date	1.75	0.038	1.202	1.80	0.58	1.67
L.S.D. at 5%	0.29	0.144	2.352	0.20	0.088	2.85

Table 6. Effect of sowing date on the oil compounds of Carum carvi L. plant in (1991).

No. of component	R.T min.	Oil Compounds	% in the 2nd date	% of the 5th date
1	2.32	Caryophyllene	1.97	0.29
2	3.67	U	1.71	2.12
3	15.52	1.8 eineol	0.58	1.09
4	17.95	Limonene	22.77	50.85
5	18.25	Linalool	0.30	--
6	19.57	Citronellol	0.26	0.08
7	20.59	Borneol	0.39	0.16
8	21.11	Menthol	0.86	0.46
9	23.44	Piperitone	1.45	0.94
10	25.27	Carvone	67.84	43.09
11	26.11	Citronellal	1.68	0.78
12	28.83	Carvacrol	0.16	0.03
13	30.65	U	0.19	0.09
Total			100.00	99.98

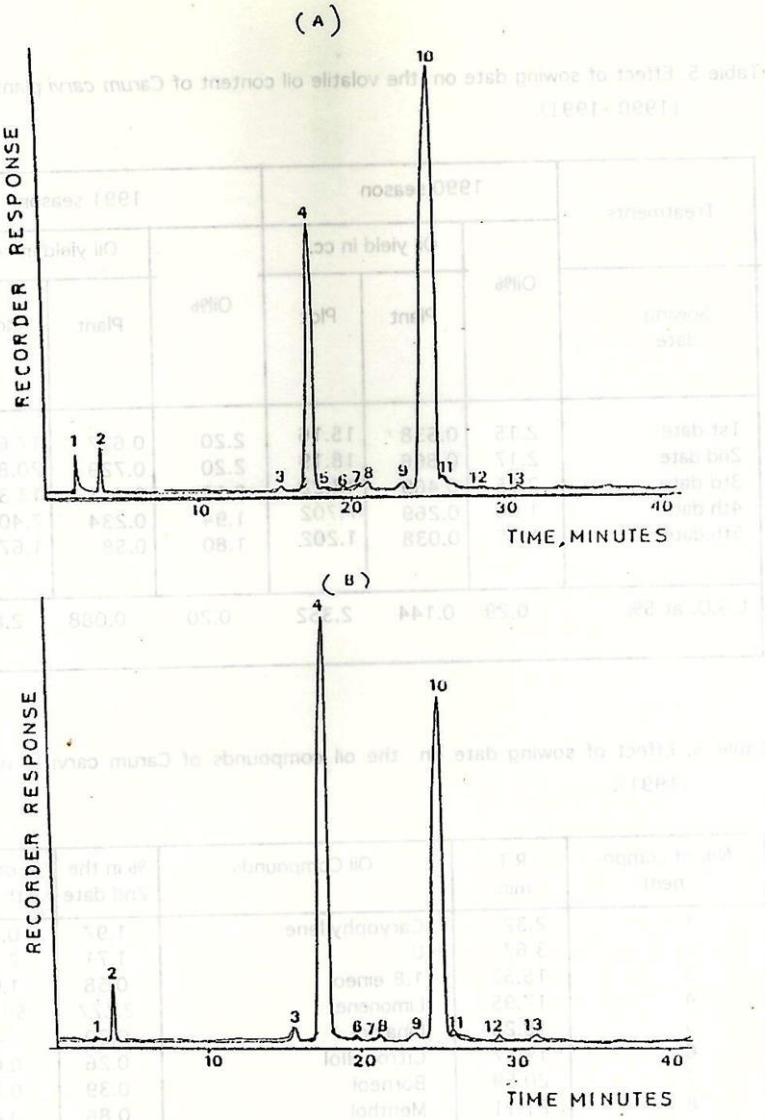

Fig 1. G.L.C. Chromatograms of essential oils of Caraway fruits as affected by sowing date.
A - Early sowing B - Late Sowing date

Component:

1 - Caryophyllene
2 - Unidentified
3 - 1,8 Cineol
4 - d - Limonene
5 - Linalool
6 - Citronellal
7 - Barneol
8 - Menthol
9 - Piperitone
10 - L-Carvone
11- Citronellol
12 - Carvacrol
13 - Unidentified

It could be concluded from the formentioned results that, in the late sowing dates the physiological changes took place in uncovenient environmental conditions, leading to decrease of the growth characters. Consequently fruit setting which took place in low temperature conditions led to slow the rate of limonene conversion into carvone resulting to decrease such desirable compound in caraway oil . In this connection 26 October could be recommmended as the optimal date of sowing under the environmental condition of the experiment in order to obtain highest yield of fruits and volatile oil with best quality and quantity.

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تأثير ميعاد الزراعة على النمو والمحصول والزيت الطيار لنبات الكراوية

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أجريت الدراسة بمحطة بحوث البساتين بسدس خلال موسمى الزراعة ١٩٩٠-١٩٩١ وذلك لدراسة خمسة مواعيد لزراعة بذور الكراويه (٥ ،١٦اكتوبر ،١٦نوفمبر ، ٣ ، ٢٧ديسمبر) وتأثير ذلك على التغيرات الفسيولوجية من حيث فترة الإنبات ، ومواعيد الإزهار ، وعقد الثمار ونضجها وكذلك تأثير هذه المواعيد علي النمو من حيث طول النبات ، وعدد الأفرع الرئيسية ، وعدد النورات ومحصول البذور للنبات الواحد ، وايضا محصول البذور للقطعة التجريبية ، ووزن مائة بذرة والمحتوى من الزيت الطيار ومكوناته .

أوضحت النتائج أن الزراعات المبكرة (٢٦اكتوبر) قد أعطت أفضل النتائج من حيث طول النباتات ، عدد الأفرع الرئيسية وعددالنورات ومحصول البذور للنبات الواحد ، وقد زاد محصول البذور للقطعة التجريبية ووزن مائة بذرة زيادة معنوية عند التبكير فى الزراعة وقد تأثر محصول الزيت كماً ونوعاً باختلاف مواعيد الزراعة ، حيث بين التحليل الكروماتوجرافى للزيت وجود ١٣مركبا ، وان الزراعة المبكرة (٢٦اكتوبر) أعطت أعلى محتوى من مركب الكارفون (وهو المكون الرئيسى لزيت الكراوية) بينما قل محتوى مركب الليمونين (المكون الثانى لزيت الكراوية) وأعطت الزراعة المتأخرة (٢٧ديسمبر)نتائج عكسية حيث زاد مركب الليمونين وقل الكارفون ، هذا وقد تأثرت نسب باقى المكونات بإختلاف موعد الزراعة .

نتيجة لهذا توصى الدراسة بأن الزراعة فى الأسبوع الأخير من اكتوبر هى أفضل موعد لمنطقة سدس (بنى سويف) تحت ظروف التجربة .