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# Planting Date Effects on Growth, Seed Yield, Essential Oil Content and Chemical Composition of Ajowan

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**Abstract**

In order to study the effects of planting date on seed yield, yield components and essential oil content and components of ajowan, an experiment was carried out in the experimental field of Agriculture College of Shiraz University in 2007 year. The experiments were conducted based on design randomized complete blocks with six treatment and four replications. Treatments included six different planting date (in 30-day intervals from October to March). The essential oil was extracted by water distilled method from seeds and it was analyzed by Gas Chromatography (GC). Measured traits in ajowan plants were significantly affected by planting dates. By delay in planting date, plant height, number of branches per plant, number of umbels/plant, seed yield, 1000 seed weight, biologic yield and essential oil yield significantly were reduced. Highest of seed yield (650.1 kg/ha) was obtained from October date and also planting date had significant effect on essential oil content and composition. Thymol is the main component of oil. On the whole, the maximum thymol (61.85) of ajowan was obtained at the first planting date. The other major oil constituents were γ-terpinene (27.35 %) p-cymene (11.79 %) and β-pinene (14.04 %). Ajowan plants can be successfully grown in the Fars regions by early October as the best time for sowing.

***Keywords:*** Essential oil, Ajowan, planting date, seed yield, yield components.

## INTRODUCTION

Ajowan (Trachyspermum ammi L.) is an aromatic, grassy, annual plant which grows in Iran, Pakistan and Egypt with white flowers and small brownish fruits. In Persian traditional medicine, fruits of ajowan were used for its therapeutic effects as diuretic, anti vomiting, carminative and antiemetic. Also, the smoke of this drug cleans the uterus. The distillate obtained from fruit that boiled with water is used as a carminative for children and as cholera remedy (Mohagheghzadeh et al. [17]). The essential oil content in coriander seeds has been found to vary between 4.6 and 9% (Mohagheghzadeh et al. [17]; Ravindran and Balachandran [22]; Saharkhiz et al. [24], Wahab and Mohamed [28]). The main component of ajowan essential oil is Thymol. Other main components of seed oil are γ-terpinene, p-cymine and β-pinene (Gurdip et al. [14]; Khajeh et al. [15]; Nagalakshmi et al. [18]; Ravindran and Balachandran [22]).

An important management factor in the production of all crops is planting date. Change in planting time leads to significant change in weather parameters and consequently the performance of the crop. In addition to crop management, the physical environment has profound influence on growth, biomass partitioning and oil accumulation of ajowan. Temperature, sunlight and other meteorological factors may individually or collectively limit the plant growth and production. Temperature is important factor that affects the growth of any plant. Time of planting controls the crop phenological development and total biomass production along with efficient conversion of biomass into economic yield (Khichar and Niwas [16]).

Yield components of ajowan include the number of plant in area unit, the number of branches per plant, the number of umbrella per plant, the number of seed per umbrella and seed weight. The number of umbrella per plant has the second rank of importance in yield components. The number of seed per umbrella is affected by environmental and field management. Ahmed and Haque [3] studied the effect of sowing time (November 1, November 20, December 10 and December 30) on the yield of black cumin in Bangladesh. They found that early sowing was the best time for higher seed yield of black cumin.

The effect of sowing dates on growth, yield and active compounds of medicinal and aromatic plants was studied by many investigators (Asghar Malik et al. [6]; Ayub et al. [7]; Carrubba et al. [10]; El-Sherbeny et al. [13]; Sadeghi et al. [23]; Sengloung et al. [25]; Shamsi [26]; Zayed et al. [29]). In the literature with delay in planting date, number of umbel per plant and umbelet per umbel, number of seed per umbelet, seed yield, plant height and biologic yield of anise (Pimpinella anisum L.) was significantly reduced (Rassam et al. [21]). Changes in essential oil yield and composition have been reported by seedling date on coriander that earlier seedling date enhanced productivity (Zhelijazkov et al. [31]). Furthermore, there is no data about the best planting date for optimizing the yield of ajowan at the climatic regions of the Fars province. Hence, this experiment was performed to find out the effect of planting dates on growth, aerial biomass, crop productivity and essential oil composition of mentioned crop.

## MATERIALS AND METHODS

**Site Information**

The experiments were carried out in the 2007 year at the experimental fields of Agricultural Collage of Shiraz University in Shiraz, located in the Badjgah (29º 36´ N, 52º 32´ E, 1810 m, yearly maximum and minimum temperature: +38 and -9 ºC, Humidity %51, yearly rain 402 mm, semi arid moderate climate), Fars province, Iran. The daily climatic data during this study were obtained from the agro-meteorological station of irrigation department located in a state farm about 1 km far from the experimental site (Table 1).

**Plant Material And Treatments**

Seeds of the Iranian natural population of ajowan were obtained from Giahafza Company (Shiraz, Iran). We investigated the effect of six different dates of planting (Oct, Nov, Dec, Jan, Feb and Mar) on ajowan plant in the field condition. Size of plots in the field was 2×3 m and the harvest area was 120 m2. The field was prepared according to agronomic recommendations for these spices (Subhan et al. [27]). Manure fertilization was quantified according to the results of chemical analysis of the soil. The soil of experimental plots was a clay loam with pH of 7.6; EC, 0.38 ds m-1; O.M., %3.36; N, 4 mg/kg; P, 67.45 mg/kg and K, 550 mg/kg. Hoeing and mechanical weed control, were done regularly by hand when it was necessary. All agronomic management practices were performed as needed. Harvest of ajowan in all treatments occurred when 70% of the seeds in the umbels were matured. Whole plants were hand harvested, the plants were air-dried at the drying facility in Shiraz and the seeds were removed by hand. Measurements were taken of Plant Morphological Characteristics (PMC) such as height, number of umbel, number of branch and biological yield. Biological yield was defined as total above ground plant yield.

**Essential Oil Extraction**

One hundred of seeds were waterdistilled for three hours using a Clevenger-type apparatus, to produce oil according to the method recommended by the European Pharmacopoeia [5]. Essential oils were dried with anhydrous sodium sulfate and kept in dark vials at 4 ºC until chromatographic analysis.

**GC Analysis**

GC analysis was performed using Agilent6890. The gas chromatograph was equipped with a HP 5 fused silicaco column (30m × 0.25mm) film thickness. 0.25µm Oven temperature was held at 60 ºC for 5 min and then programmed to 230º at rate of 3ºc/min. injector and detector (FID) temperature was 240 ºC. Nitrogen was used as carrier gas with flow rate 0.9ml/min. The percentages were calculated by electronic integration of FID peak areas without the use usage of response factors correction; linear retention indices for all components were determined by co-injection of the samples with a solution containing homologous of c8-c22 n alkanes.

**GC-MS Analysis**

The GC/MS Analyses were carried out using a Hewlett Packard 6890. The gas chromatograph was equipped with a HP-5 M capillary column (phenyl methyl siloxan, 25 m × 25 mm i.d., Hewlett-packard part No.1909150433, USA. The oven temperature was programmed from 50 °c (3min) to 250 °c at the rate of 15 °c / min and finally held for 10 min at 250. The carrier gas was helium with the flow rate of 1.2 ml/min. The mass spectrometer (Hew-lett-Packard5973, USA) was operating in EImode at 70 eV. The interface temperature was 250 °c. The mass based on a comparison of their RI and mass spectra with Willey (275) and Adams libraries spectra [1].

**Statistical Analysis**

The experiment was arranged as a completely randomized design (CRD) with four replications. All analyses were performed with a statistical software package (SPSS version 13) and the means were compared by Duncan's multiple Range test at $p \leq 0.05$.

## RESULTS AND DISCUSSION

**Plant height, number of branch and umbels/plant**

The results of sowing date effects on the ajowan productivity are shown in Table 2. It was indicated that delayed planting date was significantly reduced growth and yield.

The amount of Plant height, number of branch and umbels/plant in our work ranged from 49 cm, 36.2 and 50.1 (march) to 59.2 cm, 48.1 and 99.1 (October), respectively. The highest plant height, number of branches per plant and number of umbels/plant were obtained from October sowing. The values of these qualities by delayed sowing date were decreasing gradually. The lowest of plant height, number of branches per plant and number of umbels/plant were obtained in March date 49 cm, 36.2 and 50.1, respectively. At first planting date, plants had sufficient time for higher growth and the usage of environmental factors. But, by delay in planting date, time

**Table.1.** Average of some climate changes during 2007 season of the field under ajowan.

| Sowing date | Max T (ºC) | Min. T (ºC) | Mean T (ºC) | Precipitation (mm) | Sunshine (H/Day) |
|---|---|---|---|---|---|
| October | 25.7 | -0.2 | 11. 9 | 0 | 9.47 |
| November | 21.1 | -1.8 | 9.6 | 0 | 8.18 |
| December | 13 | -2.6 | 5.2 | 41 | 6.40 |
| January | 7.7 | -4 | 1.8 | 68 | 5.82 |
| February | 14.2 | -4.4 | 4.9 | 8.5 | 8.35 |
| March | 22.6 | 0.9 | 11.6 | 0 | 9.50 |
| April | 24.6 | 4.7 | 14.7 | 3.5 | 9.20 |
| May | 29.7 | 8.7 | 19.2 | 0 | 9.94 |

**Table.2.** Sowing date effects on average of morphological characteristics of ajowan plant.

| Sowing date | Plant height (cm) | Number of branches/plant | Number of umbels/plant |
|---|---|---|---|
| October | 59.2 a* | 48.1 a | 99.1 a |
| November | 55.3 ab | 46.2 ab | 72.5 ab |
| December | 54.5 ab | 45.1 ab | 69.4 ab |
| January | 53.5 ab | 35.1 bc | 68.1 ab |
| February | 51.2 ab | 42.0 abc | 65.4 b |
| March | 49.0 b | 6.2 c | 50.1 c |

* Columns with the same letters are not significantly different at 5% level using Duncan's multiple test.

duration for plant growth was decreased so that it resulted in decreasing the plant height, the number of branches per plant and number of umbels/plant. These results are in agreement with those of D'Antuono et al. [11] who stated that earlier planting of Nigella species resulted in higher amount of plant height, seed weight and density, yield components and dry biomass. Also, delayed planting date will be decreased plant height of different wheat cultivars (Subhan et al. [27]), mungbean (Asghar Malik et al. [6]), milk thistle (Shamsi [26]), thai hemp (Sengloung et al. [25]), plant height and number of umbrella per plant of black cumin (Sadeghi et al. [23]), coriander (Carrubba et al. [10]), and fennel (Ayub et al. [7]), plant height, number of branches/plant, number of capsules/plant and number of capsules/branch of Sesame (Alam Sarkar et al. [4]). The results indicated that October is the optimum sowing time for ajowan to have highest amount of plant height and the number of branch and umbels/plant (see Table 2).

**Seed yield, thousand seed weight (TSW) and Biological yield**

Data of planting effects on seed yield, thousand seed weight (Tsw) and Biological yield are shown in figures 1 and 2, respectively. The seed yield was significantly influenced by the sowing ($p \leq 0.05$). In this experiment, first planting time led to an increase at the seed yield from 453.2 (March) to 650.1 kg/ha (October). The highest seed yield was observed in October date (650.1 kg/ha) and significant differences with other dates (589.6, 582.3, 578.2, 569.8 and 453.2 kg/ha, respectively). Seed yield was directly correlated with most of the examined parameters, there being complex relationships involving the combined effect of number of umbels per plant, average diameter of umbels and 1000-seed weight (Carrubba et al. [10]). Results showed that the seed yield and the weight of 1000 seeds increased with increasing plant height, number of branches per plant and number of umbels/plant (Shamsi [26]). Higher seed yield in earlier planting dates resulted in increase of Tsw. So, the highest TSW was obtained in the first planting date (2.01 g) and had significant differences with February and March (1.8 and 1.78 g, respectively) at the 5% probability level.

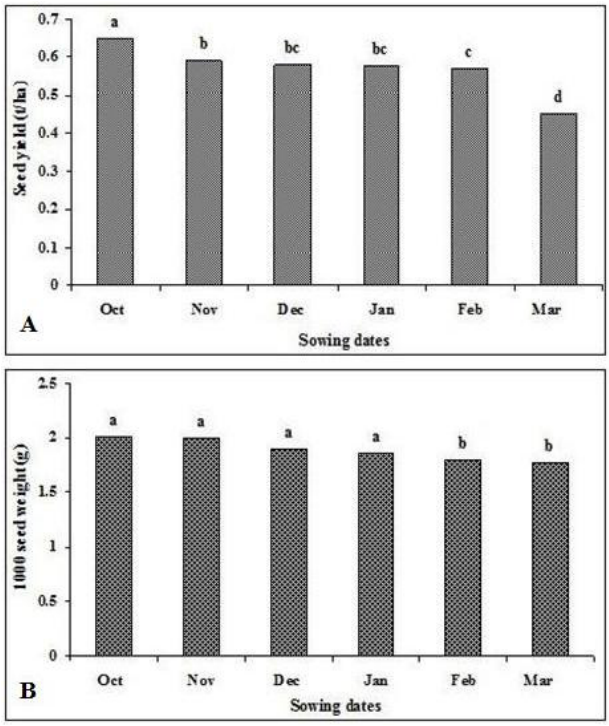


**Fig.1.** Effect of planting dates on average of seed yield (A) and 1000 seed weight (B) of ajowan.

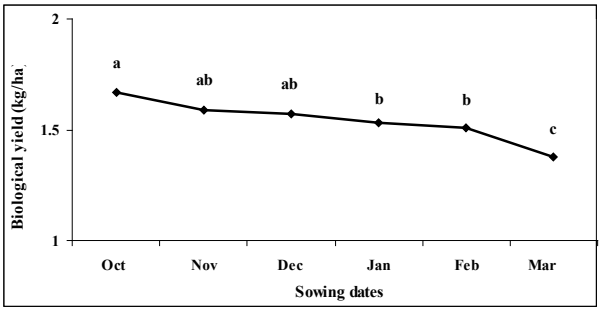


**Fig.2.** Planting date effects on average biological yield of Trachyspermum ammi L.

Also, average biological yield was significantly affected by sowing date and had a similar pattern with a more pronounced advantage of Trachyspermum ammi L. with the delay in sowing time. One reason for this was higher amount of seed yield, Tsw, plant height, number of branch and umbels/plant (Shamsi [26]). By delay in planting date, the biological yield was gradually decreased and the lowest biological yield was obtained from March treatment. The October planting date resulted in higher amount of biological yield (1.67 t/h) and had significant differences than January, February and March (1.53, 1.51 and 1.38 t/h, respectively). There was no significant difference between the first, second and the tertiary planting dates in relation to the biological yield. These results are in agreement with the findings of Ahmed and Haque [3] on black cumin, Rassam et al. [21] on anise, Zehtab-Salmasi et al. [30] on Dill, Adamsen and Coffelt [2] on rape and crambe, Alam Sarkar et al. [4] on sesame and Carrubba et al. [10] on coriander.

Adams et al. [1] demonstrated that time of sowing can influence on soybean seed quality. They found that hotter environmental conditions were had lower quality of harvested seeds. Rassam et al. [21] showed that delayed sowing date was affecting on seed yield and components yield of anise. These results suggest October sowing as best sowing date to obtain the seed yield, weight of 1000 seeds (Tsw) and Biological yield of this crop.

The time duration from planting to harvest was shortest for the latest planting date, which resulted in lower plant growth and yield components. In October treatment, plant height, number of branches per plant, number of umbels/plant, seed yields, weight of 1000 seeds, biological yield and oil concentration were greater and comparable to March planting in the Fars province.

**Essential Oil Content And Its Component**

The data showed that sowing dates had significant effects on the percent and components of essential oil (see Table 3). Essential oil percentage was significantly influenced by planting time and highest of oil value so that it was 3.3% in October. In this experiment, oil yield ranged from 10.42 kg/ha to 16.01 kg/ha in Fars region, Iran. By delayed sowing date, essential oil yield was decreased gradually. So, in latest date (March), lowest amount of essential oil was obtained (2.14% or 10.42 kg/ha) which had significant differences in comparison with other dates (at 5% of probability level). Many researchers, such as Omidbaigi and De Mastro [20], demonstrated a strong influence of sowing time on growth character on Buckwheat. Omidbaigi

**Table.3.** Effect of planting dates on main components of Trachyspermum ammi L. essential oil.

| Sowing date | Thymol (%) | γ-terpinene (%) | P-cymene (%) | β-pinene (%) | Minor components (%) | essential oil yield (kg/ha) |
|---|---|---|---|---|---|---|
| October | 61.85 | 20.16 | 11.79 | 1.93 | 4.27 | 16.01 a |
| November | 54.70 | 23.50 | 8.87 | 6.35 | 6.58 | 15.82 ab |
| December | 54.13 | 19.05 | 9.04 | 3.39 | 14.39 | 14.07 ab |
| January | 42.78 | 27.35 | 9.10 | 14.04 | 6.73 | 13.98 ab |
| February | 24.56 | 15.01 | 6.65 | 39.17 | 14.61 | 13.21 b |
| March | 30.69 | 12.52 | 4.28 | 5.62 | 46.89 | 10.42 c |

et al. [19] and Balalic et al. [9] stated that essential oil content of dragonhead and sunflower was reduced by delaying planting dates. Our results are in agreement with the findings of de la Vega and Hall [12] who claimed that planting date was the main source of variation for oil yield. In their experiment oil yield varied from 817 kg/ha (sowing in December) to 2300 kg/ha (sowing in October) in the conditions of Argentina. Balalic et al. [8] found that the contribution of year to oil yield was 76%, and of the planting date 3.9%, respectively.

The concentration of the major constituent of ajowan oil was thymol, ranging from 24.56% to 61.85%. Thymol content in the ajowan seed oil has been reported to be 50.32% - 52.11% (Wahab and Mohamed [28]) and 39.1% (Gurdip et al. [14]). Under the conditions of our experiments, ajowan seeds from all treatments contained normal to high amount of thymol. High thymol content is desirable as the ajowan essential oil so that it can be used as a natural source of the valuable commodity (+) -thymol. The other main constituents in the essential oil from our experiments were γ-terpinene, p-cymene and β-pinene that are ranging from 12.52% - 27.35%, 4.28% - 11.79% and 1.93% to 39.17%, respectively. The concentration of thymol and p-cymene were greater in seed oil from the first seedling date. The γ-terpinene was greater in January and a greater content of β-pinene had in February (Table 3). The minor constituents in the ajowan essential oil from our experiments were similar to other studies. The highest amount of minor components was observed in latest date (March) with 49.62%. Significant differences were observed in each component at different planting date ($p \leq 0.05$).

In October was suitable time to convert precursor's p-cymine and γ-terpinene to thymol. It seems that higher temperature in October and long time flowering had suitable time for synthesis essential oils. Commercially available ajowan seed oils were purchased from Indian and Egypt identified in tables. Oil components obtained from ajowan under Sinai (Egypt) were thymol (50.32%), γ-terpinene (19.02%), p-cymene (22.11%) and α-pinene (2.04%) and in India conditions were thymol (39.1%), γ-terpinene (23.2%), p-cymene (30.8%) and α-pinene (0.2%) (El-Sherbeny et al. [13]; Subhan et al. [27]). Khaje et al. [15] major components of Iranian Carum coptitum oil were identified thymol (49%), γ-terpinene (30.8%), P-cymene (15.7%) and β-pinene (2.1%). Nagalakshmi et al. [18] with Studies on chemical and technological aspects of ajowan were determined thymol (39.36%), γ-terpinene (30.97%), p-cymene (19.7%) and β-pinene (5.45%). Our results confirm previous reports on the effects of seeding date on ajowan essential oil yield and composition our results showed that for ajowan seed production, sowing in march is not preferable in Shiraz. Significant changes were attributed to long duration of crop which provided long photoperiod to synthesize more quantity of essential oil or in other words might be due to availability of higher temperatures from flowering. The environment during seed development is a major determinate of seed quality. For successful seed production at this site, ajowan must be sown in early sowing date as delaying sowing until March reduced yield and seed yield components.

In conclusion, Ajowan appears to have good potential as an essential oil source. This is the first report on ajowan in Fars regions. Our results demonstrated that ajowan could be grown as an essential oil crop in Fars province, and possibly other regions at the same latitude and longitude. Delayed planting date had significant and detrimental effects on plant growth, seed and oil yield. Our study indicated that delay in planting from October to March could result in lower plant height, number of umbel, number of branch, biological yield and essential oil content. The two field experiments showed that according to the climatic condition, seed must be planted as early as possible. Further research on early summer and fall seeding dates and on the crop mineral nutrition is needed in the region to increase seed yields and essential oil productivity. Therefore, for increasing plant growth, seed and oil yield in current weather condition and same weather, planting in October time can be suggested.

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