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Effects of Late Sowing on Quality of Coriander (*Coriandrum sativum* L.)

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Abstract**—**Coriander is an annual and herbaceous plant, belong to the apiaceae family. This plant is cultivated world widely. It is well known for having medicinal properties. The aim of this experiment was to study seed quality of species grown in Kermanshah conditions. The experiment was carried out in research farm, Campus of Agriculture and Natural Resources, Razi University, Kermanshah, Iran. Coriander (local type) was grown in late spring May (5^{th} and 20^{th}) and Jun (4^{th} and 19^{th}), and plant density (10, 30, 50 and 70 plants m^{-2}) in 2009. The experimental plots were laid out in a factorial according to a randomized complete block design with three replications. The fruits were harvest between 83.5 – 106.5 days after sowing. The essential oil and oil content was extracted by Clevenger and Soxhlet apparatuses, respectively. Results showed that delay at planting date increased the oil content. Also, with the increase at plant density was decreased oil content and essential oil.

Keywords**—**coriander, late sowing, plant density, oil content, essential oil

I. Introduction

CORIANDER (*Coriandrum sativum* L.) also called cilantro, or dhania is an annual and herbaceous plant, belonging to the Apiaceae family. This family is rich in secondary metabolites and embodies numerous genera of high economic and medicinal value. It is primarily grown for seed, seed oil and seed essential oil. Also, Coriander seeds, rich in linalool, have as a medicinal plant (analgesic, carminative, digestive, depurative, anti-rheumatic and antispasmodic agent) and a spice, for flavoring candies, in cooking and perfumery [7]-[10]-[11]-[16]-[19]-[23].

Coriander fruit contains about 0.2–1.5% of volatile oil (essential oil) and some other results indicate that some new cultivars contain it up to 2.7% [13]-[15]. The volatile oil is the active ingredient. The characteristic aroma is due to linalool (60–70%) [18]. The oil also contains geraniol, geranyl acetate, decyl acetate, decanal and thymol [17]. Essential oil contains ca 20% of terpenes.

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The fruit contains 13–20% of fat oil (oil content). The fatty oil is characterized by very high content of octadecenoic acids. Pino et al. [12] studying the chemical composition of essential oil from Cuba, identified 35 compounds and have found different percentage for linalool (54.57 %), α-pinene (1.14 %), geraniol (6.97 %), γ-terpinene (4.08 %) and limonene (1.55 %).Coriander is an autumn and spring season's crop. There is a small scientific literature on Coriander's agronomic practices specially sowing dates and plant density compare to botanical and chemical characteristics [1]-[2]-[3]-[6]. Under normal environmental conditions, autumn-winter sowing obtained the highest seed yields [9]-[20]. In rain fed conditions (Semi-arid Mediterranean) at autumn seeding obtained seed yield and biomass of coriander amount 581.3 and 970.6 kg ha^{-1}, respectively [4]. In the spring – summer grown, coriander needs to be irrigation. Coriander at spring sown between early and late seeding had not effect on grain yield [5]. The aim of this work was to evaluate, the effects of late sowing and plant densities on quality of coriander.

II. Materials and Methods

A. Experimental site and Plant materials

This experiment was carried out in research field, Campus of Agriculture and Natural Resources, Razi University, Kermanshah (34° 21′ N, 47° 9′ E; 1319 m above sea level with temperature characteristics in table 1), on soils classed a clay (Table II), during 2009, in Iran. Factors were (a) four sowing times (5 May, 20 May, 4 June and 19 June 2009) and (b) four plant densities (10, 30, 50 and 70 plants m^{-2}) of Coriander (local type). The experimental plots were laid out according to randomized complete block design (RCBD), with three replications. Sowing row intervals were 30 cm. Fertilizer was applied before sowing (100 kg ha^{-1} P2O5 and 50 kg ha^{-1} N) and at start of flowering (50 kg ha^{-1} N) [1]. At harvest time, air-drying of seeds performed in a shady place at room temperature for 10 days. The plant material was used for the isolation of the essential oil and oil content, immediately after drying.

B. Extraction of the essential oil

The essential oil of Coriander is extracted from the dried fruit. Samples of seeds 100 g of the dried were grounded in a blender separately. The grounded seeds were subjected to hydro distillation using a modified Clevenger-type of glass apparatus for 3 hours for isolation of essential oil separately [2]-[12]-[21]-[22].

C. Extraction of the oil content

The oil content or fat oil was extracted with glass Soxhlet extraction apparatus by n-hexane solvent. 5 g of seed grounded were used in each extraction (thimble) and at end of the extraction, dried 24±1 hour in Oven 40±1°C and then accomplished calculations for values oil seed [1].

Essential oil yield and oil content yield was determined using the below formula:

Essential oil yield = Essential oil percentage × seed yield

Oil content yield = oil content percentage × seed yield

D. Statistical analysis

Data were analyzed using the Statistical Analysis System (SAS). Treatment means were compared using the least significant difference (LSD) test at $p \leq 0.05$.

III. Results and Discussion

In this experiment, studied seed yield, essential oil, oil content, essential oil yield and oil content yield. The effect of sowing date and plant density were significant on seed yield (Table III). The most of seed yield obtained at 19 June (Table 4). Seed yield in 4 June, 20 May and 5 May decreased 22.9, 35.6 and 43.3% compared to 19 June, respectively. The possible reason for this variability in seed yield is increasing air temperature with flowering at sowing dates 5 May and 20 May, that decreased the number of flower in umbels, grain filling period and in the last seed yield. 50 plants m^{-2} produced the most of seed yield (Table 5). 10 and 70 plants m^{-2} had the lowest seed yield. The average seed yield did not show any significant interaction effect between the two treatments under study (S×D). It is indicates a substantially additive behavior for these two sources of variability.

TABLE I
PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOIL IN FIELD

	Soil depth (cm)	
characteristics	0-30	30-60
Sand (2-0.05 mm) (%)	2.0	1.4
Silt (0.05-0.002 mm) (%)	46.0	44.5
Clay (< 0.002 mm) (%)	52.0	54.1
pH	7.9	7.8
Organic mater (%)	2.1	1.1
Total nitrogen (%)	0.13	0.12
Available phosphorus (mg kg-1)	11.2	9.0
Exchangeable potassium (mg kg-1)	345.0	355.5

Soil was sampled before sowing

TABLE II
MONTHLY MAXIMUM, MINIMUM, AND AVERAGE TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION AT KERMANSHAH, IRAN IN DURING GROWTH SEASON OF CORIANDER

	Month					
Weather characteristics	Apr	May	Jun	July	Aug	Sep
Precipitation (mm)	7.5	6.6	0.0	0.0	0.8	9.3
Maximum temperature (^{0}C)	29.1	33.7	37.8	42.9	42.0	39.2
Minimum temperature (^{0}C)	1.1	4.4	8.7	14.4	16.2	10.1
Average temperature (^{0}C)	16.0	19.1	24.9	29.0	30.7	26.0
Evaporation (mm)	119.5	237.5	346.7	379.0	419.5	308.8
Relative Humidity (%)	35.0	34.0	20.0	16.0	17.0	25.0
Sunshiny (hour)	213.1	271.6	318.3	326.4	258.1	257.5

TABLE III
ANALYSES OF VARIANCE FOR THE EFFECTS OF SOWING DATE, PLANT DENSITY AND THEIR INTERACTION ON SEED YIELD, ESSENTIAL OIL AND OIL CONTENT OF CORIANDER (*P*-VALUES)

Treatments	Seed yield	Essential oil	Oil content	Essential oil yield	Oil content yield
Sowing date (S)	<0.001	ns	<0.001	<0.001	<0.001
Plant density (D)	<0.001	<0.001	<0.001	<0.001	<0.001
Interaction S×D	ns	<0.001	ns	ns	ns

ns = non significant

TABLE IV
EFFECTS OF SOWING DATES ON SEED YIELD, ESSENTIAL OIL, OIL CONTENT, ESSENTIAL OIL YIELD AND OIL CONTENT YIELD

Sowing times	Seed yield (kg ha^{-1})	Essential oil (%)	Oil content (%)	Essential oil yield (kg ha^{-1})	Oil content yield (kg ha^{-1})
5 May 2009	736.9^{d}	0.412^{a}	13.72^{b}	3.03^{d}	100.9^{d}
20 May 2009	837.8^{c}	0.416^{a}	13.69^{b}	3.49^{c}	114.3^{c}
4 June 2009	1003.1^{b}	0.417^{a}	14.58^{a}	4.18^{b}	145.9^{b}
19 June 2009	1299.6^{a}	0.417^{a}	14.64^{a}	5.41^{a}	190.0^{a}

Within each column, mean followed by a different letter are significantly different at 5% level (DMRT).

TABLE V
EFFECTS OF PLANT DENSITIES ON SEED YIELD, ESSENTIAL OIL, OIL CONTENT, ESSENTIAL OIL YIELD AND OIL CONTENT YIELD

Plant m^{-2}	Seed yield (kg ha^{-1})	Essential oil (%)	Oil content (%)	Essential oil yield (kg ha^{-1})	Oil content yield (kg ha^{-1})
10	794.9^{c}	0.423^{a}	14.70^{a}	3.38^{c}	117.7^{c}
30	1031.0^{ab}	0.417^{ab}	14.22^{b}	4.31^{a}	147.6^{a}
50	1092.3^{a}	0.413^{b}	13.95^{c}	4.51^{a}	152.9^{a}
70	959.3^{b}	0.409^{b}	13.76^{c}	3.90^{b}	132.8^{b}

Within each column, mean followed by a different letter are significantly different at 5% level (DMRT).

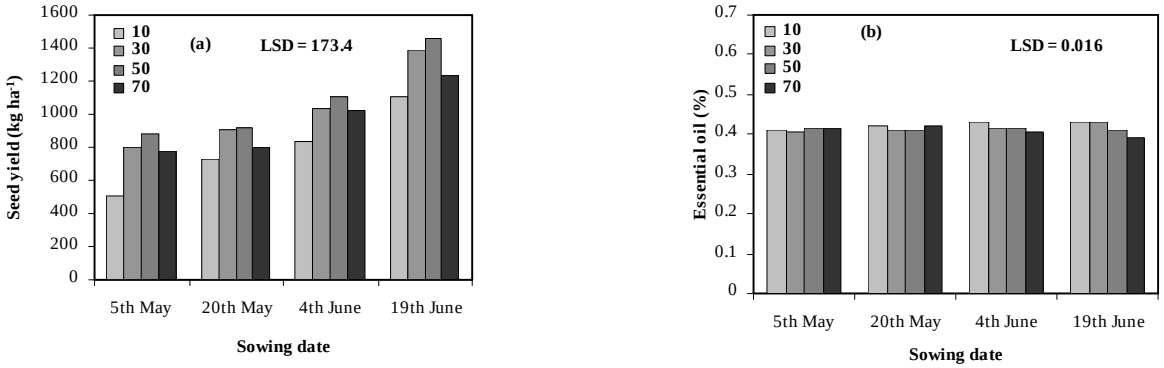

Fig. 1 Effect of sowing date and plant density on seed yield (a) and essential oil (b) of Coriander

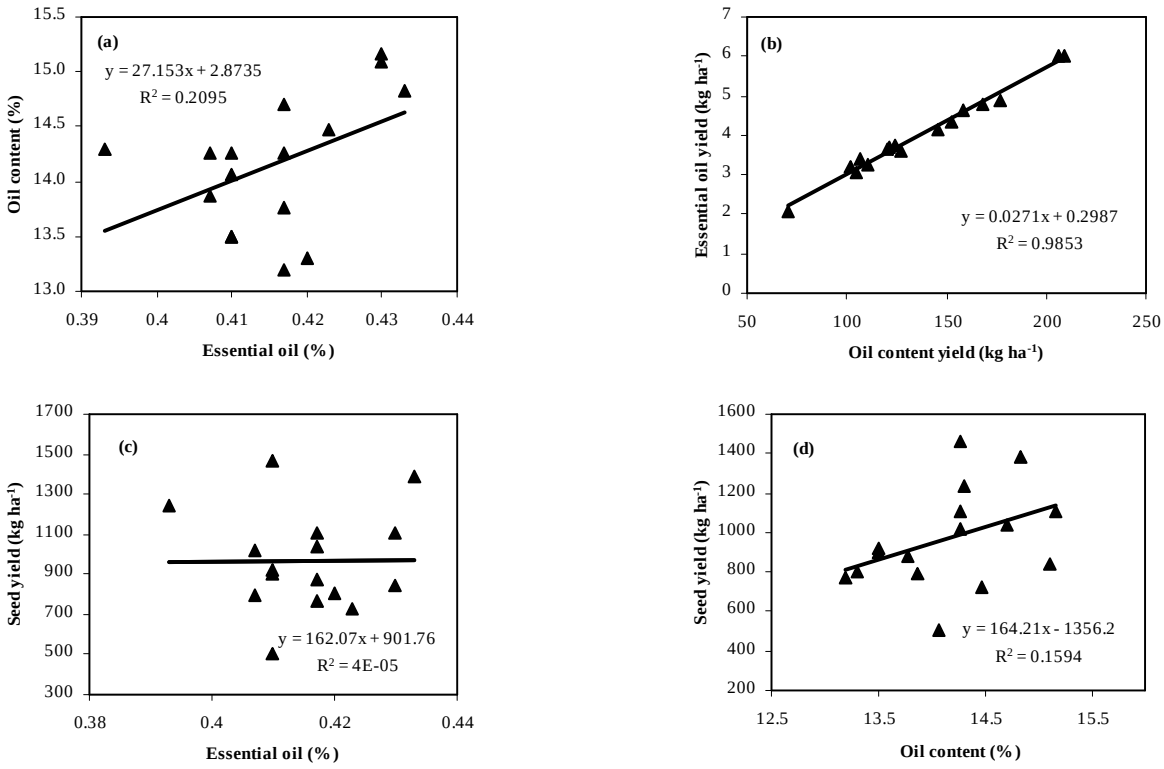

Fig. 2 Relationship between oil content percent and essential oil percent (a), essential oil yield and oil content yield (b), seed yield and essential oil percent (c) and seed yield with oil content percent (d) of Coriander

In our experiment, the lowest and the highest of seed yield were 503.3 kg ha-1 (5 May×10 plants m^{-2}) and 1462.3 kg ha^{-1} (19 June×10 plants m^{-2}), respectively. Sowing date had not affect on essential oil percent, but plant density affected. Carrubba et al., [4] in a study, did not found effect of sowing date on the compound of the essential oil of coriander. 10 plants m^{-2} had the most essential oil percent. At this density (low density), light received the better than the other treatments. Light is one of the important factors in produce of secondary compounds. Highly significant interaction for parameters were observed for essential oil percent (Fig. 1a), with a range of 0.433% (19 June×30 plants m^{-2}) to 0.393% (19 June×70 plants m^{-2}) (Fig. 1b). The results obtained by several authors compared to this work, show that essential oil and oil content variation, which may be related to climate and soil condition, harvest season and plant development [14]-[18]. Treatments had significant affect on oil content percent. 19 June and 4 June had the most of oil percent. The highest of oil obtained at 10 plants m^{-2}. Between essential oil percent and oil content percent, seed yield and oil content percent correlated positively, but did not relationship seed yield and essential oil percent (Fig. 2a and b). At 19 June obtained the highest of essential oil yield and oil content yield (kg ha^{-1}). Results indicated the main factor that increased essential oil and oil content yield were seed yield (kg ha^{-1}) than percent of them (Table V). Also 30 and 50 plants m^{-2} had the most essential oil and oil content yield. Essential oil yield correlated positively with oil content (Fig. 2c and d).

IV. Conclusion

From the present study, we concluded that, coriander crop, at late sowing and irrigation condition (at spring season), produced seed, essential and oil content yields satisfactory, although, Delay at sowing, increased of fat oil (a little). In this work, the most of essential and oil content obtained at the lowest plant m^{-2}.

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