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The Effects of Sowing Dates and Densities on Yield and Yield Components of Coriander (*Coriandrum sativum* L.)

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***Abstract*—**Sowing date and density are two important factors in produce of coriander. A field experiment was conducted with treatments: sowing time (5 May, 20 May, 4 June and 19 June 2009) and plant density (10, 30, 50 and 70 plants m^{-2}). The experimental plots were laid out in a factorial according to a RCBD with three replications. Results showed that the effect of sowing dates and densities were significant on grain yield and yield components, but interaction effects between sowing time and density were non significant for all of traits in this trial. At sowing times 5 May, 20 May, 4 June and 19 June, grain yield obtained 736.9, 837.8, 1003.1 and 1299.6 kg ha^{-1}, respectively. At 10, 30, 50 and 70 plants m^{-2}, grain yield were 794.9, 1031.0, 1092.3 and 959.3 kg ha^{-1}, respectively. In this experiment, sowing at 19 June and 50 and 30 plants m^{-2} had the most grain yield.

***Keywords*—**Coriander, sowing date, plant density, yield and yield components.

I. Introduction

CORIANDER (*Coriandrum sativum* L.) is one of the most important of vegetables, spice and medicinal plant. This crop has cultivated in ancient times in Iran. It is an annual and herbaceous plant, belonging to the Apiaceae family. It is primarily grown for grain and grain essential oil. Plant height is 60 to 90 cm and growth period is 90 to 120 days in spring grown [2]. Also, Coriander grains, 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 [6]-[7]-[8].

There is a very small works on Coriander's agronomic practices management specially sowing dates and plant density compare to other crops. It is an autumn and spring season's crop. Under normal environmental conditions, autumn-winter sowing obtained the highest grain yields [6]-[9]. In rainfed conditions (Semi-arid Mediterranean) at autumn seeding obtained seed yield and biomass of coriander amount 581.3 and 970.6 kg ha^{-1}, respectively [2].

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 [3]. The aim of this work was to evaluate, the effects of different sowing times and plant densities on yield of coriander at spring sown or late sowing times for study of grown possibility as double cropping (coriander after barley or wheat). The results this work to able to useful, because summer grown of coriander will study.

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II. Materials and Methods

This experiment was carried out in research field, Faculty of Agriculture, Razi University, Kermanshah (34° 21′ N, 47° 9′ E; 1319 m above sea level with temperature characteristics in fig. 1), on soils classed a clay, 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}). The experimental plots were laid out according to randomized complete block design (RCBD), with three replications.

Fertilizer was applied before sowing (100 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} N) and at start of flowering (50 kg ha^{-1} N) [1]. Sowing row intervals were 30 cm. The total dry weight for growth trend was measured by each 10 days from sowing. The developmental stages recorded by the method Lawrence [4]. This stages including: ST_1, start of flowering, ST_2, nearly full flowering, ST_3, full flowering, ST_4, end of flowering, ST_5, full green fruits, ST_6, brown fruits, ST_7, full ripening. The total dry weight and grain yield were measured by harvesting 2 m^2 of the central part of each plot at crop maturity. Ten plants were randomly chosen each plot to measure the no. branches per plant, no. umbels per plant, no. grain per umbels, 1000-grain weight and plant height. At harvest time, air-drying of grains performed in a shady place at room temperature for 10 days.

III. Results and Discussion

In this experiment, studied grain yield, biomass, harvest index, no. branches per plant, no. umbel per plant, no. grain per umbel, 1000- grain weight and plant height. The effect of sowing date and plant density were significant on all of traits, but interaction effect between of them non significant. It is indicates a substantially additive behavior for these two sources of variability (Table 1).

The comparison of sowing dates showed that biomass and grain yield at 19 June were high level (Table 2). Grain yield in

4 June, 20 May and 5 May decreased 22.9, 35.6 and 43.3% compared to 19 June, respectively. The reason for this variability in grain yield is increasing air temperature with flowering at sowing dates 5 May and 20 May, that decreased amount all of other traits. At between yield components, the most of effect on grain yield were due to no. grain per umbel and then 1000-grain weight and no. umbel per plant.

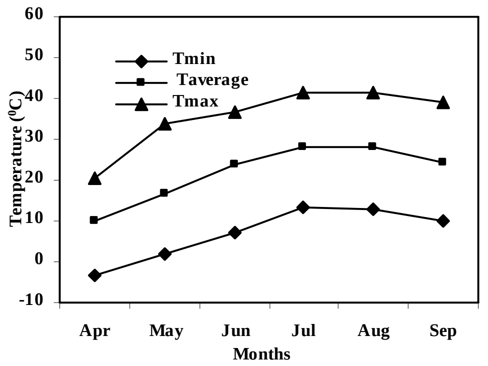

Fig. 1 Minimum (T_{min}), average ($T_{average}$) and maximum (T_{max}) monthly air temperatures of area in during growth season of coriander in 2009.

The comparison of plant density showed that 50 and 30 plant m^{-2} produced the highest grain yield (Table 3). Akbarinia et al. [1] reported that 30 plants m^{-2} in spring grown obtained the most of grain yield. With increase density and competition, decreased no. umbel per plant and no. grain per umbel, but not varied significantly in 1000-grain weight. The results showed that coriander produce ranges from 6.7 to 50.7 no. umbel per plant and 7.3 to 11.3 no. grains per umbel.

Between grain yield and biomass, grain yield and 1000-grain weight (Fig. 2a and b), no. grain per umbels and no. grain per umbels and also and no. grain per umbel with no. branches per plant (Fig. 2c and 2d) were correlated positively.

The pattern of biomass accumulation is shown in fig. 3 a, b, c and d. Result revealed a small growth rate in 40 days after sowing, a high growth rate between 40 and 60 DAS and slower growth activity after 60 DAS. There were no differences between sowing dates and densities until 40 DAS.

The trend of developmental stage for sowing date and densities of coriander shown in fig. 4 a and b. with increase plants length of growth period reached 91.5 to 102.5 days. Also at late sowing, length of growth period was 91 to 100 days.

TABLE I
ANALYSES OF VARIANCE FOR THE EFFECTS OF SOWING DATE, PLANT DENSITY AND THEIR INTERACTION ON YIELD AND YIELD COMPONENTS OF CORIANDER (*F-VALUE*)

Treatments	Biomass	Grain yield	Harvest index	No. branches per plant	No. umbels per plant	No. grain per umbel	1000-grain weight	Plant height
Sowing date (S)	**	**	**	**	**	**	**	**
Plant density (D)	**	**	**	**	**	**	ns	**
Interaction S×D	ns	ns	ns	ns	ns	ns	ns	ns

ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.

TABLE II
MEAN COMPARISON THE EFFECTS OF SOWING DATES ON YIELDS AND YIELD COMPONENTS OF CORIANDER

Sowing date	Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)	No. branches per plant	No. umbels per plant	No. grain per umbel	1000-grain weight (g)	Plant height (cm)
5 May	2001.7 c	736.9d	36.7 a	3.4 c	21.8 bc	7.7 c	9.36 b	66.3 d
20 May	2822.2 b	837.8c	30.3 b	3.7 bc	21.2 c	8.5 bc	9.40 b	69.2 c
4 June	3067.5 b	1003.1b	32.8 b	4.1 ab	23.9 ab	9.3 b	9.89 b	77.2 b
19 June	4221.0 a	1299.6a	31.3 b	4.6 a	24.8 a	10.3 a	10.05 a	81.2 a

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

TABLE III
MEAN COMPARISON THE EFFECTS OF PLANT DENSITIES ON YIELD AND YIELD COMPONENTS OF CORIANDER

Plant m^{-2}	Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)	No. branches per plant	No. umbels per plant	No. grain per umbel	1000-grain weight (g)	Plant height (cm)
10	2594.1 b	794.9 c	31.2 bc	11.0 a	50.7 a	11.3 a	9.75 a	69.6 d
30	2877.7 b	1031.0 ab	36.2 a	3.0 b	21.0 b	9.7 b	9.70 a	71.8 c
50	3227.2 b	1092.3 a	34.1 ab	1.2 c	13.2 c	7.5 c	9.63 a	74.6 b
70	3413.4 a	959.3 b	29.2 c	0.7 c	6.7 d	7.3 c	9.62 a	77.7 a

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

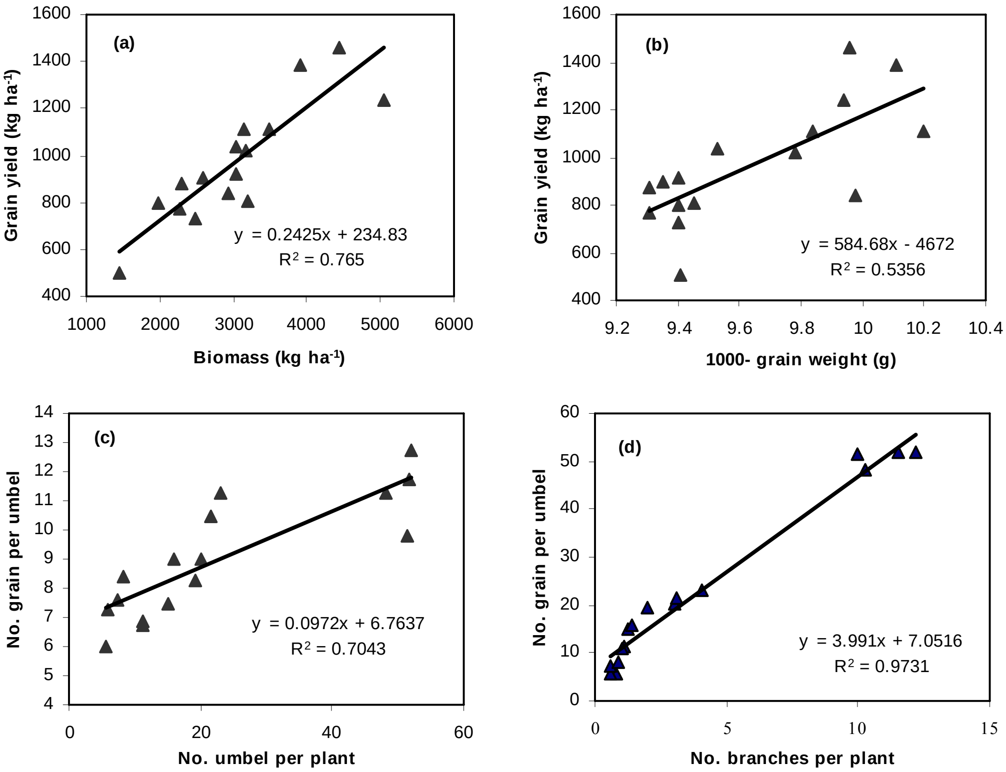

Fig. 2 Relationship between grain yield with biomass (a) and 1000-grain weight (b), also between no. grain per umbel with no. umbels per plant (c) and no. grain per umbel with no. branches per plant (d), in coriander at different sowing dates and different densities.

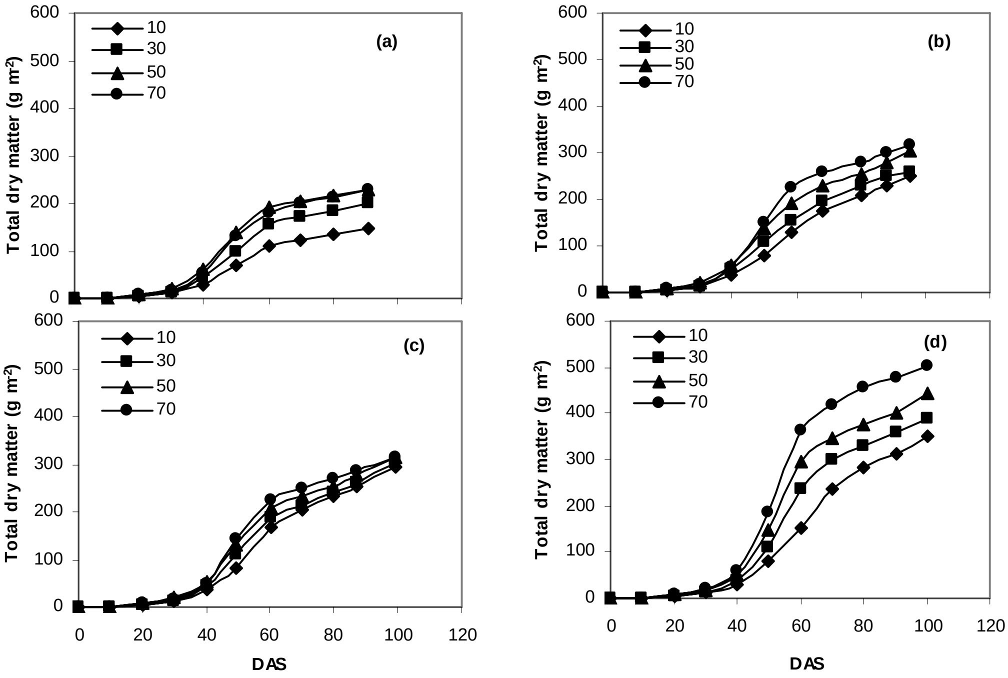

Fig. 3 Trends of average total dry matter measured of coriander in terms of DAS (days after sowing) at sowing times 5 May (a), 20 May (b), 4 June (c) and 19 June (d) in 2009, and plant densities (10, 30, 50 and 70 plant m^{-2}).

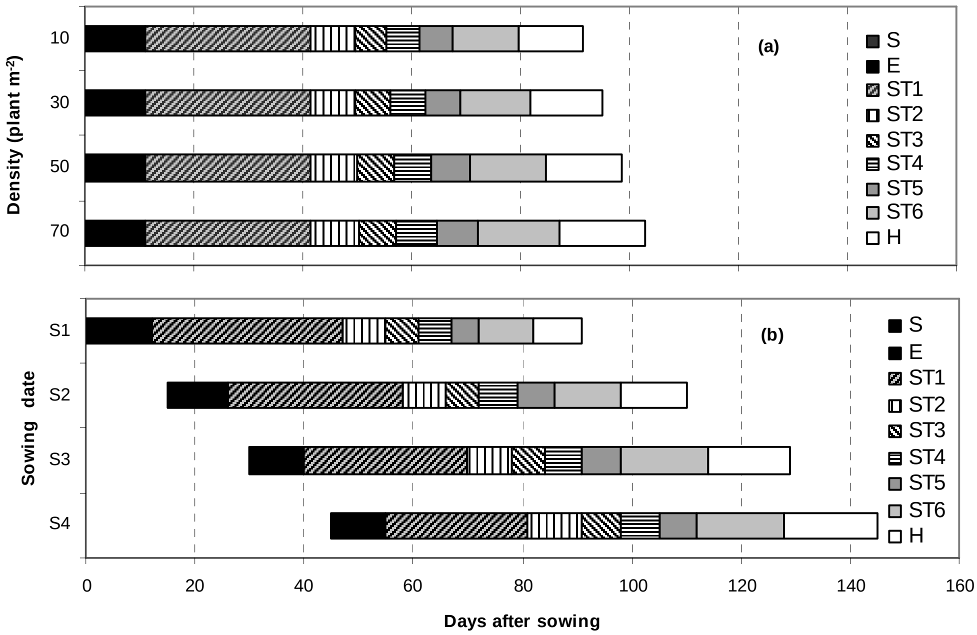

Fig. 4 Trend of the development stages in coriander at densities (10, 30, 50 and 70 plant m^{-2}) (a), and sowing date (S_1=5 May, S_2=20 May, S_3=4 June and S_4=19 June) in 2009 (b). S= sowing, E= emergency, ST_1= start of flowering, ST_2= nearly full flowering, ST_3= full flowering, ST_4= end of flowering, ST_5= full green fruits, ST_6= brown fruits and H = ST_7= full ripening.

IV. CONCLUSIONS

This study suggests that Coriander could be a suitable crop for after harvesting barley and wheat in irrigation conditions as a dabble cropping. Considering the low use of inputs, the grain yields obtained satisfactory and economic. Also the postponement of sowing time in spring sown significantly increased seed yield. At 50 and 30 plants m^{-2} obtained the most of grain yield.

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