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ORIGINAL ARTICLE

The Effects of Planting date and Plant Spacing on Yield and Yield Components of Fennel

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ABSTRACT
In order to study the effect of planting date and plant spacing on yield and yield components of fennel, an experiment was conducted in a split plot in a randomized complete block design with three replications at the Research Farm in Ilam, Iran in 2011-2012 cropping season. Experimental factors such as planting date at 3 levels (5 March, 20 March and 5 April) were chosen as main plot and plant spacing at four levels (2, 3, 4 and 5 cm) were assigned as subplot. Planting date had significantly affected on the number of primary branches, number of secondary branches, number of grain per head and grain yield. The highest number of primary branches (7.5 branches), number of grain per head (199.8 grain) and grain yield (704.7 kg.ha^{-1}) was gained in planting date of 5 March. Maximum number of head per plant (22.3 head), number of grain per head I (195 grain) and grain yield (702 kg.ha^{-1}) was obtained at plant spacing of 3 cm. Interaction effect between planting date and plant spacing on number of primary branches, 1000-grain weight and grain yield was significant. The highest number of primary branches, 1000-grain weight and grain yield were obtained at planting date of 5 March and plant spacing of 4 cm. The results of this study, early planting of fennel had better conditions of vegetative and reproductive growth and better yield, and plant spacing of 3 cm had more impact on grain yield in the Ilam region.
Keywords: *Fennel, Planting date, Grain yield*

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INTRODUCTION

One of the most important factors in crop production management is determination of appropriate planting date. Determination of proper Planting date of crop production for use of potential of each variety in each regions for different region will be important in programing and crop management. Planting date has effect on characteristic and different stage of growth and developing and improves use efficiency from environmental factors. Proper planting date change grain yield by changing components yield and proper planting date increase maximum efficiency from crop season and ultimately will cause to arriving to favorable growth and maximum of yield that for each variety determine according to planting goal and season [1]. Absorbed sunlight efficiency by crop needed to enough a leaf area to distributing equally, this aim done by changing row spacing and distributing plants over soil [2]. Goals such as improving absorbed sunlight by changing plant density and also changing row spacing pursued in agricultural plants planting [3]. Hunter [4] indicated that delay in planting date cause to shorting growth period, producing enough photosynthesis material decrease for save in the grain. Growth and development of medicinal plants as other crop plants influenced by genetic and environmental factors and the maximum yield is obtained only when the appropriate combination of environmental factors is provided for plant.

Changes in planting date change during the day, maximum and minimum temperature, relative humidity and other environmental conditions during the growing season and the crop during the growing season, plant phenological stages and ultimately affect the qualitative and quantitative yield [5-6]. Some researchers reported that the yield of the fennel plant in autumn planting is more than spring planting and stated that cultivated in autumn due to better posture, Cold tolerance, early spring and the foliage and grain weight more, has a higher yield. Basically, for each product there is a good planting time which

delay can cause yield loss [7]. Gupta [8] argues that because of delay planting date, the yield drops drastically, considered the reason for the decrease in yield decrease in during the length of growth period. Vildova and Stolcova [9] in a study on chamomile at the University of Jinnah Belgium, the effects of four planting dates (mid-March, late April, early May and late May) were evaluated on yield flower and reported that the best time for planting these plants for maximum yield, is mid-April.

Based on the experimental results [10] increased the number of branches and plants that have been planted with a density less than the density plants more are planted in the competition for light, space, water and nutrients knew the additional space will allow the plant to produce more branches. Thus, method of the distribution and density of the branches in the field, and productivity of environmental factors affecting impacts on plant growth, competition of external and internal in bush ultimately is one the determinants of yield grain [11].

Sharma and Prasad [12] showed that Fennel increased from 15 to 30 cm row spacing, grain yield increased significantly. Also Singh [13] reported that row spacing of 30 cm had the best follow and essential yield. Datta and Singh [14] reported that the highest yield was obtained in row spacing of 30 cm. Other researchers with peppermint grown in different planting densities reported that plant spacing had not a significant effect on product characteristics such as leaf yield, total yield and active ingredient [15]. The results of another study that was done on peppermint the highest grain yield was obtained in plant density of 7.4 plants.m^{-2} [16].

In a study planting basil in different densities (20, 40 and 60 plants.m^{-2}) was reported that most amount of the grain yield was obtained in 20 plants.m^{-2} [17]. Therefore this experiment was carried out in order to investigate the effect of planting date and plant density on yield and yield components of fennel in Ilam, Iran region

MATERIAL AND METHODS

In order to study the effect of planting date and plant spacing on yield and yield components of fennel, an experiment was conducted in a split plot in a randomized complete block design with three replications at the research farm in Ilam (with 46º 36' longitude and 33º 47' latitude and 975 m height sea), in Iran in 2011-2012 cropping season. Experimental factors such as planting date at 3 levels (5 March, 20 March and 5 April) were chosen as main plot and plant spacing at 4 levels (2, 3, 4 and 5 cm) were assigned as subplot. Annual Precipitation is shown in Table 1.

Table 1: Monthly mean value of precipitation and relative humidity in, Ilam station in 2011-2012 cropping season

Month	Max wind (m/s)	Precipitation (mm)	RH (%)
Oct.	15	0.2	29
Nov.	13	1.7	37
Dec.	18	52.1	37
Jan.	13	82.2	62
Feb.	8	125.2	70
Mar.	17	29.1	55
Apr.	25	65.5	48
May	14	87.6	54
Jun.	14	0	26
Jul.	15	0	8

Measured traits including: number of primary branches, number of secondary branches, number of grain per head, number of head per plant, 100-grain weight and grain yield. To measure grain yield in each plot was calculated and remove omission after removal of the bottom margin of 2 square meters separately. Data obtained using SAS and Excel software were analyzed and the mean data were compared using Duncan's multiple range test.

RESULTS AND DISCUSSION

Number of primary branches

Analysis of variance showed that the number of primary branches significantly influenced by planting date, plant spacing and their interaction were effect at 1% probability level (Table 2). So that the planting date of 5 March with an average of 7.5 branches maximum and mean planting date of 5 April with 3.8 allocated to the lowest number of primary branches (Table 3). It seems that the effect of early planting date, because of the long growing period, the plants produced more branches and increase the reproductive period, number of head per plant increased head. The next thing is that in early planting nutrient stress and foodstuffs is somewhat weak, In other words, early planting for vegetative and

reproductive plants have enough time and are less affected by drought last season. Maximum and minimum number of primary branches was obtained from in plant spacing of 4 and 2 cm with the average 7.7 and 4.3 branches, respectively (Table 4), the overall number of branches per plant genetic trait is partly influenced by environmental factors. So in plant spacing of 4 cm, increase space between plants by shading the plants with wide row to be delayed or reduced. So at plant spacing of 4 cm, received more energy radiation than plant spacing of 2 cm, this increase of receiving light led to increase number of initial branches. Decrease of plant density in unit area cause increasing light in population of plant and more space is available for plant development. In this case decrease Predominance effect of terminal plant and more small and larger tributaries of the plant will begin branches grow and develop in plant and increases use of condition environmental, thus increasing the number of primary branches [18]. The results of the interaction between planting date and plant spacing showed that number of primary branch increase on 5 March and plant spacing of 4 cm with a primary an average of 12 branches and reduce the early planting on 5 April and plant spacing of 3 cm with an average of 3.3 branches, respectively (Fig 1).

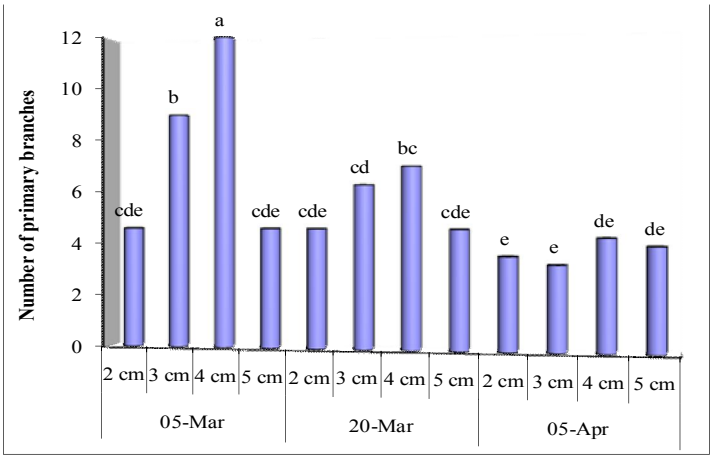

Fig 1: Interaction effect of planting date and plant spacing on number of primary branches

Table 2: Variance analysis for studied crop and quality traits in experiment

Source of variances	D.F	Number of primary branches	Number of Second branches	Number of head in plant	Number of grain in head	1000 grains weight	Grain yield
replication	2	6.3	21.7	111.3	3381.1	11.9	74014.03
Planting date	2	42.1**	61.6*	99.6ns	8812.4**	7.9ns	12887.7**
Residual (a)	4	1.5	4.8	9.7	172.4	2.5	138892.4
Space bush	3	24.1**	40.5**	95.1**	6255.1**	4.8**	138892.4**
Residual (b)	6	9.6**	5.8ns	8.9ns	3313.8ns	0.9*	6361.8*
Space bush * Planting date	18	1.7	3.6	8	351.5	0.5	4380.3
CV	-	23.5	23.1	15.4	10.8	21.7	11.2

ns, * and**:Non- significant and significant at 5% and 1% levels, respectively

Table 3: Mean comparison of effect of planting date on studied crop and quality traits in experiment

planting date	Number of primary branches	Number of Second branches	Number of head in plant	Number of grain in head	1000 grains weight (g)	Grain yield ($kg.ha^{-1}$)
5 March	7.5a	10.9a	21.6a	199.8a	4.1a	704.7a
20 March	5.6ab	7.1ab	17.2a	171.1ab	3.2a	588.1ab
5 April	3.8b	6.8b	16.3a	145.6b	2.5a	477.9b

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

Table 4: Mean comparison of effect of space of row on studied crop and quality traits in experiment

space of row	Number of primary branches	Number of second branches	Number of head in plant	Number of grain in head	1000 grains weight (g)	Grain yield ($kg.ha^{-1}$)
2 cm	4.3b	7.3bc	16.4b	160b	2.36b	498b
3 cm	6.2ab	9.8ab	22.3a	195a	3.06ab	702a
4 cm	7.7a	10.2a	19.6ab	192a	3.75a	692a
5 cm	4.4b	5.7c	15.1b	140b	4.07a	475b

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

Number of secondary branches

The results of the analysis of variance showed a significant effect of planting date and plant spacing on the 5% probability level based on the number of secondary branches (Table 2). So that planting date of 5 March with average 10.9 branches had maximum of secondary branches and with delay in planting date, decrease number of secondary branches as accounted for planting date of 5 April with an average of 6.8 minimum numbers of secondary branches. Also maximum number of secondary branches was to plant spacing of 4 cm by reducing or increasing the row spacing decreased number of secondary branches. In the distance between the plants that used in these experiments, plant spacing of 5 cm with an average of 5.7 branches, had the lowest secondary branches (Table 4). This results were according to the findings Bellido et al., [19] and Board [20], which increases the row spacing and plan spacing or reduce plant density, number of secondary branches and increased and increased operating due to the increased number of secondary branches and the distances between the rows at most, low intraspecific competition and reduce the possibility of competition for plant growth, provides the spaces are empty, the result will be increasing the number of secondary branches.

Number of grains per head

The results of variance data analysis showed that there was a significant effect on number of grains per head by planting date and plant spacing at 1% probability level (Table 2). As the table of average data, the highest and lowest number of grains per head with an average of 199.8 and 145.6 grain observed on 5 March and 5 April, respectively (Table 3), so that the optimum planting date in different areas, has impact on plant vegetative and reproductive growth, and increasing photosynthesis efficiency, transportation of photosynthesis materials and store them in grain increase the grain yield. What is clear is that more applicable at the time of flowering and pollination, and proper temperate it could increase number of grains per head in planting date of 5 March. Reduce the number of grains per plant on April 5 could be due to short-term growth and reduce the amount of carbohydrates and minerals and materials and the reduction of the grain as grain. According to the results of this experiment, between plant spacing that was studied plant spacing of 3 cm with Average 195 grain per head was far more than other and with plant spacing of 4 cm and statistically had not significant difference put in the same statistically group. The minimum number of grain per head was in spacing plant of 5 cm with average of 140 grain per head (Table 4).

Number of head per plant

This trait significantly was not influenced by planting date, but the effect of plant spacing was significant on number of head per plant at 1% probability level (Table 2). As indicated in the comparison mean, maximum and minimum number of head per was obtain at plant spacing of 3 cm with an average of 22.3 and plant spacing of 5 cm with an average of 15.1 heads per plant (Table 3). According to the results of these tests can be inferred that the increased plant density and greater competition for water and nutrients, and limit of their growing, growth of head and their maturity happen in a short period and the leaves grow more quickly as this results the Number of head per plant decreases in plant and in other hand decrease the amount of irrigation water and a sudden increase in temperature causes premature oldness in plants. The next thing is that if the water content be low, the plant is less vegetation that could feed tank and the smaller generative work and does not allocate enough dry matter and as a result, can produce fewer pods per plant. Also reduce plant density per unit area increase light in plant population and more space is available for plant development. In this case reduce predominance effect of terminal plant and more branchlets start growth in plant and use of environmental condition increase and greater number of flowers produced as the result number of head per plant is greater. In this study looked at the plant spacing of 3 cm is proper in plant density and plant use of well of water, nutrients and light, and has more number of head in plant. Emami et al., [21] in his experiments concluded that plant density had significant effect on number of grains per panicle and grain weight of fennel.

1000-grain weight

This trait was not significantly affected by planting date but the plant spacing and interaction effect between planting date and planting space were significant effect on 1000-grain weight at 1% and 5% probability level, respectively (Table 2). As the average comparison Table showed that planting date of 5 March and 5 April, with an average of 4.1 and 2.5 g had the highest and lowest 1000-grain weight, respectively (Table 3). In general grain weight is a function of the rate and length duration of grain filling that produce from two source of current photosynthesis and again transport of saved matter in plant. Planting dates in different regions, increase impact of increasing the efficiency of photosynthesis and plant vegetative and reproductive growth, photosynthesis and store in grain handling and yield. As Horn and Burnside [22] showed delay in planting decreased 1000-grain weight due to low humidity, announced late in the growing season. Delayed planting reduced the grain filling period and decreased during grain filling has a negative effect on grain weight due to reduced accumulation in grain is raised.

According to the results of this experiment, the plant spacing of 5 cm with an average of 4.07 g was highest 1000-grain weight and plant spacing of 4 cm with an average grain weight 3.7 g in same statically group by reduction of plant spacing, decreased grain weight and 1000-grain weight allocated Least 2 cm between plants in the row with the average 2.3 g (Table 4). 1000-grain weight depends to hydrate carbon, grain filling, It seems that reason of high grain weight per plant spacing of 5 cm, is less of number of grains per head and number of head in plant, which was much larger and had more weight. As the comparison of mean indicated, 5 March and plant spacing of 4 cm with mean of 1000-grain weight 5.2g had the greatest 1000-grain weight between and planting date of 20 March and plant spacing of 2 cm with average 1.9 g had the lowest 1000-grain weight (Fig 2).

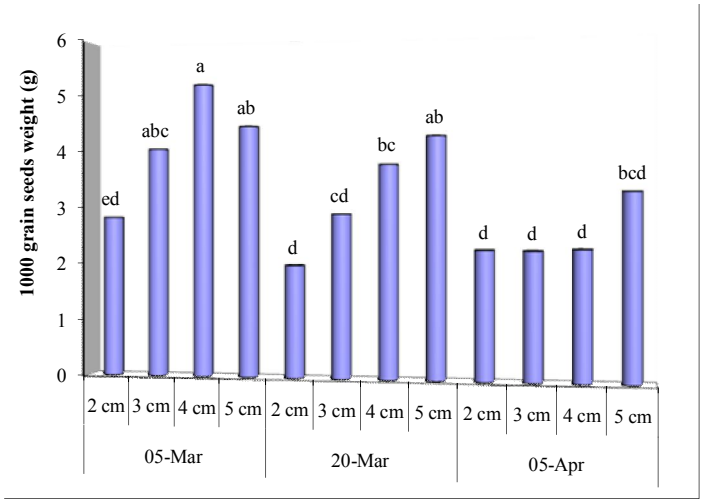

Fig 2: Interaction effect of planting date and plant spacing on 1000-grain weight

Grain yield

The results of data variance analysis indicated a significant difference at 5% probability level was on grain yield by planting date (Table 2). The planting dates were different in terms of grain yield, so that planting date of on 5 March with average of 704.7 kg.ha^{-1} and planting date of on 5 April with average of 477.9 kg.ha^{-1} had the highest and lowest grain yield, respectively (Table 3). Noting that planting data is restoration on one of the most effective non-economic factors on the optimal operation of the cultivated plant on the last day of planting dealing growing seasons with the short days and occurred earlier flowering and reproductive competition with the growing consumption of photosynthesis affect yield and reduced. Successful germination may be grain because of early planting, while the yield of late planting due to facing of growth period with unfavorable environmental factors, is include low yield [23].

It is concluded that the effect of delayed planting, growth period of fennel was be short and before the plant can produce maximum foliage, enter to they are generative phase. As a result, the total amount of assimilates produced in comparison with the number of leaves in per single plant, will be reduced. In other hand total numbers of prolific location reduce, and this led to reduction of number of branches in per plant. Also, due to the short duration of grain filling reduce grain reserve amount which reduces 1000-grain weight. In addition, in late planting date early facing levels of exposure to high temperatures in day can also cause to reduce the grain filling result cases which mentioned above are a reason for reduction of ultimate grains. Research of other researchers also stated the yield loss due to delay in planting date [24]. Also, Johnson et al., [25] studied the different effect of planting date and showed that delayed planting date cause to decreased significant grain yield. Reduce the size of the canopy than desirable, and shorten the growth period of the growth is one of the main reasons for reduce of grain yield in delayed planting date [26]. Egli, D. B., and Bruening [27] in their study reported a decrease in yield with delayed planting date. In response to the trend of grain yield, showed that plant spacing had a significant effect on grain yield at 1% probability level (Table 2). Plant spacing of 3 cm with an average grain yield of 702 kg.ha^{-1} was superior to other varieties and allocated to itself the highest yield and the lowest allocated to grain yield from plant spacing of 5 cm (Table 4). The results of several studies on crop, yield increase by soil fertility, improve water availability and increased plant density per unit area as well. But increasing plant density more than desired, due to increased intraspecific competition, lodging, etc., despite the increase in soil fertility and plant available water, is an important factor in reducing grain yield [28-29-30]. However this was consistent with the experimental results. However, the yield of the

plant as the result of intraspecific and interspecific competition was for most environmental conditions and maximum grain yield unit is obtained when the competition is minimized. Interactions effect between planting date and plant spacing on at 5% probability level was significant effect on grain yield (Table 2). Overall, the results of Fig 3 showed that planting date of 5 March with plant spacing of 3 and 4 cm, respectively, with average of 869 and 822 kg.ha^{-1} had greatest grain yield and were within a statistically group. The lowest grain yield had on planting date of 5 April and plant spacing of 2 and 5 cm with a mean of 381 and 383 kg.ha^{-1} which were not significantly different, and placed in a same group.

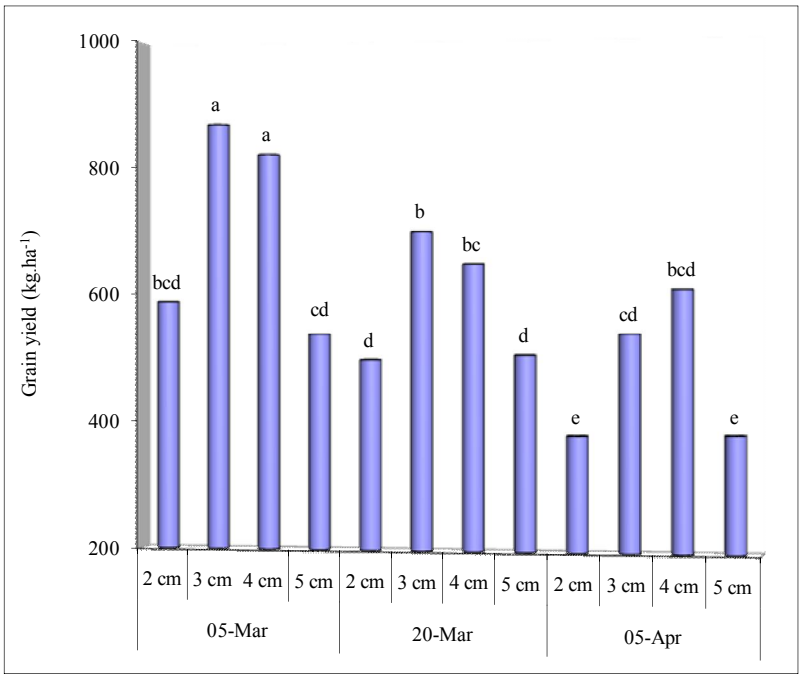

Fig 3:. Interaction effect of planting date and plant spacing on grain yield

CONCLUSION

The results of this study, planting date was positive effects on traits such as grain yield in climatic conditions in this experiment, planting date of 5 March had the highest grain yield to other planting dates. Also plant spacing of 3 cm dye to Number of head in plant Number of grain in head had the highest grain yield.

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