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Effects of planting date and plant density on yield and some physiological characteristics of single cross 550 hybrid maize as a second crop

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ABSTRACT
Maize grain yield has a high potential and as planting late maturing cultivars is delayed for any reason, middle-aged maize cultivars can be used as an alternative plant. Observing planting date and plant density is very important in increasing maize yield. In 2019 in Koohdasht City, Iran, a statistical design of split plots was performed based on complete blocks with three replications. The aim of this study was to investigate the effect of density (6, 7, 8 and 9 plants m^{-2}) and planting date (6, 13 and 20 July) on grain yield and its components in single cross maize cultivar 550. Planting dates were considered as main plots and planting densities were considered as sub-plots. By increasing density, traits such as number of leaves per plant, number of leaves above maize, stem diameter, maize diameter, maize length, number of grains per row and 1000-grain weight decreased. By delay in planting, plant height, number of leaves per plant, maize length, stem diameter, maize diameter, number of grains per row and 1000-grain weight decreased. The highest grain yield (14.313 tons per hectare) was obtained from the first planting date (6 July) with a density of 9 plants m^{-2}. By elevating density, plant height, maize height, grain yield, biological yield and degree of fruiting increased and the number of rows per maize, number of grains per row, maize diameter, cob diameter, stem diameter and 1000-grain weight decreased.

Keywords: Planting date, Density, Maize, Second planting, Grain yield.
Article type: Research Article.

INTRODUCTION
Increasing the production of agricultural products is possible in two ways: upraising the area under cultivation and elevating the yield per unit area. Due to the limitation of arable and arable lands and the unsuitable climate, it is necessary to increase the yield per unit area of leaves, which is the main purpose of agriculture. Using improved cultivars, preparation of the desired substrate, selection of suitable planting date and method, grain rate, crop rotation, etc. increase crop efficiency or elevate yield per unit area (Khajepour 2000). Maize is the third most resistant crop in terms of area under world cultivation and second in terms of world production (Shevchenko *et al.* 2021; Sahi *et al.* 2022). Given the important role of maize in feeding livestock and poultry and importing 1.5 million tons maize per year in the country, it is necessary to achieve self-sufficiency and cut the dependence on the outside using appropriate techniques of planting, holding and harvesting and using high-yielding and suitable cultivars. Yield per unit area and by promoting and developing the second crop of maize after harvesting barley, wheat, oat and rape grain took basic steps to increase maize production (Koucaki *et al.* 1991). By increasing plant density and intensifying competition between plants for optimal environmental factors, photosynthesis in a single plant decreases followed by reduction in the transfer of photosynthetic products from leaves and stems to cob. As a result, cob diameter decreases by upraising density (Oktem 2005). In high densities, due to the reduction of optical degradation of auxin, the distance between nodes and also the height elevates. However, in low densities, due to more radiation in the plant community, the optical degradation of auxin upraises and its further degradation, leads to reduction in plant height. In addition, the plant slows down through diameter and as a result, the plant height does not elevate. At densities below the desired level per unit area, storage organs are reduced and we will

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face the loss of inputs, especially radiation, followed by alterations in the distribution of photosynthetic materials, and finally, economic performance drops. Reduction of light intensity and competitive effects of shading and high-density cause elongation of the growing season and delayed flowering. It is used to increase plant length and plant growth processes (Uhart & Andrate 1995). Afsharmanesh (2007) found that by elevating density, grain yield upraised and the highest grain yield was obtained for a density of 5.5 plants per m^2. Shahkarami & Rafiee (2009) reported in their experiment that the maximum grain yield was obtained from the density of 70,000 plants per hectare. Delay in planting reduces yield, because the grains reach maturity in shorter periods of the day and also the plants have less leaf area and as a result, the total dry matter production will be less. Spring planting has a higher yield than late planting date due to the symmetry of grain formation and filling stage with long days as well as the presence of more radiant energy for the photosynthesis process. Grain yield in late sowing is much more affected than biological yield. This indicates that the adverse effect of planting date is not limited to photosynthesis. However, in late planting, the vegetative growth period is much shorter and flowering occurs at a time when there is not enough time for full maturity and the resulting maize. They are physiologically immature (Hashemi Dezfouli & Herbert 1992). Alterations in the planting date due to changes in climatic parameters depending on the type of crop can lead to an increase or decrease in yield (He *et al.* 2018). Mokhtarpour *et al.* (2008), in the study of planting date and plant density, reported that the maximum yield of maize on the date of planting was 9 May and the density of 55 to 65 thousand plants per hectare was determined for spring maize cultivation. Lorestan Province, Central Iran, with its diverse climates and very fertile plains, has suitable fields for cultivation of various maize hybrids in all maturity groups in the country in the form of spring and summer crops. Hence, it can be used by alterations in the planting date and using a suitable hybrid with suitable densities and achieving the desired yield per unit area. This project was carried out to determine the planting date and suitable density for Single Cross 550 cultivar in the climatic conditions of Koohdasht, Lorestan Province, Central Iran after harvesting fine grains such as wheat, barley and canola as the second crop.

MATERIAL AND METHODS

This experiment was carried out in 2019 in Koohdasht region, Lorestan Province with a latitude of 33 degrees and 36 minutes north and longitude 47 degrees and 40 minutes east and at an altitude of 1200 meters above sea level. According to the Climatic Division, this region has a subtropical climate with hot and dry summers. Single Cross 550 cultivar is one of the new cultivars of maize and is middle aged, which is considered as the second crop after wheat, barley and rape grain. This experiment was performed using a split plot design in the form of randomized complete blocks in three replications. Planting dates of 6 July, 13 July and 20 July were considered as main plots and densities of 6, 7, 8 and 9 plants per m^2 were considered as sub-plots. The land was plowed in the spring 2019 with a reversible plow after canola harvest. After selecting and sampling the soil to determine the fertility of the soil, all complementary land preparation operations, including plowing and disc to prepare the grain bed, were performed. Irrigation method was considered as sprinkling according to the climatic conditions. Disc and leveling and adding 120 kg phosphorus from triple superphosphate source, 50 kg potassium sulfate fertilizer and 300 kg ha^{-1} of urea fertilizer, one third of urea fertilizer was spread and mixed with soil before plowing and planting. Another third was added to the soil as a road in the 4-6 leaf stage and the remaining one third was used in the stem stage before flowering. In order to achieve the desired densities, planting was done by hand. In each place, three grains were placed at a depth of 7 cm and in the two to three leaf stage. After complete establishment of the plants, thinning operations were performed and additional plants were removed from the field. The distances between two plants on planting lines for densities of 6, 7, 8 and 9 per m^2 were 22, 19, 17 and 15 cm, respectively. In order to control weeds, 3-4 kg ha^{-1} (atrazine + lasso) was added to the soil in a ratio of 50:50 before planting and then in the six-leaf stage, a herbicide (2.5 liters per hectare) was added. Necessary care was taken during the experiment, including manual weeding. Irrigation was performed once every four days from planting to 50% emergence and once a week thereafter. To compare the final yield, maize were located at an area of 4.2 m^2 were harvested and measured by removing the marginal rows at the physiological maturation stage (formation of a black layer at the bottom of the grain; Lemcoff & Loomis 1986; Sadeghi &, Bahrani 2001). The number of grains per maize was the weight of 1000 grains (based on five samples of 200 grains per plot) was calculated by random sampling of 10 plants from each subplot in the final harvest. In this experiment, biological yield (including all plant and maize shoots) and harvest index were also calculated. The yield is the sum of grain yield (tons per hectare), biological yield (tons per hectare) and harvest index (%). The reaction of these variables to a treatment shows a unit value. This index is scale-less (Koucaki & Khalqani 1995). Grain yield was calculated based on 14% moisture. To measure the maize diameter of 10 maize from four rows in the middle of each plot, a caliper was used in the middle part of the maize and the average of the obtained numbers was considered as the maize diameter of each plot. To measure the grain depth of cob diameter obtained from the small cob diameter, we divided it into two to obtain the grain depth, and to measure the percentage of cob wood, weighed 10 cobs from the four rows in the middle of each plot and then the grains. They were isolated and after weighing the grains and reducing their weight from the cobs, the percentage of cobs was calculated by weighing the cobs and multiplying them by 100. Data analysis of variance was performed using MSTATC, SAS and Excel software and all means were compared using Duncan's multiple range test at 5% level.

RESAULT AND DISCUSSION

The final height of the plant was affected by the planting date. The highest plant height (237.93 cm) was related to the first planting date. In addition, the plant height decreased by a delay in the planting date. Plant final height was affected by plant density (Table 1).

Table 1. Analysis of variance of studied traits.

Sources of changes	Degree of freedom	Bush height (cm)	Numbr of leaves per bush	Number of leaves above the maize	Maize height (cm)	Stem diameter (mm)	Grain depth (mm)	Maize diameter (mm)	Maize length (cm)	Cob diameter (mm)
Frequency	2	6.056	0.041	0.068	4.629	0.442	0.132	1	0.020	2.694
Planting date	2	33.930**	168.3**	739.4**	6124.56**	151.75**	28.965**	367**	73.95**	87.028**
Error a	4	1.548	0.008	0.104	0.794	0.016	1.257	2	0.025	1.444
Bush density	3	977.2**	190.0*	0.045*	80.95**	26.087**	0.102 ns	5.037**	0.86**	4.852**
Interaction	6	1.722^{ns}	0.039^{ns}	0.059^{ns}	8.642**	0.379**	0.150*	0.148^{ns}	^{ns}0.06	0.213^{ns}
Error b	18	0.821	0.046	0.010	0.288	0.035	0.058	0.111	0.002	0.120
Total	35									

Note: ns, *, ** meaning non-significant, significant at 5% and 1 % respectively.

Table 1. (continued). Analysis of variance of studied traits…

Sources of changes	Degree of freedom	Number of grains per row	Number of rows of grains per maize	The weight of thousand grains	Biological function	Grain performance	Harvest index	Degree of efficiency
Frequency	2	0.067	0.101	75.929	0.763	0.356	3.124	11.098
Planting date	2	798.603**	10.101*	75.9137**	182.99**	169.46**	13.9255**	14.400**
Error a	4	0.013	0.018	0.004	0.004	0.107	0.284	0.536
Bush density	3	0.031*	0.164*	89.12**	42.54**	32.62**	253.15**	8.85602**
interactions	6	0.007^{ns}	0.001^{ns}	0.467^{ns}	1.4**	2.329**	0.98**	1.5691**
Error b	18	0.010.	0.0001	0.467	0.017	0.036	0.97	0.144
Total	35							

Ans, *, ** non-significant, significant at 5% and 1 % respectively.

The maize plant has to increase its height to compensate the lack of light, but this increase is to the extent that biological storage allows (Koucaki *et al.* 1991). In high densities, due to the reduction of light auxin degradation, the distance between nodes and also the height increases. However, in low densities, due to more radiation in the plant community, the light degradation of auxin elevates plant height, while its further shortening reduces it. The plant grows in diameter so the plant height does not increase. By increasing density, the storage capacity of the reservoir drops, while the ratio of sterile florets rises, leading to a decrease in the number of cob grains. The effect of planting date on stem diameter was very significant (Table 1). Stem diameter decreased. The highest stem diameter at the first planting date was 24.72 mm, while the lowest at the third planting date was 17.62 mm (Table 2). The stem diameter decreased by upraising the plant density with a very significant difference. It was observed between the means (Table 3) that the highest stem diameter was obtained from the density of 6 plants per m^2. The decreased stem diameter at higher densities may be due to intensification of competition and the reduction of cultivated material allocated to the stem. Similar results have been reported by Ulger *et al.* (1997). The interaction effects of planting date and plant density on stem diameter were significant, so that, the maximum stem diameter (27.332 mm) was observed at 6 plants per m^2. In addition, by delayed date of first planting, maize diameter decreased (Table 2). There was also a significant difference between different planting dates (Table 1). Mute (53.5 mm) was related to the first planting date and also the lowest cob diameter (42.5 mm) was related to the third planting date (Table 2).

Table 2. Comparison of mean grain yield, yield components and morphological characteristics in different planting dates.

Planting date	Bush height (cm)	Number of leaves per bush	Number of leaves above the maize	Maize height (cm)	Stem diameter (mm)	Grain depth	Maize diameter (mm)	maize length (cm)	Cob diameter (mm)
19/07/06 T_1	237.925 a	15.4 a	7.225 b	104.233 a	27.729 a	9.825 a	53.5 a	22.25 a	33.25 a
19/07/13 T_2	219.908 b	14.95 b	8.167 a	80.9 b	21.438 b	9.408 a	49 b	17.317 b	29.58 b
19/07/20 T_3	204.642 c	14.375 c	8.417 a	59.06 c	17.623 c	6.950 b	42.5 c	19.3 c	28 c

Note. Means that have at least one letter in common do not differ significantly at the 5% probability level based on Duncan's multiple range test.

Table 2. (continued). Comparison of mean grain yield, yield components…

Planting date	Degree of freedom	Number of grains per row	Number of rows of grains per maize	The weight of thousand grains (g)	Biological function (ton ha^{-1})	Grain performance (ton ha^{-1})	Harvest index (%)	Degree of efficiency
19/07/06 T_1	39.07 a	17.18 a	15.4 a	272.919 a	30.166 a	11.074 a	36.293 a	77.532 a
19/07/13 T_2	29.21 b	16.33 b	14.95 b	252.95 b	27.195 b	6.428 b	23.318 b	56.941 b
19/07/20 T_3	22.892 c	15.35 c	14.375 c	222.95 c	22.425 c	3.634 c	15.2 c	41.114 c

Note. Means that have at least one letter in common do not differ significantly at the 5% probability level based on Duncan's multiple range test.

By increasing density, the maize diameter declined and there was a very significant difference between different densities (Table 3). The highest cob diameter (49.222 mm) was obtained from the lowest plant density which was significantly different from other densities. Similar results were reported by Akintoye *et al.* (1977) and Ulger *et al.* (1997). The highest cob diameter (54.33 mm) from the date of first planting and a density of 6 plants per square meter were obtained. The interaction effect of planting date and plant density on maize diameter was not significant (Table 4) which is consistent with the results of Sadeghi & Bahrani (2001) and Oktem (2005). Cob diameter is higher in the first planting date due to longer growth period, suitable time interval between emergence to pollination, length of grain germination period, leaf area index as well as leaf area durability and optimal use of environmental factors (Damavandi & Latifi 2003).

Table 3. Comparison of mean grain yield, yield components and morphological characteristics at different seed densities.

Bush density levels	Bush height (cm)	Number of leaves per bush	Number of leaves above the maize	Maize height (cm)	Stem diameter (mm)	Grain depth (mm)	Maize diameter (mm)	Maize length (cm)	Cob diameter (mm)
D1 6 bushes m-2	209.956 d	14.911 ab	7.944 a	77.544 d	23.361 a	8.811 a	49.222 a	19.733 a	31 a
D2 7 bushes m-2	215.433 c	14.9 a	7.889 b	80.622 c	21.677 b	8.859 a	48.566 b	19.667 a	30.778 a
D3 8 bushes m-2	224.144 b	15.089 a	8.033 a	83.067 b	20.702 c	8.812 a	48.111 c	19.578 a	29.889 b
D4 9 bushes per m2	233.767 a	14.733 b	7.878 b	84.356 a a	19.313 d	8.7 a	47.444 d	19.511 a	29.444 c

Table 3. (continued). Comparison of mean grain yield, yield components and morphological …

Bush density levels	Degree of efficiency	Number of grains per row	Number of rows of grains per maize	The weight of thousand grains(g)	Biological function (Ton per hectare)	Grain performance (Ton per hectare)	Harvest index (%)	Degree of efficiency
6 bushes m-2 D1	30.389 ab	16.444 a	18.709 d	253.326 a	23.773 d	4.872 d	18.709 d	47.132 d
7 bushes m-2 D2	30.422 a	16.344 b	23.003 c	250.867 b	26.122c	6.253 c	23.003 c	55.370 c
8 bushes m-2 D3	30.3444 a	16.233 c	26.990 b	248.089 c	27.736 b	7.776 b	26.990 b	62.503 b
9 bushes m-2 D4	30.311 b	16.133 d	31.072 a	246.144 d	28.760 a	9.279 a	31.072 a	69.110 a

By increasing plant density and intensifying competition between plants for optimal environmental factors, photosynthesis in a single plant as well as the transfer of photosynthetic products from leaves and stems to cob decrease. Oktem (2005) pointed out that cob diameter decreases by elevating in density. Analysis of variance on the number of leaves per plant exhibited that there is a significant difference between planting date and plant density (Table 1). However, there was no significant difference between the interaction effects of density and date. Cob height (104.23 cm) was obtained on the first planting date, while by a delay in the planting date, the cob height decreased. So that, the lowest cob height (59.06 cm) was obtained on the third planting date (Table 4), probably due to food supply and longer growth period along with using more light and temperature, which is consistent with the results of Ulger *et al.* (1999). Plant maize height was affected by plant density (Table 1) and the highest maize height (84.35 cm) was obtained from 9 plant m^{-2} (Table 3). The maize plant has to elevate its height to compensate for the lack of light, however, this elevation is to the extent that biological storage allows (Koucaki *et al.* 1991). Grain depth decreased with delay in planting. Plant density had no significant effect on grain depth, but the highest grain depth was obtained from the density of 6 plants m^{-2}. By delay in planting, cob diameter decreased and there was a very significant difference between different planting dates (Table 1).

Table 4. Comparison of mean interaction effects of planting date and plant density on grain yield, yield components and morphological characteristics.

Plant date * bush density	Number of grains per row	Number of rows of grains per maize	The weight of thousand grains (g)	Grain performance (Ton per hectare)	Biological function (Ton per hectare)	Harvest index (%)	Degree of efficiency
$T_1 D_1$	39.03^{a}	17.33^{a}	276.577^{a}	7.819^{e}	26.58^{e}	29.41^{d}	63.81^{e}
$T_1 D_2$	39.17^{a}	17.23^{b}	274.2^{b}	10.034^{c}	29.457^{c}	34.06^{c}	73.55^{c}
$T_1 D_3$	39.1^{a}	17.13^{c}	270.867^{c}	12.127^{b}	31.567^{b}	b38.41^{b}	82.103^{b}
$T_1 D_4$	39^{a}	17.03^{d}	270.033^{c}	a14.313^{a}	33.06^{a}	43.29^{a}	90.667^{a}
$T_2 D_1$	29.26^{b}	16.5e	256.7^{d}	4.202^{i}	24.3^{f}	17.29^{h}	45.79^{i}
$T_2 D_2$	29.2^{b}	16.4^{f}	254.2^{e}	5.738^{g}	26.68^{e}	21.5^{f}	53.92^{g}
$T_2 D_3$	29.27^{b}	16.267^{g}	251.7^{f}	7.189^{f}	28.34^{d}	25.36	60.89^{f}
$T_2 D_4$	29.1^{b}	16.167^{h}	249.2^{g}	8.582^{d}	29.46^{c}	29.13^{d}	67.163^{d}
$T_3 D_1$	22.86^{c}	15.5^{i}	226.7^{h}	2.596^{k}	20.44^{j}	19.43^{j}	31.8^{k}
$T_3 D_2$	22.9^{c}	15.4^{j}	224.2^{i}	2.988^{j}	22.2^{i}	13.45^{i}	38.64^{j}
$T_3 D_3$	22.97^{c}	15.3^{k}	221.7^{j}	4.010^{i}	23.3^{h}	17.2^{h}	44.517^{i}
$T_3 D_4$	15.2 l	15.2^{k}	219.2^{k}	4.943^{h}	23.76^{g}	20.79^{g}	49.5^{h}

Note. Means that have at least one common letter are not significantly different at the 5% probability level based on Duncan's multiple range test.

Table 4. (continued). Comparison of mean interaction effects of planting …

Plant date × bush density	Bush height (cm)	Number of leaves per bush	Number of leaves above the maize	Maize height (cm)	Stem diameter (mm)	Grain depth (mm)	Maize diameter (mm)	maize length (cm)
$T_1 D_1$	227.8^{abc}	15.43^{ab}	7.167^{ef}	102.533^{c}	30.467^{a}	9.867^{a}	54.33^{a}	22.4^{a}
$T_1 D_2$	231.9^{abc}	15.4^{ab}	7.07^{f}	104.267^{b}	28.017^{b}	9.7^{ab}	53.67^{b}	22.3^{b}
$T_1 D_3$	241.17^{ab}	15.47^{a}	7.367^{d}	104.567^{b}	27.055^{c}	9.86^{a}	53.33^{b}	22.2^{c}
$T_1 D_4$	250.83^{ab}	15.3^{abc}	7.3^{de}	105.57^{a}	25.523^{e}	9.87^{a}	52.67^{c}	22.1^{d}
$T_2 D_1$	207.9^{def}	15.033^{bcd}	8.27^{ab}	76.27^{f}	26.370^{d}	9.2^{c}	49.67^{d}	17.37^{h}
$T_2 D_2$	215.467^{cde}	14.933^{cd}	8.17^{b}	78.77^{e}	25.115^{f}	9.37^{bc}	49.33^{d}	17.37^{h}
$T_2 D_3$	223.367^{bcd}	15.067^{abcd}	8.33^{ab}	83.83^{d}	23.983^{g}	9.53^{abc}	48.67^{e}	17.27^{i}
$T_2 D_4$	232.9^{bcd}	14.767^{d}	7.9^{c}	84.73^{h}	22.145^{h}	9.53^{abc}	48.33^{e}	17.27^{i}
$T_3 D_1$	194.167^{f}	14.267^{f}	8.4^{a}	53.83^{j}	22.315^{h}	7.367^{d}	43.67^{f}	19.43^{e}
$T_3 D_2$	198.933^{ef}	14.367^{ef}	8.43^{a}	58.83^{i}	20.9^{i}	6.7^{e}		19.33^{f}
$T_3 D_3$	207.9^{def}	14.733^{de}	8.4^{a}	6.08^{h}	20.143^{j}	7.033^{de}	42.33^{g}	19.27^{f}
$T_3 D_4$	217.567^{bcd}	14.133^{f}	8.43^{a}	62.77^{g}	19.057^{k}	6.7^{e}	41.33^{h}	19.17^{g}

Note. Means that have at least one common letter are not significantly different at the 5% probability level based on Duncan's multiple range test.

The largest diameter of cob was related to the date of first planting (33.25 mm), while the lowest to the third planting date (28 mm). The highest amount of cob diameter (31 mm) was obtained by the density of 6 plants m^{-2} and a significant difference was observed by the densities of 8 and 9 plants m^{-2}. The results of analysis of variance showed that there was a very significant difference between the number of grains per row (Table 1). In addition, the number of grains per row dropped by a delay in planting date. The highest number of grains per row (39.08 grains) was related to the first planting date, while the lowest number to the third planting date (22.89 grains per row; Table 2), similar to the results of Chogan & Samavat (2000). The decreased number of grains per row can be explained by the reduction in current photosynthesis and, of course, the analysis of the upper cob's grains when the grains are filled due to photosynthetic material limitation and less inoculation of the final grains of the treatment. Since the filling of maize kernels first begins in the middle to fertilize the lower and middle embryos of the maize and gradually continues to the tip of the maize, so the final grains are not large enough to count and trying to inoculate such cocoons rarely leads to failure and they develop to grains. The critical period of grain formation is between one to two weeks before- and three weeks after-germination (Uhart & Andrate 1995). Reduction in nutrients, moisture and light by affecting the supply of nutrients to the maize as a result of reducing leaf area index, leaf area durability and plant photosynthesis and finally the penetration of light and its efficiency exhibit a negative effect on the number of grains per maize (Andrata *et al.* 1993; Uhart & Andrate 1995). Comparison of the average number of rows per maize at different planting dates showed that the first planting date produced the highest number of rows per maize (17.18; Table 2) and by delaying in planting, the number of rows per maize gradually decreased, and in the date, the third planting reached 15.35 rows in cob. The results showed that by a delay in planting date, 1000-grain weight decreased (Table 2), hence, the lowest 1000-grain weight (222.95 g) was obtained from the third planting date, which was significantly different from other dates (Table 1). Alterations in planting date depending on the plant type can lead to increased or decreased yield (He *et al.* 2018). In the present study, 1000-grain weight was affected by plant density (Table 1) and decreased by rising in 1000-grain weight density, moreover, between different densities, this 1000-grain weight loss was significant (Table 3). The difference between the lowest and highest densities shows that the weight of 1000 grains in the range of density has little change and in high densities, the weight of 1000 grains was also affected, so that, decreased by elevating the density of 1000 grains. At lower densities, the plant has more access to environmental factors (light, heat and humidity) and eventually transfers more photosynthetic material to the grains. However, at higher densities these factors are less available to the plant and cause a weight of a thousand. Hence the grains are reduced. In the first planting date, due to the long growth period of each developmental stage, suitable growth characteristics, using environmental factors affecting growth, upraising the photosynthetic efficiency and elevating the dry weight of different plant organs, biological yield increases. Analysis of variance of biological yield showed that biological yield in different planting dates is very different (Table 1). Comparison of the mean of traits in different sowing dates showed that the first sowing date has produced the highest biological yield (30.166 tons per hectare) and by delay in sowing, grain yield gradually decreased, such that in the third sowing date reached 22.425 tons per hectare (Table 2). The most important environmental factors affecting the planting date are day length (photoperiod), temperature and humidity (Latifi & Damavandi 2003). By planting maize at the right date, optimal conditions of these environmental factors lead to rise in biomass. The results obtained from analysis of variance showed a significant difference between different densities (Tables 1 and 3). Biological yield increased by elevating in density. Maximum biomass yield was obtained from the density of 9 plants m^{-2} (32.180 tons ha^{-1}; Table 3). Analysis of variance of grain yield showed that grain yield at different planting dates is significantly different (Table 2). Comparison of the mean of traits in different sowing dates showed that the first sowing date has produced the highest grain yield (11.074 tons ha^{-1}) and by delay in sowing, grain yield gradually decreased, so that in the third sowing date reached 3.634 tons tons ha^{-1} (Table 2). Delay in planting date reduces the length of the plant growth period and also delay in cultivation reduces yield. Since the grains reach the ripening stage in shorter periods of the day and also the plants have less leaf area, hence as a result the total dry matter production will be less. Maize spring planting has a higher yield than late planting date due to the symmetry of grain formation and filling stage in long days along with the presence of more radiant energy for the photosynthesis process. Grain yield in late sowing is much more affected than biological yield. This indicates that the adverse effect of planting date is not limited to the process of photosynthesis, however, in late planting, the vegetative growth period is much shorter and flowering occurs at a time when there is not enough time for full maturity. Hence, the resulting maize is physiologically immature (Hashemi Dezfouli & Herbert 1992; Mokhtarpour 2008).

CONCLUSION

Statistically, changes in the number of grains per row also follow this pattern of grain yield, so that this trait, like grain yield, shows a decreasing trend from the first to third planting date. In the first planting date, the number of grains per row, number of grains per row, maize length, 1000-grain weight and number of leaves per plant were higher than in the second and third planting dates, hence, this increase in yield components upraised grain yield, albeit with a delay. At the planting date, grain yield components decreased, leading to a drop in grain yield per unit area. The most important environmental factors affecting the planting date are day length (photoperiod), temperature and humidity. By planting maize at the right date, the optimal conditions of these environmental factors, raise the yield through its various components. The results obtained from analysis of variance showed a significant difference between various densities (Tables 1 and 3). The single-plant grain yield decreased by raising in density. Maximum grain yield was obtained from a density of 9 plants m^{-2} equal to 14.313 tons per hectare. Due to sufficient solar radiation in Koohdasht City and low number of cloudy days in summer, higher densities seem to produce more yields. The results of the present study and other reports in the same area (Noor Mohammadi *et al.* 1997) indicate the fact that maize, especially in the areas of Koohdasht, has a very high production capacity. By increasing plant density, the number of grains per row, maize length and the 1000-grain weight decreased, however, due to the elevated number of plants, the final grain yield per unit area raised. Moisture and nutrients are provided as needed. Certainly, the non-uniform distribution of radiation in the plant community and its loss has had a special place in yield reduction (Hashemi Dezfouli & Herbert 1992). At less-than-optimal densities per unit area, storage organs will be reduced and inputs, especially radiation, will be lost, hence, the distribution of photosynthetic materials will be altered, so economic performance will be declined. The more space and space available to the plant, the more single plants will grow and yield. However, ultimately the lower the number of plants per unit, the lower the yield. The effect of competition between plants is reflected in the components of the crop, and therefore competition at excessive densities reduces the yield of each plant. In addition, the cob grain size and reproduction are affected by the method of pollination and inoculation of grains; all are directly related to the amount of radiation. Produced maize kernels are affected by environmental conditions during the growing season. Kouchaki *et al*. (1991) found a positive relationship between radiation and grain yield. The reduced light intensity and competitive effects of shading, along with high density prolong the growing cycle and delay flowering in terms of vegetation. Finally, the allocation of assimilated substances instead of interfering with granulation and storage in reservoir tissues lead to elevation in plant length and the plant growth processes. In maize and many other species, very large populations increase the percentage of plants that are infertile and ultimately do not ripe as maize fruit (Koucaki *et al.* 1991). Studies by Videcombe & Taslter (2002) also showed that grain yield can be increased to some extent by increasing the yield. Liang *et al.* (1996) reported that maximum maize grain yield required high density, high irrigation, high fertilizer consumption and high heat demand. The results showed that the harvest index was affected by the planting date in a way that decreased by the delay in planting. The lowest harvest index (15.20%) was obtained from the third planting date (Table 2). Increasing the harvest index indicates more ability of the plant to transfer and allocate more nutrients to the shoots and is one of the indicators used to evaluate the efficiency of crop dry matter distribution. The ratio of cob dry matter to plant dry matter is very closely related to the number and activity of the destination, its reproductive and these reproductive destinations are directly related to the growth rate. Therefore, as a result of nutrient deficiency, plant growth rate reduces the ratio of cob dry matter to total plant dry matter by affecting reproductive destinations (Uhart & Andrate 1995). Yield is the sum of grain yield, biomass yield and harvest index, which shows the reaction of the aforementioned variables against a treatment as a unit value. It is useful to use the degree of fruiting to show the sensitivity of maize cultivars to environmental stresses (Koucaki & Khalqani 1995). Using fruiting degree, the cultivars that have more production power are easily selected. The results of analysis of variance (Table 1) showed that there is a significant difference between different planting dates in terms of fruiting degree, so that, the first planting date has the highest fruiting grade (77.5) which was probably due to the efficient use of water and soil resources and the production of photosynthetic materials, dry matter and finally higher grain yield. These factors exhibited a higher degree of fruiting, due to leaf arrangement and better distribution of the root system. Thus, by using the degree of fertility, the planting date that has more production power can be easily selected. Therefore, using the degree of fruiting for data available from sources indicates the usefulness of the degree of fertility and understanding the reactions. It is a product and, contrary to the results obtained from statistical analyzes, the degrees of yield are easily understood by farmers and provide a broader view for the adoption of management methods in them (Koucaki & Khalqani 1995). By increasing density, the degree of fruiting raised to the desired level and the highest degree of fruiting (69.11) was obtained from the density of 9 plants per square meter (Table 3).

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