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Study of grain yield and its components in corn hybrids in two planting dates using different rates of biofertilizers in Karaj region, Iran

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Abstract

In order to evaluate the yield and grain yield components of corn hybrids in two successive planting dates under Karaj conditions, two experiments were conducted at Seed and Plant Certification and Registration Institute (SPCRI). The experiments were carried out in a split plot design based on randomized complete blocks with four replications. In this research, five levels of biofertilizers (control, three different levels of Humiforte, Aminol-forte, fosnutren and kadostim and also a combined level of Aminol-forte-Humiforte and kadostim-fosnutren) were arranged in main plots and three maize hybrids (including SC704, SC500 and SC260) were regarded as the sub-plots. Some traits such as grain yield, grain row number, grain number/row, 1000-grain weight and total grain number/ear were studied. The results of variance analysis in the first planting date disclosed that the effects of different fertilizers, different hybrids and also their interactions on grain yield were not significant, while the results of second planting date showed that different corn hybrids had significant effects on grain yield. Mean comparisons of two successive planting dates revealed that the cultivar 704 produced the highest yield (14.31 and 14.17 t/ha, respectively).

Keywords: biofertilizers; plant regulators; single-cross SC704, SC500, SC206; planting date.

Introduction

Planting date is one of the most important aspects of management in agricultural system which can affect yield through influencing emergence date, plant density, normal growth, and pollination and maturity date (Noormohammadi *et al*., 1997). Seed planting in suitable date results in root development, increment of plant tolerance against stresses and maize growth cycle completion and finally yield increment (Dasilva *et al*., 1999). Early planting along with humidity stress or drought stress can disrupt plant reproductive development stages. These kinds of stresses can result in yield decrement through kernel abortion and production of kernels with lower 1000-grain weight on plants which have been cultivated with delay (Colvile, 1962). Grain yield is a complex character determined by several components which reflect positive or negative effects upon this trait. Meanwhile, it is important to examine the contribution of each of the various components in order to consider the ones which have the greatest influences on yield (Özer *et al*., 1999). Maize grain yield potential has dramatically increased during the last 50 years especially in the temperate regions of the world (Russel., 1991; Tollenaar *et al*., 1994). This yield enhancement can be largely attributed to the release of genetically superior hybrids, higher plant densities, increased use of chemical fertilizers, reduction of row spacing, improved cultural practices, and better weed and pest control (Carlon and Russel, 1987; Dwyer *et al*., 1991). In many parts of Iran, after harvesting winter cereal crop

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(wheat and barley) and rapeseed (*Brassica napus* L.) at the end of spring to the next planting in autumn, there is an 80 to 90-day time gap. As a short duration cereal crop, maize hybrids have attained top priority in the areas of high mountains, where water scarcity, chilling conditions and snowfall limit the growing period of other cereals. Therefore, selecting the crops with a short growth duration is a good choice for planting in this period. Results of an experiment conducted by Siadat and Shaigan (1994) to evaluate the effect of hybrid types and planting date on grain yield in Khoozestan province revealed that maize single-cross hybrid 704 produced the highest yield and was superior among the hybrids. Dungan (1974) reported that late-maturing maize hybrids produced higher yield than early- and medium-maturing cultivars. Maize hybrids differ in nutrient uptake potential. The results from different researches about the effect of using micronutrients on crop yields are not consistent. Some researchers indicated that using micronutrients did not increase maize yield (Sajedi, 2004; Fotouhi *et al*., 2006; Mohseni *et al*, 2000) while others showed different results (Robson *et al*., 1984; Lisuma *et al*., 2006; Slaton *et al*., 2005). In an experiment on evaluation of the best plant density, maize single-cross hybrid 711 (with the density of 65000 plants/ha) reportedly produced higher yield (8.86 ton/ha) compared with maize single-cross hybrid 704 (Ganjeh, 1998). Sadeghi and Bahrani (2000) indicated that the highest yield of late-maturing cultivars belonged to maize single-cross hybrid 704 while the highest yield was observed in medium-maturing cultivars.

This study was carried out to evaluate the effects of different planting dates, various hybrid types and different biofertilizers on maize grain yield.

Materials and Methods

The study was carried out in experimental field of Seed and Plant Certification and Registration Institute (SPCRI), Karaj, Iran in 2008-09.

The climate of the region was arid and semi-arid. Experiment was conducted in a split plot design based on randomized complete blocks with four replications. Each replication consisted of 15 plots. In this research, five levels of biofertilizers (control, three different levels of Humiforte, Aminol-forte, Fosnutren and Kadostim and also a combined level of Aminolforte-Humiforte and Kadostim-Fosnutren) and three maize single-cross hybrids (SC704, SC500 and SC260) were considered as main plots and sub-plots, respectively. Also, all three different levels of Humiforte, Aminol-forte, Fosnutren and Kadostim were used as below formula:

(1) Suggested standard biofertilizer levels (2) 25% more than standard dosage (3) 25% less than standard dosage (4) combined form of suggested biofertilizer dosage. Biofertilizers were applied at different stages of plant growth in all plots without control treatment: (1) Aminol-forte was used at 2-3-leaf stage, (2) Humiforte was applied at primary growth stages to supply N-P-K, (3) Fosnutren was used before tasselling and silking stages, and (4) Kadostim was applied before maturity between milky and dough stages. Each plot consisted of six rows 75 cm apart and 8 meter long. In this research, plant density of maize single-cross hybrids (SC704, SC500 and SC260) were considered as 65, 75 and 85 plants/m^2, respectively (with in-row spacing of 20, 18 and 16 cm).

Results and Discussion

Total grain yield

The results of variance analysis of the first planting date showed that the effect of bioferilizer, hybrids and their interaction on grain yield was not significant (Table 1). Also means comparison of biofertilizers × hybrids interaction by Duncan Multiple Range Test (DMRT) recognized F3V1 treatment (applied biofertilizer 25% more than standard dosage with SC704) produced the highest grain yield (14.31 t/ha) (Table 2). The results of variance analysis of the second planting date showed that the effect of bioferilizers and their interaction was not significant but the hybrids effect on grain yield was significant at 1% probability (Table 1). Also, SC704 produced the highest grain yield (14.17 t/ha) and also there was not observed significant difference between hybrids SC500 and SC260 (Table 2). Also, means comparison of biofertilizers × hybrids interaction in the second planting date by DMRT showed that F2V1 treatment (standard dosage of applied biofertilizer with SC704) produced the highest grain yield (14.43 t/ha) (Table 3). The results of variance analysis of the combined two planting dates made clear that the grain yield was not affected by the planting date and biofertilizers (Table 4) but mean comparison

Table 1. Analysis of variance of grain yield and related characteristics in the corn hybrids

S.O.V.	df	First planting date (MS)				
		Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
Replication	3	14.208	0.407	23.496	9025.974	2071.667
Fertilizer	4	5.182 ns	1.052 ns	16.582 ns	6620.611 ns	6191.150 ns
Error	12	3.511	0.265	9.197	3628.938	4266.081
Hybrids	2	5.137 ns	63.185**	197.288**	84958.887**	8431.023**
Hybrids × fertilizer	8	3.821 ns	0.238 ns	10.164 ns	3132.267 ns	1572.951 ns
Total error	30	3.107	0.464	7.121	2550.875	1626.135
Total mean		239.515	150.804	936.705	368609.772	160402.278
C.V.		13.94	3.91	6.70	7.28	14.18
S.O.V.	df	Second planting date (MS)				
		Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
Replication	3	2.772	17.659	7.216	6452.937	1321.695*
Fertilizer	4	0.220 ns	14.370 ns	0.799 ns	5772.702 ns	4.846 ns
Error	12	1.536	22.253	0.551	7302.995	296.260
Hybrids	2	27.212**	744.842**	62.256**	97873.737**	7931.612**
Hybrids × fertilizer	8	0.820 ns	5.273 ns	0.233 ns	1288.357 ns	175.423 ns
Total error	30	1.435	11.563	0.408	3517.864	145.644
Total mean		131.669	2256.262	170.086	441675.811	29175.515
C.V.		9.30	8.15	3.94	8.85	3.98

showed that the first planting date accompanied with the applied biofertilizer 25% more than standard dosage produced the highest yield (Fig. 1). Furthermore, combined variance analysis of two planting dates showed grain yield was affected by hybrids (P < 0.01) and also planting date × cultivar interaction was significant (P < 0.05). Also, second planting date with hybrid SC704 produced the highest grain yield (14.17 t/ha) (Table 4)

The results of combined variance analysis of hybrids was significant (P<0.01). It was recognized that SC704 and SC260 produced the highest (13.46 ton/ha) and lowest (12.00 t/ha) grain yield, respectively (Fig. 2).

The results of combined variance analysis of cultivars and bioertilizers were not significant (Table 4) but mean comparisons indicated that the highest and lowest grain yields were obtained by F3V1 (biofertilizer applied 25% more than standard dosage with SC704) and F1V3 (control biofertilizer treatment and SC260) treatments as 14.15 and 11.60 t/ha, respectively (Fig. 3).

The effects in combined variance analysis of hybrids, biofertilizer and planting date were not significant (Table 4) but means comparison revealed that the highest and lowest grain yields were obtained by L2F2V1 (second planting date, standard biofertilizer dosage treatment with SC704) and L1F1V1 (first planting date, control

Table 2. Means comparison of simple effect of hybrids in two planting dates on the measured characteristics

Treatment	First planting date				
	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
SC704	12.7 a	43.48 a	16.62 b	722.1 a	304.2 a
SC500	12.09 a	38 b	19.49 a	740.1 a	263.1 b
SC206	12.13 a	38.08 b	16.23 b	619.3 b	285.6 ab
Treatment	Second planting date				
	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
SC704	14.17 a	14.97 c	48.76 a	724.1 a	318.2 a
SC500	12.61 b	18.23 a	38.13 b	694.5 a	280.5 b
SC206	11.88 b	15.44 b	38.25 b	590.9 b	310.5 a

Means with similar letters in each column are not significantly different.

Table 3. Means comparison of interaction between fertilizer and hybrids in two planting dates

Treatment	First planting date (MS)				
	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
F1V1	10.66 c	39.72 bc	17.03 b	676.3 bcd	2998.2 a
F1V2	12.24 abc	37.43 cd	19.87 a	743.5 abc	218.1 b
F1V3	12.80 abc	37.70 cd	16.05	607.5 de	219.9 b
F2V1	12.60 abc	43.96 ab	16.25 bc	714.3 abc	288.9 a
F2V2	12.74 abc	38.17 cd	19.36 a	738.7 abc	269.5 ab
F2V3	14.04 ab	40.09 bc	16.42 bc	659 cd	297.2 a
F3V1	14.31 a	45.54 a	16.98 b	771.6 a	305.3 a
F3V2	12.60 abc	38.40 cd	19.53 a	750 ab	291 a
F3V3	13.63 abc	39.84 bc	16.60 bc	662 cd	305.4 a
F4V1	12.20 abc	43.32 ab	16.64 bc	721.2 abc	298.3 a
F4V2	11.73 abc	37.79 cd	19.63 a	741.5 abc	271.5 ab
F4V3	13 abc	37.55 cd	16.40 bc	614.9 de	300.8 a
F5V1	13.97 ab	44.85 a	16.21 bc	727.2 abc	330.1 a
F5V2	11.16 bc	38.18 cd	19.04 a	726.8 abc	265.7
F5V3	11.98 abc	35.21 d	15.69 c	553 e	304.7 a

Treatment	Second planting date (MS)				
	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
F1V1	13.91 abcd	48.62 a	15.12 bc	734.4 a	312.7 ab
F1V2	13.33 abcde	39.07 b	18.72 a	730.5 a	287.5 cd
F1V3	11.77 e	38.15 b	15.87 b	605.8 b	309.1 ab
F2V1	14.43 a	49.58 a	14.86 bc	736.2 a	319.3 ab
F2V2	12.15 de	41.15 b	17.97 a	733.4 a	272.5 d
F2V3	11.70 e	39.20	15.40 bc	603 b	314.1 ab
F3V1	13.90 abcd	47.51 a	14.88 bc	707.6 a	324.7 a
F3V2	12.42 bcde	36.42 b	17.83 a	652.3 ab	273 d
F3V3	11.95 de	37.42 b	14.97 bc	561.7 b	313.1 ab
F4V1	14.26 abc	49.72 a	15.27 bc	731.2 a	318.6 ab
F4V2	12.02 de	36.23 b	18.10 a	656.8 ab	286.8 cd
F4V3	12.30 cde	36.97 b	15.67 bc	578.8 b	304.3 bc
F5V1	14.33 ab	48.37 a	14.70 c	711.2 a	315.6 ab
F5V2	13.12 abcde	37.78 b	18.54 a	699.6 a	282.8 d
F5V3	11.70 e	39.53 b	15.30 bc	605.2 b	311.8 ab

Means with similar letters in each column are not significantly different.

biofertilizer treatment and SC704) treatments as 14.43 and 10.66 t/ha, respectively (Table 4) (Fig. 4).

General observation of data showed that SC704 used biofertilizers more than other hybrids (SC500 and SC260) although no significant difference was observed between biofertilizers and hybrids. In away, grain yield is an indicator that shows whether or not maize yield affected by applied nutrients. Dungan (1974) noted that late-

Table 4. Combined analysis of variance for grain yield and related characteristics in the corn hybrids

S.O.V.	df	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
Planting date	1	9.537^{**}	104.179^{ns}	45.547^{**}	17278.799^{ns}	10562.255^{*}
Error	6	5.563	20.578	3.811	7739.455	1696.170
Fertilizer	4	1.804^{ns}	13.722^{ns}	1.031^{ns}	2636.322^{ns}	3134.651^{ns}
Planting date × fertilizer	4	3.342^{ns}	17.230^{ns}	0.819	9756.991^{ns}	3060.991^{ns}
Error	24	2.279	15.745	0.408	5465.966	2281.268
Hybrid	2	23.075^{**}	854.402^{**}	123.585^{**}	177024.899^{**}	16047.001^{**}
Planting date × hybrid	2	6.88^{ns}	87.728^{**}	1.857^{**}	5807.725^{ns}	309.326^{ns}
Fertilizer × hybrid	8	2.366^{ns}	5.985^{ns}	0.226^{ns}	2109.896^{ns}	630.059^{ns}
Planting date × fertilizer × hybrid	8	1.771^{ns}	9.452^{ns}	0.245^{ns}	2310.728^{ns}	1116.119^{ns}
Error	60	2.289	9.342	0.436	3034.369	885.547
Total error		1373.880	633.437	3297.146	527564.383	200087.177
C.V.		11.34	3.92	7.49	8.08	10.13

ns, * and **: non-significant and significant at 5% and 1% probability levels, respectively.

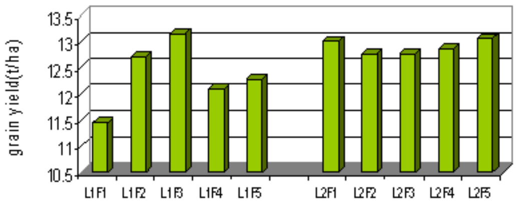

Fig. 1. Means comparison of interaction of planting dates and biofertilizers for average grain yield of maize cultivars.

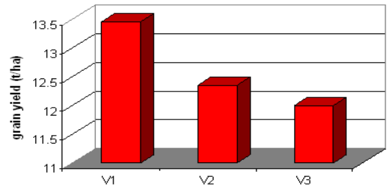

Fig. 2. Combined means comparison of grain yield in maize hybrids

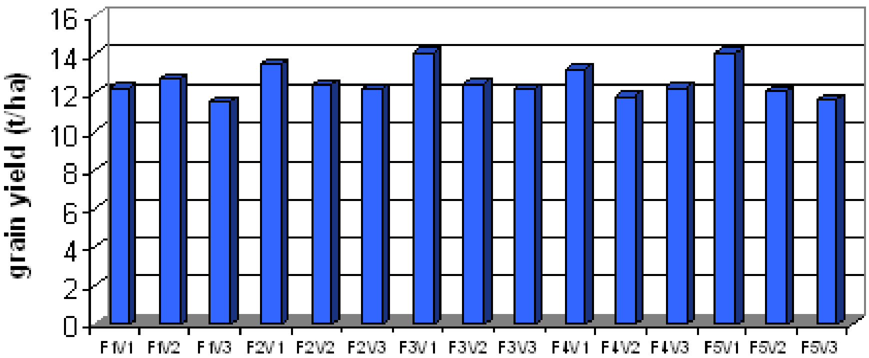

Fig. 3. Combined means comparison of interactions of biofertilizers and hybrids for grain yield

maturing cultivars could produce higher grain yield than early- and medium-maturity cultivars in order to preserve the suitable environmental and agronomical conditions. In another research, it was reported that late-maturing cultivars produced higher grain yield than early- and medium-maturity cultivars (Sarmadnia and Tahmasebi, 1993).

Sadeghi and Bahrani (2002) found that the increase in grain yield of each plant through applying higher nitrogen rate was due to the increase in grain number/ear. By applying higher pure nitrogen rate (from 138 and 184 to 230 kg/ha), Hamidi *et al*. (2000) observed maximum yield in corn.

Row number/ear

According to the results of variance analysis at the first planting date, it was clear that biofertilizers and hybrids × biofertilizers interactions did not have significant effects on row number/ear, but it was affected by hybrids at 1% probability (Table 1). Hybrids means comparison showed that SC704 produced the highest row number/ear (19.87) (Table 2). Means comparison of biofertilizers × hybrids by DMRT at the first planting date indicated that SC500 produced the highest row number/ear (19.87) (Table 3). According to the results of variance analysis at the second planting date, it was observed that row number/ear was affected by hybrids ($P < 0.01$) (Table 1). SC500 was the superior hybrid in producing the highest row number/ear (18.23) (Table 2). Also, means comparison of hybrids × biofertilizers interaction at the second planting date by DMRT showed that SC500 produced the highest row number/ear (18.72) in all applied biofertilizer levels (Table 3). Also, the results of combined variance analysis showed that planting date × biofertilizers interaction was not significant (Table 4). The results of means comparison showed that the highest row number/ear was attained from L1F3 (first planting date and standard biofertilizer dosage) treatment as 17.70, meanwhile L2F3 (second planting date and applied biofertilizer 25% more than standard dosage) treatment produced the lowest row number/ear as 15.89 (Table 6). Combined variance analysis indicated that row number/ear was affected by planting date × hybrids interaction at 1% probability (Table 4). The highest and lowest row numbers/ear were attained by L1V2 (first planting date and SC500) and L2V1 (second planting date and SC704) treatments, respectively (Table 5). Although hybrids × biofertilizers interaction was not significant (Table 4) but the highest row number/ear was belonged to F1V2 (standard biofertilizer and SC500) treatment, while the lowest

Table 5. Means comparison of interaction between planting dates × hybrids in two planting dates

Treatments	Grain yield	Rows/ear	Grains/row	Weight (g)	Total grains/ear
L1V1	12.75 b	722.1 ab	16.62 c	304.1 ab	43.48 b
L1V2	12.09 b	740.1 a	19.49.a	263.1 d	38 c
L1V3	12.13 b	619.3 c	16.23 c	285.5 bc	38.08 c
L2V1	14.17 a	724.1 ab	14.97 e	318.1 a	48.76 a
L2V2	12.61 b	694.5 b	18.23 b	280.5 cd	38.13 c
L2V3	11.88.b	590.9 c	15.44 d	310.4 a	38.25 c

Means with similar letters in each column are not significantly different.

Table 6. Means comparison composite interactions of planting date × biofertilizer

Treatments	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
L1F1	11.44b	17.65a	38.28b	675.8ab	245.4b
L1F2	12.70ab	17.34ab	40.74ab	704.0ab	285.2ab
L1F3	13.13a	17.70a	41.26ab	727.9a	300.5a
L1F4	12.08ab	17.55a	39.55ab	692.5ab	290.1a
L1F5	12.27ab	16.98bc	39.41b	669.0ab	300.1a
L2F1	13.00a	16.57cd	41.94ab	690.2ab	303.1a
L2F2	12.76ab	16.8de	43.31a	690.9ab	301.9a
L2F3	12.76ab	15.89e	40.45ab	640.5b	303.5a
L2F4	12.86ab	16.35de	40.97ab	655.6b	303.2a
L2F5	13.05a	16.18 de	41.89ab	672.0ab	303.3a

Means with similar letters in each column are not significantly different.

row number/ear was attained from F5V1 (combined biofertilizer level and SC704) treatment (Table 7). Furthermore, it can be observed that planting date × biofertilizer levels × hybrids interactions were not significant (Table 4). As it can be seen (Table 8), the highest and lowest treatments regarding row number/ear were belonged to L1F1V1 (first planting date, standard level of biofertilizer and SC500) and L2F5V1 (second planting date, combined biofertilizer level and SC704) treatments, respectively. Our results are consistent with the results of other researchers such as Sadeghi and Bahrani (2002), Ghasemi Pirbalouti *et al*., (2002) and Mokhtarpour (2002). It was reported that high plant density in maize made more competition among plants for photosynthetically active radiation (PAR) absorption and it would result in reduction in row number/ear and delayed silking date (Hashemi-Dezfouli and Herbert, 1992; Vatal, 1991). Roy and Biswas (1992) declared that by the increase in plant density from 75000 to 85000 plants/ha, row number/ear slightly decreased. SC500 with standard biofertilizer application produced the highest row number/ear.

Grain number/ row

Table 7. Means comparison composite interaction of hybrid × biofertilizer

Treatments	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
F1V1	12.28bc	16.08b	44.17a	705.4a	305.4abc
F1V2	12.78 abc	19.30a	38.25b	737.0a	252.7e
F1V3	11.60 c	15.96b	37.92b	606.6b	264.5e
F2V1	13.52 ab	15.55b	46.77a	725.2a	304.1abcd
F2V2	12.45 abc	18.66a	39.66b	736.1a	271.0de
F2V3	12.23 bc	15.91b	39.65b	631.0b	305.6abc
F3V1	14.5 a	15.93b	46.52a	739.6a	315.0ab
F3V2	12/51 abc	18.68a	37.41b	701.2a	281.9bcde
F3V3	12/22 bc	15.79b	38.63b	611.9b	309.2abc
F4V1	13/23 abc	15.95b	46.52a	726.2a	308.4abc
F4V2	11/87 bc	18.87a	37.01b	699.1a	279.1cde
F4V3	12/30 bc	16.03b	37.26b	596.9b	302.5abcd
F5V1	14/11 a	15.45b	46.61a	719.2a	322.8a
F5V2	12/14 bc	18.79a	37.98b	713.2a	274.2cde
F5V3	11/69 c	15.49b	37.37b	579.b	308.2abc

Means with similar letters in each column are not significantly different.

Table 8. Means comparison of interactions of planting dates × varieties × biofertilizers

Treatments	Grain yield	Grains/row	Rows/ear	Total grains/ear	1000-grain weight (g)
L1F1V1	10.66 f	39.72fghi	17.03fg	676.3bcde	298.2abcd
L1F1V2	12/24 abcdef	37.43hi	19.87a	743.5abc	218.1e
L1F1V3	11/42 def	37.70hi	16.05ghijkl	607.5efg	219.8e
L1F2V1	12/60 abcdef	43.96bcdef	16.25ghij	714.3abc	288.9abcd
L1F2V2	12/74 abcdef	38.17hi	19.36abc	738.7abc	269.5cd
L1F2V3	12/75 abcdef	40.09efghi	16.42ghi	659.0bcdef	297.1abcd
L1F3V1	14/31 abc	45.54abcd	16.98fg	771.6a	305.3abcd
L1F3V2	12/59 abcdef	38.40ghi	19.53abc	750.0ab	290.9abcd
L1F3V3	12/49 abcdef	39.84fghi	16.60gh	662.0bcdef	305.3abcd
L1F4V1	12/20 abcdef	43.32cdefg	16.64gh	721.2abc	298.2abcd
L1F4V2	11/73 bcdef	37.79hi	19.63ab	741.5abc	271.4cd
L1F4V3	12/30 abcdef	37.55hi	16.40ghi	614.9defg	300.8abcd
L1F5V1	13/97 abcd	44.85abcde	16.21ghijk	727.2abc	330.0a
L1F5V2	11/16 ef	38.18hi	19.04abcd	726.8abc	265.7d
L1F5V3	11/68 cdef	35.21i	15.69hijklmn	553.0g	304.6abcd
L2F1V1	13/91 abcd	48.62ab	15.12klmn	734.4abc	312.7abcd
L2F1V2	13/33 abcde	39.07fghi	18.72bcde	730.5abc	287.4abcd
L2F1V3	11/77 bcdef	38.15hi	15.87hijklm	605.8efg	309.1abcd
L2F2V1	14/43 a	49.58a	14.86mn	733.4abc	319.3abc
L2F2V2	12/15 abcdef	41.15defgh	17.97ef	603.0efg	272.5cd
L2F2V3	11/70 bcdef	39.20fghi	15.40ijklm	707.6abc	314.0abcd
L2F3V1	13/90 abcd	47.51abc	14.88mn	652.3cdef	324.7ab
L2F3V2	12/42 abcdef	36.42hi	17.83ef	561.7g	273.0bcd
L2F3V3	11/95 abcdef	37.42hi	14.97lmn	731.2abc	313.0abcd
L2F4V1	14/26 abc	49.72a	15.27jklmn	656.8bcdef	318.6abc
L2F4V2	12/02 abcdef	36.23hi	18.10de	578.8fg	286.8abcd
L2F4V3	12/30 abcdef	36.97hi	15.67hijklmn	711.2abc	304.3abcd
L2F5V1	14/33 ab	48.37ab	14.70n	699.6abcd	315.5abcd
L2F5V2	13/12 abcdef	37.98hi	18.54cde	605.2efg	282.7abcd
L2F5V3	11/70 bcdef	39.53fghi	15.30jklmn		311.8abcd

Means with similar letters in each column are not significantly different.

Variance analysis showed that biofertilizers and their interaction with hybrids at the first planting date were not significant, but grain number/row was affected by hybrids ($P < 0.01$) (Table 1). Also, it was noticed that the highest grain number/row was attained by SC704 (Table 2). The results of the second planting date were similar to the first planting date (Table 1). Also, the interaction of biofertilizers × hybrids showed that the highest and lowest grain number/row belonged to F4V1 (applied biofertilizer 25% less than standard dosage with SC704) and F4V2 (applied biofertilizer 25% less than standard dosage with SC500) treatments, respectively (Table 3). According to the combined variance analysis results of the two planting dates, it was observed that the interaction of biofertilizers × hybrids did not have significant effect on grain number/row (Table 4). Also, L2F3 (second planting date and standard biofertilizer dosage) and L1F1 (first planting date and control) treatments produced the highest and lowest grain number/row, respectively (Table 6). According to the combined variance analysis of the second planting date, it was observed that grain number/row was not affected by hybrids (Table 4). So, the highest and lowest grain numbers/row were obtained by SC704 and SC500, respectively (Table 4). As it can be seen (Table 4), grain number/row was affected by planting date × hybrids interaction ($P < 0.01$). The highest grain number/row was attained from L2V1 (second planting date and SC704) as 48.76 (Table 5) as well. Also, the interactions of biofertilizers × hybrids and planting dates × biofertilizers × hybrids were not significant for this trait (Table 4). Furthermore, it was recognized that F2V1 (standard biofertilizer dosage and SC704) produced the highest grain number/row (46.77) (Table 7). As it can be seen (Table 8), the interaction of planting dates × biofertilizers × hybrids showed the L2F4V1 (second planting date, applied biofertilizer 25% less than standard dosage and SC704) and L1F5V3 (first planting date, combined biofertilizer and SC260) treatments produced the highest and lowest grain number/row (49.72 and 35.21), respectively. Grain number/row in ear is one of the most important yield constituents which is slightly affected by environmental conditions (Sabindemetes and Pellrin, 1992). Also, linear reduction in grain number/row concurrently with plant density increment has been reported (Siadat and Shaigan, 1994). Also, it has been found that this trait is slightly affected by plant density and shadow rather than other grain yield components. The result of the current study showed that SC704 produced the highest grain number/row because of having bigger ear size which is consistent with previous researches.

Total grain number/ear

The results of variance analysis for the first planting date showed that the effect of bioferilizers and interaction of bioferilizers × hybrids on grain yield were not significant but this characteristic was affected by hybrids (Table 1). Also, means comparison of hybrids showed that SC500 and SC704 were in the same statistical group (740.1 and 722.1, respectively) (Table2). Also, means comparison of biofertilizers × hybrids interaction indicated that F3V1 (applied biofertilizer 25% more than standard dosage and SC704) and F5V3 (combined biofertilize level and SC260) treatments produced the highest and lowest grain yield, respectively (771.6 and 553 grain number/ear on average) (Table 3). The results of variance analysis of the second planting date showed that the effect of hybrids on grain number/ear was significant ($P < 0.01$), but bioferilizers and bioferilizers × hybrids interaction were not significant (Table 1). Means comparison of hybrids in the second planting date showed that SC704 and SC500 produced the highest grain number/ear and were in the same statistical group (Table 2). Furthermore, it was observed that F2V1 (standard biofertilizers level and SC704) and F5V3 (combined biofertilize level and SC206) treatments were in the highest and lowest statistical groups (Table 3). Based on the combined analysis results, it was observed that the effects of planting dates, different levels of biofertilizers and their interactions were not significant on this trait (Table 4). Also, means comparison of planting date × biofertilizers interaction showed that L1F3 (first planting date, applied biofertilizer 25% more than standard dosage) and L2F3 (second planting date, applied biofertilizer 25% more than standard dosage) treatments produced the highest and lowest total grain number/ear, respectively (Table 6). According to the combined variance analysis, this characteristic was affected by hybrids ($P < 0.01$) (Table 4). As it can be seen, the highest and lowest total grain number/ear belonged to SC704 and SC260, respectively. Means comparison of planting date × hybrids interaction indicated that L1V1 (first planting date and SC500) treatment produced the highest total grain yield (Table 5). Interaction of hybrids × biofertilizers and also planting date × biofertilizers × hybrids interactions were not significant for total grain number/ear (Table 4). Furthermore, it was observed that through interaction of hybrids × biofertilizers, F3V1 (applied biofertilizer 25% more than standard dosage and SC704) and F5V3 (combined biofertilize level and SC206) treatments produced the highest and lowest total grain yield/ear (Table 7).

Means comparison of planting date × hybrids × biofertilizers interactions showed that the highest total grain yield/ear belonged to L1F3V1 (first planting date, applied biofertilizer 25% more than standard dosage and SC704 hybrid) treatment (Table 8). Also, it has been noticed that corn ear weight reduction had been occurred because of plant density increments which is in agreement with our results (Dungan, 1974).

Also, based on hybrids × biofertilizers × planting date interactions, it was observed that total grain yield/ear had been affected by SC704 in the first planting date.

Thousand-grain weight

Thousand-grain weight is one of the most important yield components that has a significant effect on grain yield. This characteristic depends on four factors, i.e. grain filling period, active leaf number at reproductive stage, leaf area and stem dry weight (Kouchaki and Banaian, 1994). Results of variance analysis from the first planting date showed that the effect of hybrids on 1000-grain weight was significant but the effects of bioferilizers and interaction of bioferilizers × hybrids were not significant on this trait (Table 1). Hybrids means comparison showed that SC704 was in the highest statistical level (304.2 g on average) (Table 2). Means comparison of biofertilizers × hybrids interaction revealed that F5V1 (combined biofertilizer level and SC704) and F5V2 (combined biofertilizer level and SC500) treatments were in the lowest statistical group (330.1 and 265.7 g in average, respectively) (Table 3). Also, the results of variance analysis of the second planting date were similar to the first planting date in this sense (Table 1). Means comparison of the hybrids showed the SC704 was in the highest statistical group (318.2 gr on average) (Table 2). As it can be seen (Table 3), F3V1 (applied biofertilizer 25% more than standard dosage and SC704) and F5V2 (combined biofertilizer level and SC500) treatments were in the highest and lowest statistical groups, respectively. Results of combined variance analysis indicated that 1000-grain weight was affected by the two planting dates ($P < 0.05$), but it was not affected by planting date × biofertilizers interaction (Table 4). Also, it was found that the effects of hybrids on this trait was significant ($P < 0.01$). In addition, the highest and lowest 1000-grain weights were attained by SC704 and SC500, respectively (311.1 and 271.8 g) (Table 4). Planting date × hybrids interaction was not significant but means comparison showed L2V1 (second planting date and SC704) and L1V2 (first planting date and SC500) treatments produced the highest and lowest 1000-grain weight (318.1 and 263.1 gr on average), respectively (Table 5).

Biofertilizers × hybrids interaction was not significant and it was observed that F5V1 (combined biofertilizer level and SC704) treatment was in the highest statistical group (Table 7). Furthermore, planting date × biofertilizers × hybrids interactions were not significant for 1000-grain weight. It was observed that L1F5V1 (first planting date, combined biofertilize level and SC704) and L1F1V2 (first planting date, control biofertilize level and SC500) treatments produced the highest and lowest 1000-grain weight (330 and 218.1 g on average), respectively (Table 8). The results indicated that 1000-grain weight change can be due to various reasons such as different plant densities. It has been reported that 1000-grain weight would be decreased significantly by the increase in plant density (Hashemi-Dezfouli *et al*., 2001). The highest 1000-grain weight in SC704 (at the second planting date by using combined biofertilizer level) can be related to the longer growth period, higher leaf number and higher active leaf accompanied with using growth regulators and micronutrients, specially at reproductive stage. These findings are consistent with Mostafavirad and Tahmasebi-Sarvestani (2006).

References

Carlone, M.R and W.A. Russel. 1987. Response to plant densities and nitrogen levels for four maize cultivars from different eras of breeding. Crop Science, Madison, 27(2): 465-470.

Colvile, W.L. 1962. Influence of rate and method of planting on several components of irrigated corn yield. Agron. J. 24: 247-300.

Dasilva, P.R.F., G. Argenta and F. Rezera. 1999. Response of irrigated corn hybrids to plant density in three sowing dates, literature update on maize, CIMMYT. 5(4): 5

Dungan, G.H. 1974. Yield bushel weight of corn grain as influenced by time of planting. Agron.j.36:166-170.

Dwyer, L., M. Tollenaar and D.W. Stewardt. 1991. Changes in plant density dependence of leaf photosynthesis of maize (*Zea mays* L.) hybrids, 1959 to 1988. Canadian Journal of Plant Science, Ottawa, 71(1): 1-11.

Fotouhi, R., M. Rafiei, S. Noormoharmmadi, H. Mohseni, M.R. Ramezanpouur and A. Dehestani. 2006. Evaluation of low irrigation at vegetative growth stage and foliar application of micronutrients on yield and yield components and enrichment of corn yield. The 9th Iranian Crop Sciences Congress, Tehran Univ.

Ganjeh, R. 1998. Evaluation and determination of plant density on late-maturing maizes in Damghan region. The 5th Iranian Crop Sciences Congress, Karaj, Iran.

Ghasemi-Pirbalouti, A., G.H. Akbari, M. Nasiri-Mahalati and H. Sadeghi. 2002. Evaluation of the effect of different rates of Nitrogen on dry matter accumulation and corn growth traits. The 7th Iranian Crop Sciences Congress, Karaj, Iran.

Hamidi, A., N. Khodabandeh and A.D. Mohammadinsab. 2000. Evaluation of grain yield and its constituents, Biomass and Harvest Index of two hybrids of Maize under different plant densities and nitrogen rates. Aronomy Magazine.10 (1).

Hashemi-Dezfuli, A. and S.J. Herbert. 1992. Intensifying plant density response of corn with artificial shade. Agron. J. 84:547-551.

Hashemi-Dezfuli, A., K.H. Alami, S.A. Siadat and M.R. Komeili. 2001. Effect of planting date on two Sweet corn potential yield in Khoozestan climate, Iran Agricultural Science Magazine. 32(4):681-689.

Kouchaki, A. and M. Banaian. 1994. Yield Physiology in crops. Jihad-e- Daneshgahi of Mashhad Pub.

Lisuma, J.B., J.M.R. Semoka and E. Semu. 2006. Maize yield response and nutrient uptake after micronutrient application on a volcanic soil. Agron. J.83:559-564

Mohseni, M., H. Kazemi, M. Valizadeh and K. Ghasemi-Goladani. 2000. The effects of plant density on single-crosses maize hybrid 704 and 604. The 6th Iranian Crop Sciences Congress, Baboulsar- Iran.

Mokhtarpour, H., 2002. The effect of sowing date and plant density on ear yield and some agronomical traits of sweet corn. The 7th Iranian Crop Sciences Congress. Karaj, Iran.

Mostafavirad, M. and Z. Tahmasebi-Sarvestani. 2006. Agricultural and Natural Resources Science Journal. 13(6).

Noormohammadi, Q., S.E. Siadat and E. Kashani. 1997. Agronomy. Shahid Chamran University of Ahvaz. vol 1.

Özer, H., E. Oral and Ü. Doðru. 1999. Relationships between yield and yield components on currently improved spring rapeseed cultivars. Tur. J. Agriculture and Foresty, 23:603-607.

Robson, A.D., J.F. Loneragan, W. Gartrell and K. Sonwball. 1984. Diagnosis of copper deficiency in wheat by plant analysis .Australian Journal of Agricultural Research, 35:374-358.

Roy, S.K. and P.K. Biswas. 1992. Effect of plant density and detopping fallowing silking on cob growth. Fodder and grain yield of maize .J.Agri.Sci (Camb).119:297-301

Russel, W.A. 1991. Genetic improvement of maize yields. Advances in Agronomy, San Diego, 46(1):245-298,

Sabindemetes, M. and S. Pellrin. 1992. Effect of mutual shading on the emergence of nodal and root /shoot ratio of maize. Plant and Soil. 147:87-93

Sadeghi, H. and M. Bahrani. 2000. The effect of plant density and nitrogen rates on grain yield, yield components and grains protein in corn. The 6th Iranian Crop Sciences Congress, Karaj- Iran.

Sadeghi, H. and M. Bahrani. 2002. The relations of physiological traits to corn yield under plant density and nitrogen rates, The 7th Iranian Crop Sciences Congress, Karaj, Iran.

Sajedi, N.E. 2004. Evaluation of different rates of N, Fe and Zn on qualitative and quantitative traits of single-cross maize hybrid 704 in Markazi province, Iran. M.Sc. Thesis. Boroujerd Islamic Azad Univ. 227.

Sarmadnia, G.H. and Z. Tahmasebi. 1993. The effect of planting date on grain yield and yield components of different corn cultivars. The 1st Iranian Crop Sciences Congress, Karaj, Iran.

Siadat, E., A. Shaigan. 1994. Grain yield comparison and some agronomic traits summer corn in different planting date in Khoozestan. Agr. Sci. J. Shahid chamran Univ. 17: 75-91.

Slaton, N.A., R.J. Norman and J.C.E. Wilson. 2005. Effect of Zinc source and application time on Zinc uptake and grain yield of flood–irrigated rice. Agron.J.97:272-278

Tollenaar, M., D.E. Mccullough and L.M. Dwyer. 1994. Physiological basis of the genetic improvement of corn. In: Slafer, G. A. (Ed), p. 183-236.

Vatal, W. 1991. Responses of maize to plant population density. Agron. J.11:930-935