African Journal of Biotechnology Vol. 11(37), pp. 9007-9012, 8 May, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.3175
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Response of S.C.704 maize hybrid seed production to planting pattern

M. Sharafizadeh[1], M. R. EnayatGholizadeh[2]*, N. Aryannia[2] and M. Razaz[2]

[1]Safiabad Research Center, Dezful, Iran.
[2]Department of Agronomy and Plant Breeding, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran.

Accepted 10 April, 2012

In order to determine the best planting pattern for producing the S.C.704 hybrid seed of maize, a field experiment was conducted in 2007 at Safiabad Dezful Research Center via a complete block design with four treatments and replicates each. The treatments were: D1 (one row each of paternal and maternal lines), D2 (two rows of paternal line and one row of maternal line), D3 (two rows each of paternal and maternal lines) and D4 (one row of paternal line and two rows of maternal line). The result indicates that planting pattern has a significant effect on most of the characteristics of corn studied. Ear weight, seed weight on ear (maximum 97 g), ear weight ratio, seed weight, cob weight ratio (maximum 66%) and grain yield increased with differences from one row planting pattern to two row planting pattern. So, varying the planting pattern from one-row pattern to two-row pattern increased some of the characteristics, though there were no significant differences between one and two-row planting patterns. The fourth treatment (one row of paternal line and two rows of maternal line planting pattern) was the best on grain yield (2,753 kg/ha).

Key words: Planting pattern, seed produce, corn grain, S.C.704 hybrid.

INTRODUCTION

Corn is one of the valuable agricultural plants whose diversity, high adaptability and great nutritional value make it one of the most important agricultural plants in the world, such that it is in the third rank after wheat and rice (Imam, 2007). Though the quantity of corn grain used inside our country is about 4 million tons, domestic production is just about 2.6 million tons per year (Anonymous, 2006). Thus, the development and spread of this exceptional product is very important. The development of under-planted areas poses so many problems because of the restrictions on the use of soil and water resources. Therefore, the best acceptable solution for achieving self-sufficiency in corn production and subsequently economic self-sufficiency is increasing yield per surface unit. The under-planted area of corn grain in Khuzestan province is about 80,000 ha now. Increasing the under-plated area to 120,000 ha is expected since “Karkheh Dam” has come into existence; this will produce about 2,400 to 3,000 tons of hybrid seed. In addition, there is the need to do several researches in optimum exploitation of seed producing areas so as to increase the production of seed.Increasing agricultural crops production is possible by increasing planting surface and yield in square units. In spite of natural resource (soil, water, etc.) limitations, there is the need to increase yield in square units; this is the main purpose of agriculture. By using modified cultivar, preparing desired bed, choosing date and appropriate planting patterns, agricultural fallow units can lead to efficiency in the increase of crop yield in square meters (Khajepoor, 2000). One of the main factors in agricultural plants production is the amount of solar radiation that penetrates through the canopy (Daughtry et al., 1983). The efficiency of photosynthesis and crop maturity depends extensively on vertical light distribution to the canopy (Williams et al., 1968) and also, photosynthetic yield depends extensively on leaf area index (Pearce and Blaser, 1965). Again, grain yield in corn has a close relationship with leaf area index and canopy (Williams et al., 1968). Hunter(1980) reported that larger leaf surface

*Corresponding author. E-mail: Enayat_mohamad@yahoo.com.

Table 1. Physicochemical traits of the soil of the field used in the experiment.

Physicochemical trait	Value
EC (m mho/cm)	1.2
pH	8
Total N (mg/kg)	3.32
P (mg/kg)	10
K (mg/kg)	150
OC (%)	1
Soil type	Clay loam

EC, Electrical conductivity; N, nitrogen; P, phosphorus; K, potassium; OC, organic carbon.

in plants leads to more assimilation in them, thereby increasing yield. Leaf area index increases yield in two ways: increase in the reformation of leaf surface in plants and increase in plant density. Planting pattern within a certain density is important, so the width of the planting row and the distance of plants on the lines are two factors which should be considered simultaneously. Planting patterns with geometric conditions can be changed by changing the width of the row and the distance between plants in the row. The wider the rows, the more the seeds that are planted until a certain density is reached (Sarmadnia and Koochaki, 1993). Theoretically, those plants which have a square-like pattern use resources more efficiently than those with a rectangular pattern. Duncan (1984) remarked that maximum performance in any density is obtained when the planting pattern is hexagonal. Through double-space planting of corn, there may be a possibility of increasing the density from 100,000 to 150,000 plants/ha more than the recommended densities, for plants to have an appropriate and desirable distribution. In the absence of 10 to 15% of seeds which lack viability, adjacent plants that have better light and nutrition can produce a higher yield (four and five). Zamaani (1993) reported that when rows are planted in a twin-row pattern per stack, more densities can be planted uniformly, and maximum crop yield would be obtained. In such a situation, competition between plants for light, moisture and food would decrease and plants will have a wider space for growth (Zamani, 1993). Narrower rows can increase light absorption and seed yield, decrease evapo-transpiration and subsequently lead to an increase in water-use-efficiency indirectly. Although water consumption does not change significantly, seed yield increases considerably per unit of water (Kord, 1996). Karlen and Camp (1985) reported that by using equal planting space in twin-row planting pattern as against single-row planting in 1980, 1981 and 1982, the yield increased by 630, 520 and 760 kg/ha, respectively. However, there was no meaningful difference between ears of corn per plant, weight of corn and weight of grains. Bullock et al. (1988) opined that in square-like patterns, compared to general patterns, the yield is high due to better enjoyment of the environment by plants, and decrease of competition (Bullock et al., 2002). Barzegari (2002) reported that the planting pattern of one stack in two rows has the maximum yield of seed per surface unit in the North of Khuzestan province. Kim and Chung (1988) and Stewart (2000) reported that when planting pattern is two-row-like, its yield is more than that of single-row pattern (22 and 25). Aryannia et al. (2011) showed that 6:2 planting pattern, from the point of view of grain yield uniformity and production costs, was better than 4:2 planting pattern, and also, by increasing the density of grain yield, the highest yield for the interaction of the highest densities (90,000 plants) and the highest number of maternal lines (six maternal lines) was increased. In accordance with the reviewed cases, this study is done to determine the best planting pattern for producing a hybrid seed of corn.

MATERIALS AND METHODS

The test for this study was done in the format of randomized complete block design with four treatments and replicates each (different planting patterns) on the farm of Agricultural Research Center of Safi-Abad, Dezful, which is at 48°C and 25 min of east longitude, 32°C and 16 min of north latitude, and with an average altitude of 82 m above sea level by the farming soil profile.

Climatically, the area under study is considered as a part of hot and dry region, and has long hot summers, such that in some years, the temperature may reach 50°C above zero in July and August. Average annual rainfall in this region is 279 mm, which is mainly recorded at the end of autumn and winter. The maximum of average annual temperature in August is 48.4°C, while the minimum in July is 4.2°C. In this study, the density of plants is considered to be consistent and equal to 89,000 plants/ha. To determine physical and chemical soil characteristics after choosing the place of test operation before any land preparation, operations on samples from 0 to 30 cm land depth on a 10 point sampling was randomly performed. Obtained result of soil deposition in soil laboratory is expressed in Table 1. Test treatments are:

D1: The ratio of maternal lines to paternal lines was 4:2 which means that just one line each of the mentioned parents and the control treatment was planted as usual on every stack.

D2: The ratio of maternal lines was 4:2 which was just on the paternal lines; two lines of seed were planted instead of one line.

D3: The ratio of maternal lines to paternal lines was 4:2 which indicates that on the maternal and paternal stacks, twin rows of seed were planted.

D4: The ratio of maternal lines to paternal lines was 4:2 that is, in this method twin rows of seed were planted on the stack instead of one row on the maternal lines.

The spacing between two plants in the twin-row planting pattern was considered to be two times greater than the usual spacing.

Ammonium phosphate fertilizer of 300 kg/ha, total nitrogen of 50% (pure nitrogen of 240 kg/ha including N-ammonium phosphate as base nitrogen) and 240 kg/ha of potassium sulfate were sprinkled by hand on the farm separately and consistently. Then, they were mixed together to the depth of about 15 to 20 cm of surface soil by a disk after which they were buried to a depth of about 10 to 30 cm in the soil by a moldboard plow. The spacing between stacks was 75 cm and the space between seeds in every planting row of the maternal lines was 15 cm, while that of the paternal lines was 10 cm. In the twin-row planting pattern, seeds were planted in twin-row patterns for every stack, with a spacing of 30 and 20 cm in maternal

Table 2. Analysis of variance (mean squares) of morphological characteristics and yield component.

S. O. V	df	Ear length	Ratio of grain weight to ear weight	Cob wood weight	Grain weight per ear
Planting pattern	3	1.53^{ns}	7.55*	0.83^{ns}	4.36^{ns}
Block	2	0.22^{ns}	0.32^{ns}	0.12^{ns}	0.31^{ns}
Error	6	0.0455	0.00018	26.527	91.250

ns, Non significant; df, degree of freedom; *respectively significant ($P \leq 0.05$).

Table 3. Analysis of variance (mean squares) of yield component.

S. O. V	df	Grain yield (kg/ha)	Row per ear	Grain per row	Grain per ear	Thousand-grain weight (g)
Planting pattern	3	4.89*	0.3^{ns}	1.25^{ns}	2.16^{ns}	1.97^{ns}
Block	2	0.18^{ns}	0.53^{ns}	0.29^{ns}	0.14^{ns}	0.35^{ns}
Error	6	240359.47	0.498	5.143	1227.63	224.608

ns, Non significant; df, degree of freedom

and paternal lines, respectively. Lines were irrigated after they had been planted. The paternal and maternal parents were irrigated at different times to observe the occurrence and emergence of silkworms, male flowers and pollination. To do this, first, all the maternal lines were irrigated, then after 48 h, when the tip of coleoptiles were out of soil, the first paternal line was irrigated, while the second paternal line was irrigated after 48 h. They were irrigated once a week until the stage of maturity. After harvesting operations and transfer of the samples to seed control and certification at the laboratory of the research center of Safi-Abad, features such as weight of ear wood, diameter of ear, weight of grain on ear, number of grains on ear, number of grain rows on ear, number of grains in each row, number of grains per square meter, ratio of grain weight to ear, ratio of grain weight to ear wood, ear length, grain weight and grain yield were measured. Analysis of variance and other statistical calculations were done using Statistical Analysis System (SAS) and Statistical Package for the Social Sciences (SPSS) softwares. The average comparison of features was done by using Duncan test. Then, the correlation coefficients of all the features which were studied by the aforenamed softwares were calculated.

RESULTS AND DISCUSSION

The ear length

A study of the results obtained in the table of analysis of variance (Table 2) show that there was no meaningful difference between the four planting patterns in terms of the feature ear length. Also, there was no considerable difference in the mentioned feature when the averages were compared via Duncan method (Table 4). However, the maximum ear length (20.2 cm) was observed in relation to the second treatment, while the minimum ear length (19.9 cm) was observed in relation to the fourth treatment (Table 4). Akbari (1991) and Pouryousef (2003) reported the same results, however, Bankehsaz (1999), Bazrafshan (2005) and Aasgarirad (2003) reported dissimilar results. These contradictions exist probably because of different reasons like difference in statistics, weather conditions, etc. (Sadiqzadeh et al., 2002; Maraashi et al., 2007).

The ratio of grain weight to ear

The results obtained in the table of analysis of variance (Table 2) show that there was a meaningful difference in terms of the ratio of grain weight to ear. In comparing the averages of treatments, there was a considerable difference in the named feature, such that the maximum grain weight ratio to ear weight was equal to 66% with regard to the second treatment (two rows of paternal line and one row of maternal line), while the minimum was equal to 61% with regard to the first treatment (one row each of paternal and maternal lines) (Table 4). The possible reason for this was that in the second treatment (two rows of paternal line and one row of maternal line of each stack), the produced pollens were more, and that led to increase in the insemination power of pollens which consequently increased the fertility rate and filling up of ears (preventing a form of ear baldness) as well as the transfer of photosynthetic substances towards the grain.

One thousand seed weight

The results of the analysis of variance (Table 3) show that there was no meaningful difference between treatments with respect to this feature. Also, by comparing the means, we observed that in relation to the named feature, there was no meaningful difference between treatments (Table 5). However, the maximum ear weight of about 294 g was obtained with the first treatment (planting one row each of paternal and maternal lines), while the minimum ear weight of 276 g was obtained from

Table 4. Mean comparison of morphological characteristics and yield component.

Treatment	Grain yield (kg/ha)	Cob weight (g)	Grain weight per ear (g)	Ear length (cm)	Ear diameter (cm)	Ratio of grain weight to ear weight
D_1	1270.00[b]	45.60[a]	73.00[b]	20.10[a]	51.30[a]	0.61[b]
D_2	2480.00[a]	50.00[a]	97.00[a]	20.00[a]	52.40[a]	0.66[a]
D_3	2200.00[ab]	49.70[a]	96.00[a]	20.20[a]	52.00[a]	0.65[a]
D_4	2753.00[a]	52.40[a]	97.00[a]	19.90[a]	52.00[a]	0.64[a]

Means followed by the same letters in each column are not significantly different when Duncan multiple range test at 5% probability level is used.

Table 5. Mean comparison of yield component.

Treatment	Grain yield (kg/ha)	Grain per m^2	Row per ear	Grain per row	Grain per ear	Thousand-grain weight (g)
D_1	1270.00[b]	3640[a]	17.8[a]	23.2[a]	409[a]	294[a]
D_2	2480.00[a]	3628[a]	18.1[a]	22.7[a]	408[a]	265[a]
D_3	2200.00[ab]	3705[a]	17.8[a]	23[a]	416[a]	278[a]
D_4	2753.00[a]	3133[a]	17.4[a]	20.2[a]	352[a]	277[a]

Means followed by the same letters in each column are not significantly different when Duncan multiple range test at 5% probability level is used.

the fourth treatment (one row of paternal line and two rows of maternal line). Karlen and Camp (1985) and Akbari (1991) reported the same results, while Asgarirad (2003), Glenn and Daynard (1997) and Nasiri (1999) reported dissimilar results. The characteristic grain weight is greatly influenced by environmental conditions and this explains the existing similarities and contradictions.

Number of grains per row

The results in the table of analysis of variance (Table 3) show that there was no meaningful difference between treatments with respect to the named characteristic. It was observed that by comparing the means, there was no considerable difference between treatments in view of the aforementioned characteristic (Table 5). It was observed that the maximum number of grains per row was 23 with regard to the third treatment (two rows each of paternal and maternal lines of each stack), while the minimum was 20 with regard to the fourth treatment (one row of paternal line and two rows of maternal line). Zamani and Akbari (1991), Bankehsaz (2002), Asgarirad (2003) and Nasiri (1999) reported dissimilar results. The number of grains per row is greatly influenced by test conditions.

The competition rate between plants increased due to alternations in planting patterns, therefore so many differences with respect to the number of grains per row were observed.

Number of grains per ear

The results in the table of the analysis of variance (Table 3) show that there was no meaningful difference between the planting treatments in terms of the number of grains per ear. Again, there was no meaningful difference between treatments when the means were compared (Table 5). However, the maximum number of grain per ear (416) was obtained with regard to the third treatment (two rows each of paternal and maternal lines of each stack), while the minimum (352) was obtained with regard to the fourth treatment (single row planting of paternal lines, and twin row planting of maternal lines). Nielson (1999), Stewart (2000) and Asgarirad (2003) reported similar results, while Nasiri (1999) and Akbari (1991) reported dissimilar results. This difference may be because of the difference in treatments or factors affecting the test, like increase in the efficiency of light consumption in the twin row planting pattern of the corn (Yadavi et al., 2008).

Grain yield

The results in the table of the analysis of variance (Table 3) show that there was a meaningful difference between different planting patterns by comparing the means of grain yield in the different treatments (Table 5). The maximum grain yield of 2,753 kg/ha was obtained in the fourth treatment (single row planting pattern of paternal lines and twin row planting pattern of maternal lines), while the minimum (1270 kg/ha) was obtained in the first treatment (one row planting pattern of paternal and maternal lines). The reason for this was that the competition between the plants for light, moisture and nutrition decreased, and plants had a wider space for root development and growth. In addition, solar energy efficiency increased in leaves due to more absorption of

Table 6. Correlation matrix of yield components in different planting patterns.

Treatment block	Cob wood weight	Cob weight	Grain weight per ear	Grain weight/cob weight	Ratio of grain weight to ear weight	Grain yield	Ear length	Ear diameter	Row per ear	Grain per m^2	Thousand-grain weight (g)	Grain per ear
Cob wood weight	1	-	-	-	-	-	-	-	-	-	-	-
Cob weight	0.0003**	1	-	-	-	-	-	-	-	-	-	-
Grain weight per ear	0.0036**	0.0001**	1	-	-	-	-	-	-	-	-	-
Grain weight/cob weight	0.03754^{ns}	0.00091**	0.0010**	1	-	-	-	-	-	-	-	-
Ratio of grain weight to ear weight	0.3266^{ns}	0.0072**	0.0008**	0.00001**	1	-	-	-	-	-	-	-
Grain yield	0.1908^{ns}	0.0329*	0.0214*	0.0285*	0.0124*	1	-	-	-	-	-	-
Ear length	0.8767^{ns}	0.9897^{ns}	0.9690^{ns}	0.9811^{ns}	0.8795^{ns}	0.3552^{ns}	1	-	-	-	-	-
Ear diameter	0.4736^{ns}	0.4100^{ns}	0.4187^{ns}	0.4571^{ns}	0.6559^{ns}	0.8621^{ns}	0.6321^{ns}	1	-	-	-	-
Row per ear	0.5144^{ns}	0.4795^{ns}	0.4958^{ns}	0.5623^{ns}	0.7764^{ns}	0.9696^{ns}	0.5916^{ns}	0.0001**	1	-	-	-
Grain per m^2	0.7104^{ns}	0.9805^{ns}	0.8696^{ns}	0.5670^{ns}	0.4449^{ns}	0.0926^{ns}	0.3761^{ns}	0.7395^{ns}	0.7187^{ns}	1	-	-
Grain per row	0.2056^{ns}	0.2925^{ns}	0.3633^{ns}	0.5754^{ns}	0.6109^{ns}	0.1146^{ns}	0.6307^{ns}	0.3886^{ns}	0.5019^{ns}	0.9974^{ns}	1	-
Thousand grain weight	0.6603^{ns}	0.6952^{ns}	0.5033^{ns}	0.0788^{ns}	0.0580^{ns}	0.1140^{ns}	0.5067^{ns}	0.8013^{ns}	0.6890^{ns}	0.3029^{ns}	0.4648^{ns}	-
Grain per ear	0.3413^{ns}	0.4078^{ns}	0.4652^{ns}	0.6306^{ns}	0.6144^{ns}	0.2143^{ns}	0.4249^{ns}	0.8341^{ns}	0.7008^{ns}	0.5787^{ns}	0.0001	1

Ns, Non significant, * and **Respectively significant ($P \leq 0.05$) and highly significant ($P \leq 0.01$).

radiation. Cook and Rossman (1966), Pouryousef (2003), Asgarirad (2003), Bankehsaz (2002) and Nasiri (1999) reported similar results, while Buehring (2002) and Akbari (1991) reported different results. The increase in seed yield in D4 treatment may be due to more reception of light resulting from the suitability of the planting pattern per unit area which made the crop growth rate and grain yield to increase. The correlation coefficients of the studied characteristics and obtained results indicate that the ear diameter had a correlation of 99% with the number of ears per row (Table 6). The number of grains per row had a correlation of 90% with the number of grains per ear. The weight of ear wood had correlations of 87 and 77% with the features of ear weight and weight of grain per ear respectively. There were high correlations between the ratio of grain weight to ear weight with ear weight characteristics (71%), grain weight per ear (82%), grain weight ratio to the ear (98%) and seed yield (63%). Also, there were high correlations between the ratio of grain weight to ear weight with ear weight characteristics (72%), grain weight per ear (83%), grain weight ratio to the ear (98%) and seed yield (69%). Grain weight had 77% correlation with grain weight per ear characteristic, 98% correlation with ear weight characteristic, 83 and 82% correlations with grain weight ratio to ear weight and grain weight ratio to the ear wood, respectively, and 65% correlation with the grain yield. Ear weight had a correlation of 87% with the ear wood weight characteristic, 98% correlation with grain weight per ear, 72 and 71% correlations with grain weight ratio to the ear weight and grain weight ratio to the ear wood, respectively, and 62% correlation with the seed yield characteristic. Seed yield had correlations of 69 and 63% with grain weight ratio to the ear weight and grain weight ratio to the ear wood, respectively. This characteristic (seed yield) had correlations of 62% with the cob wood weight characteristic and 65% correlation with the grain weight per ear too.

Conclusion

The results obtained from this study show that the fourth treatment (single row of each stack for paternal lines and twin rows of each stack for maternal lines) had the most meaningful effect on the yield of the corn hybrid used for the study. Some of the characteristics which we studied like ear weight, grain weight ratio to the ear weight, grain weight per ear and grain weight ratio to the ear wood increased meaningfully by shifting the planting pattern from single-row to twin rows.

Thus, yield per unit area can be increased by changing the single-row planting pattern (of both paternal and maternal lines) which is the current planting pattern for seed production in the region to twin-row planting pattern (planting one row of paternal line and two rows of maternal line of every stack), thereby increasing the number of maternal lines planted in the area.

REFERENCES

Agricultural statistics book of ministry of Agricultural Jihad (2006).

Akbari G (1991). Studying the effects of plant density and planting patternon the corn's growth, yield and yield components in Isfahan. MA thesis. Isfahan University of Technology.

Aryannia N, Alamisaeed KhMR, Enayat G (2011). Effects of plant density and the ratio of maternal lines on producing seed Corn hybrid S.C.704 in the Khuzestan state of Iran. Adv. Environ. Biol. 5(7): 1811-1820.

Asgarirad M (2003). Studying the planting pattern and planting density on the yield and yield components in the medium-range single cross hybrid corn 647. MA thesis. Agriculture College of Karaj, Tehran University.

BankehSaz A (1999). Guidelines for twin-row planting of corn. Seed and Seedling's research, breeding and preparation Institute. The ministry of agricultural Jihad.

Bankehsaz A (2002). Evaluation of dry matter re-transforming in twin-row planting pattern of corn under the influence of nitrogen fertilizer density. Seed and seedling's research, breeding and preparation institute, the ministry of Agricultural Jihad.

Barzegari M (2002). Studying and comparing the planting pattern and density on the corn's yield in the north of Khuzestan. The report of agricultural research center's press. Dezful, Safiabad.

Bazrafshan F, Fathi Gh, Siadat A, Ayenehband A, AslamiSaeid Kh (2005). Studing the effects of planting pattern and plant density on the sweet corn's yield and yield components. Sci. J. Agric. 28(2): 117-126.

Buehring NW, Harison MP (2002). Corn response to twin and narrow rows with selected seeding rate. Agric. Expt. Stat. Info 386: 30-33.

Bullock DJ, Nielson RL, Nyluist WE (1998). A growth analysis comparison of corn in conventional and equidistant plant Spacing. 8:73-79.

Daughtry CSTKP, Gallo ME, Bauer (1983). Spectral estimates of solar radiation intercepted by Corn canopies. Agron. J. 75: 527-531.

Duncan WG (1984). A theory to explain the relationship between corn population and grain yield. Crop Sci. 24(6): 1141-1195.

Glenn FB, Daynard TB (1973). Effect of genotype, planting pattern and density on plant – to plant Variability and grain yield of Corn. Plant Sci. 54: 323-30.

Hunter ROB (1980). Increased leaf area (Source) and yield of maize in short season areas. Crop Sci. 20: 571-574.

Imam Y (2007). Grain's Agronomy, Shiraz University publications.

Karlen DL, Camp CR (1985). Row spacing, plant population and water management, effect on corn in the Atlantic Castal.

Khajehpoor MR (2000). Principles and Fundamentals of Agronomy. Isfehan University of Technology press. Iran. p. 412

Kim Jg, Chung ES (1998). Effect of plant density on forage yield and quality of Corn. Grass Sci. 18(7): 49-54.

Kord H (1996). Studying the effect of planting method in two densities on the grain corn yield single cross 704, in the weather conditions of Ahvaz.

Mar'ashi K, Zakernejad S, Lak Sh, Siadat A (2007). Studying the different planting pattern and plant density in the yield and yield components of hybrid grain corn S.C704 in the weather conditions of Ahvaz. Scient.J. Agricult. Univ. Varamin., 16: 59-71.

Nielson RL (1999). Perspectives on narrow row spacing for Corn. Weed Sci. 42: 354-361.

Pearce RBRE, Blaser (1965). Relationship between leaf area index, light interception and net photosynthesis in orchard grass. Crop Sci. 5: 553-556.

Pouryusuf M (2003). The effect of planting pattern and planting density on the yield and its components in two kinds of hybrid corns. MA Thesis. Agriculture university of Karaj, Tehran University.

Rossman EC, Cook RL (1996). Soil pre parathion, planting date and pattern of planting. in, pierrcetal. Adv. Corn, Prod. 80: 53-101.

Sadiqzadeh Hemayati S, Siadat A, Sadiqzadeh Hemayati F, Valizadeh M, Fathi Gh (2002). Evaluation of mixed planting of two kinds of grain corn in different levels of density. The Scientific Journal of Agriculture. 25(1): 73-88.

Sarmadnia Gh, Kuchaki A (1993). Physiology of agricultural plants (translation). Univ. Jihad, Pub. Mashhad. pp. 397.

Stewart G (2000). Twin row results, Durham eastside university of Guelph sites. Average of 1996, 1998 and 1999.

Williams, W. A., R. S. Loomis., W. G. Duncan., A. Dovert., and F. Nunez. 1968. Canopy architecture at various population densities and the growth and grain of com. Crop Sci. 8: 303-308.

Yadavi A, Ghalavand A, Fallah S, Omidi H (2008). The effect of plant density and planting pattern on the growth indices of grain corn (*Zea mays* L.) under competition of red root tumbleweed (*Amaranthus retroflexus*). The summary of articles from the Tenth congress of Agriculture and plant breeding science of Iran, August 28-30, Karaj. p. 83.

Yadavi A, Ghalavand A, Fallah S, Omidi H (2008). The effect of plant density and corn plant pattern on the efficiency of canopy corn and tumbleweed's light consumption. The summary of articles from the Tenth congress of Agriculture and plant breeding science of Iran, August 28-30, Karaj.

Zamani G (1993). Studying the effect of the planting pattern and density on the yield and yield components of grain corn. MA Thesis. Agriculture College of Mashhad University.