Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 3 (4): 429-432, 2004
ISSN 1682-3974

The Effects of Intra-row Spacings on the Grain Yield and Some Agronomic Characteristics of Maize (*Zea mays* L.) Hybrids

Okan Sener, Huseyin Gozubenli, Omer Konuskan and Mehmet Kilinc
Department of Field Crops, Faculty of Agricultural, Mustafa Kemal University, Hatay/Turkey

Abstract: Maize hybrids react differently to various plant density and intra-row spacing. A two-year study was conducted at Mustafa Kemal University, Agricultural Faculty, Research Farm to determine the optimum intra-row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. The experimental design was a Randomized Complete Block in a split-plot arrangement with three replications. Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626. Split-plots were intra-row spacing of 10.0, 12.5, 15.0, 17.5 and 20.0 cm. Split-plot size was 2.8 by 5.0 m with four rows per plot. The effects of intra-row spacings on the grain yield and some agronomic characteristics were statistically significant. Hybrid x intra-row spacing interaction effects were significant only at ear length and grain yield. The highest grain yields were obtained from Pioneer 3223 and Dracma at 15.0 cm intra-row spacing (11718 and 11180 kg ha^{-1}, respectively).

Key words: Maize, hybrid, intra-row spacing, grain yield

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereals grown in most countries of the world. Thus, there have been many studies to determine the optimum plant density for maize. However, there is no single recommendation for all environmental factors as well as controlled factors such as soil fertility, hybrid selection, planting date and planting pattern[1].

Yield increases with increasing plant density up to a maximum for a corn genotype grown under a set of particular environmental and management conditions and declines when plant density is increased further[2].

Hybrids developed in recent years are able to withstand higher plant density levels than older hybrids[3] and newer hybrids have greater grain yield at higher plant densities than older hybrids[4]. The current hybrids were found to have decreased lodging frequencies at the higher plant populations. Also newer hybrids were able to better withstand environmental stress, resulting in production of fewer barren plants[5] .

Widdicombe and Thelen[6] reported that plant density had a significant effect on grain yield and the highest plant density level evaluated (90000 plant ha^{-1}) resulting in the highest grain yield may have been too low to establish the true plant density for maximum yield. Porter *et al.*[7] reported inconsistent optimal plant density levels ranging from 86000 to 101270 plants ha^{-1} for corn grain yield across three Minnesota locations. Larson and Clegg[8] found a full-season hybrid to produce maximum yield at 85000 plant ha^{-1} in Central and Eastern Nebraska. Farnham[9] determined that, corn grain yield increased from 10.1 to 10.8 t ha^{-1} as plant density increased from 59000 to 89000 plant ha^{-1}.

These studies indicated that optimum plant densities are different according to maize hybrids and locations.

The objective of this study was to characterize optimum intra-row spacing for maize hybrids commercially grown in Eastern Mediterranean Region of Turkey.

MATERIALS AND METHODS

Field experiments were conducted at Mustafa Kemal University, Agricultural Faculty research farm as a second crop of the year after wheat harvest during 2000 and 2001. The soil of experimental site was clay loam having a pH 7.7, with low concentration of available phosphorus (17.2 kg ha^{-1}) and low organic matter content (0.23%).

The experimental field was prepared after wheat harvest in June and corn seeds in these experiments were hand-planted with 70 cm inter-row spacing at 26 June in 2000 and at 22 June in 2001. N-P-K (90 kg ha^{-1}) was applied and mixed into soil before planting and N (180 kg ha^{-1}) was applied at knee-high stage as top dressing. Weed control and irrigation were done when necessary.

The experimental design was a Randomized Complete Block in a split-plot arrangement with three replications.

Corresponding Author: Okan Sener, Department of Field Crops, Faculty of Agricultural, Mustafa Kemal University, Hatay/Turkey Tel: 90 326 2455836 Fax: 90 326 2455832 E-mail: osener@mku.edu.tr

Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626. Split-plots were intra-row spacing of 10.0, 12.5, 15.0, 17.5 and 20.0 cm. Split-plot size was 2.8 m by 5.0 m with four rows per plot.

Grain yield (adjusted to 150 g kg^{-1} moisture) and yield components (tasseling period, plant height, stem diameter, ear length, ear diameter, grain weight ear^{-1}) were determined in the center two rows of each plot according to Ulger[10].

Data were analyzed using analysis of variance (ANOVA) technique and means were compared by using least significant difference (LSD) test.

RESULTS AND DISCUSSION

Tasseling period: Tasseling period was significantly varied among maize hybrids. Pioneer 3223 had the longest (57.8 day) tasseling period while Pioneer 3335 had the shortest (54.5 day) tasseling period (Table 1). Gozubenli[11] and Thiraporn *et al.*[12] reported that tasseling period was variable in maize and longer season cultivars took more time to reach tasseling and maturation than did the shorter season cultivars.

Present findings indicated that intra-row spacing did not significantly affect on tasseling period and mean tasseling period was 55.3 days (Table 1). However, tasseling periods were significantly affected by plant spacing in the studies of Konuskan[13] and Gokmen *et al.*[14]. Tasseling period was highly weather dependent and this might be expected since light energy and temperature are near optimum in Eastern Mediterranean.

Plant height: Plant height was significantly affected by maize hybrids and by intra-row spacing. The tallest plants were measured at Dekalb 626 in both years (Table 1). There is a considerable varietal variation in this characteristic, when the height of final plant is strongly influenced by environmental conditions during stem elongation[15]. Also, Gözübenli[11] and Konuskan[13] reported that there were varietal variations in plant height.

Results showed that there were differences among intra-row spacing in plant height. Plant height increased with decreases in intra-row spacing and the tallest plants were measured at 10.0 cm intra-row spacing (Table 1). Konuskan[13] found that plant height increased with increases in plant density up to 10 plant m^{-2}. Whereas, Turgut[16] reported there were no intra-row spacing effects on plant height.

Stem diameter: Maize hybrids and intra-row spacing significantly affected stem diameter. The highest stem diameter was determined at Dekalb 626 with 20.4 mm and the lowest one at Pioneer 32223 with 17.8 mm (Table 1). Considerable varietal variations have been observed in stem diameter by many researchers[11,13].

Stem diameter increased with the increasing intra-row spacing and the highest stem diameter (20.1 mm) was determined at 20.0 cm intra-row spacing and the lowest stem diameter (17.7 mm) was determined at 10.0 cm intra-row spacing (Table 1). Stem diameter is strongly influenced by environmental conditions during stem elongation. Some researchers reported that stem diameter were lower in higher plant densities as a consequence of interplant competitions[13,17].

Ear length: There were significant differences among maize hybrids and intra-row spacing in ear length. The longest ear (189.3 mm) was obtained from Dekalb 711 hybrid and the lowest one (153.0 mm) from Pioneer 3223 (Table 2).

Variations in ear characteristics of maize depend on genotype and environmental conditions. Konuskan[13] and Gozubenli *et al.*[11] reported that ear length was significantly affected by hybrids.

Table 1: Hybrid and intra-row spacing effects on tasseling period, plant height and stem diameter of maize in Hatay-Turkey

	Tasseling period (day)			Plant height (cm)			Stem diameter (mm)		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Hybrid									
Dracma	53.9	55.5	54.7	198.3	168.8	183.6	18.9	19.0	18.9
P.3223	56.9	58.8	57.8	200.9	191.9	196.4	17.9	17.8	17.8
P.3335	52.8	56.2	54.5	197.0	170.7	183.9	18.3	18.3	18.3
Dk.711	54.1	55.2	54.7	201.7	192.6	197.1	18.5	19.2	18.9
Dk.626	54.0	55.4	54.7	206.5	195.8	201.1	20.2	20.6	20.4
L.S.D.(%5)	1.47	N.S.	1.62	N.S.	11.3	6.5	1.33	N.S.	1.4
Intra-row Spacing									
10.0 cm	53.90	56.4	55.1	204.5	188.3	196.4	17.8	17.7	17.7
12.5 cm	53.70	56.5	55.1	203.7	185.0	194.4	18.2	18.2	18.2
15.0 cm	55.00	56.3	55.6	199.7	184.6	192.1	18.7	19.0	18.9
17.5 cm	55.00	56.2	55.6	198.5	183.1	190.8	19.1	19.8	19.5
20.0 cm	54.10	55.8	55.0	197.9	178.8	188.4	20.0	20.2	20.1
L.S.D. (%5)	N.S.	N.S.	N.S.	N.S.	5.0	4.3	0.93	1.1	0.64

Table 2: Hybrid and intra-row spacing effects on ear length, ear diameter, grain weight ear^{-1} and grain yield of maize in Hatay-Turkey

	Ear lenght (mm)			Ear diameter (mm)			Grain weight ear^{-1} (g)			Grain yield (kg ha^{-1})		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Hybrid												
Dracma	171.0	186.5	178.8	45.3	46.5	45.9	140.9	110.4	125.7	11201.0	10196.0	10699.0
P.3223	153.9	152.0	153.0	49.0	49.3	49.1	147.7	118.9	133.3	10621.0	10652.0	10636.0
P.3335	166.1	171.7	168.9	48.8	50.9	49.9	141.2	128.5	134.9	10115.0	9179.0	9647.0
Dk.711	183.9	194.7	189.3	44.8	43.6	44.2	156.6	113.0	134.8	9641.0	9516.0	9578.0
Dk.626	153.4	172.8	163.1	48.5	47.4	48.0	137.1	112.7	124.9	9999.0	9730.0	9864.0
L.S.D.(%5)	14.1	20.7	11.5	2.56	1.11	1.28	12.0	N.S.	N.S.	648.6	839.7	487.7
Intra-row spacing (cm)												
10.0	159.6	164.3	161.9	46.5	46.8	46.7	127.3	97.2	112.2	9435.0	9090.0	9263.0
12.5	162.3	167.2	164.7	47.3	47.0	47.2	136.3	104.9	120.6	9945.0	9810.0	9878.0
15.0	166.7	173.3	170.0	47.6	47.3	47.4	146.4	114.5	130.4	10924.0	10523.0	10724.0
17.5	168.9	181.9	175.4	47.5	48.4	47.9	151.1	128.3	139.7	10654.0	9887.0	10271.0
20.0	170.9	191.1	181.0	47.6	48.1	47.9	162.5	138.7	150.6	10617.0	9962.0	10290.0
L.S.D. (%5)	6.0	5.3	3.9	0.76	0.93	0.59	12.7	8.30	7.48	623.2	534.0	404.0

Table 3: Hybrid x intra-row spacing interaction effects on grain yield of maize (kg ha^{-1})

	Intra-row spacing (cm)				
	10	12.5	15.0	17.5	20.0
Hybrid					
Dracma	10150.0	10848	11180	10520	10795
P.3223	10040.0	10127	11718	10677	10620
P.3335	8583.0	9867	10157	9887	9740
Dk.711	9280.0	9485	9985	9593	9548
Dk626	8260.0	9062	10578	10677	10745
L.S.D.(%5)	90.4				

Ear length increased with increasing intra-row spacing and the longest ear obtained at 20.0 cm spacing with 181.0 mm and the shortest ear obtained at 10.0 cm spacing with 161.9 mm (Table 2). Konuskan[13], Gokmen[14] and Turgut[16] reported that shorter ears were obtained at higher plant densities as a consequence of interplant competitions.

Hybrid x intra-row spacing interaction was important for this study, since varietal reaction to intra-row spacing was different in ear length. Aldrich *et al.*[18] indicated that maize hybrids react differently to increased planting rates and population-tolerant hybrids usually produces a good sound ear even at high populations.

Ear diameter: Ear diameter differed according to hybrid and the thickest ears were obtained from Pioneer 3335 and Pioneer 3223 when the thinnest ones from Dekalb 711 Variations in ear diameter depend on genotype and environmental conditions as in ear length. Gozubenli[11] and Konuskan[13] indicated that ear diameter was affected by genotype.

Ear diameter increased with the increase of intra-row spacing and the thickest ears were obtained from 17.5 and 20.0 cm with 47.9 mm when the thinnest ears were obtained from 10.0 cm with 46.7 mm (Table 2). It was reported plant densities affected ear diameter and thinner ears were obtained at high densities[13,16].

Grain weight ear^{-1}: Grain weight ear^{-1} varied among maize hybrids, but the variation was significant only in 2000 (Table 2). Rogers and Lomman[19], Gozubenli *et al.*[11] and Konuskan[13] indicated that there were varietal differences in grain weight ear^{-1} and some hybrids produced big ears when others had smaller ears.

Grain weight ear^{-1} increased with increasing spacing and the weightiest ears obtained from 20.0 cm intra-row spacing with 150.6 g ear^{-1} and the lightest ears obtained from 10.0 cm intra-row spacing with 112.2 g ear^{-1} (Table 2).

It is well known that plants grown under less competition have higher potential yields than those from dense plantings and the grain yield of a single corn plant is reduced by the nearness of its neighbors. As plant density increases, grain yield per plant decreases. If this were not true it would be easy to produce very high yields. Investigators agreed that the yield reduction per plant is due to the effects of interplant competition for light, water, nutrients and other yield-limiting environmental factors[1,16,20].

Grain yield: Grain yield was significantly affected by hybrid, intra-row spacing and hybrid x intra-row spacing interaction.

When maize hybrids were in consideration, the highest grain yields were obtained from Dracma and Pioneer 3223 in both years (Table 2). Present results are in a good agreement with the findings of Gozubenli *et al.*[11], Konuskan[13] and Farnham[9].

When intra-row spacing were in consideration, the highest and the lowest grain yields were obtained from 15.0 cm intra-row spacing and 10.0 cm intra-row spacing, respectively (Table 2).

There were varietal differences in response to intra-row spacing. Hybrid Dekalb 626 gave the highest grain yield at 20.0 and 17.5 cm intra-row spacing, while the other hybrids gave at 15.0 cm intra-row spacing. The highest grain yields obtained from Pioneer 3223 (11718 kg ha^{-1}) and Dracma (11180 kg ha^{-1}) hybrids at 15.0 cm intra-row spacing application (Table 3).

Grain yield is the product of crop dry matter accumulation and the proportion of the dry matter allocated to the grain (i.e., harvest index) and harvest index in corn declines when plant density increases above the critical plant density. The yield reduction per plant may be due to the effects of interplant competition for light, water, nutrients and other yield-limiting environmental factors[1].

Our findings are in good agreement with the reports of many workers. For instance, the optimum plant density for corn hybrid Pride 5 was determined as 9.1 plants/m^2 by Tollenaar *et al.*[2]. Farnham[9] determined that, corn grain yield increased from 10.1 to 10.8 t ha^{-1} as plant density increased from 59000 to 89000 plant ha^{-1}. Porter *et al.* [7] reported inconsistent optimal plant density levels ranging from 86000 to 101270 plants ha^{-1} for corn grain yield across three Minnesota locations.

Consequently, Pioneer3223 and Dracma hybrids should be planted at 15.0 cm intra-row spacing in Amik Plain.

REFERENCES

1. Olson, R.A. and D.H. Sander, 1988. Corn production in Corn and Corn Improvement. 3rd Edn. (Ed. Spraque, G.F. and J.W. Dudley). ASA, CSSA and SSSA, Wisconsin USA, pp: 639-686.
2. Tollenaar, M., D.E. McCullough and L.M. Dwyer, 1994. Physiological Basis of the Genetic Improvement of Corn in Genetic Improvement of Field Crops. (Ed. Slafe, G.A.) Marcel. Dekker Inc. New York, pp: 183-236.
3. Tollenaar, M., 1989. Genetic improvement in grain yield of commercial maize hybrids grown in Ontario from 1959 to 1988. Crop Sci., 29: 1365-1371.
4. Nafziger, E., 1994. Corn planting date and plant population. J. Prod. Agric., 7: 59-62.
5. Tollenaar, M., 1991. Physiological basis genetic improvement of maize hybrids in Ontario from 1959 to 1988. Crop. Sci., 31: 119-124.
6. Widdicombe, W.D. and K.D. Thelen, 2002. Row width and plant density effects on corn grain production in the northern Corn Belt. Agron. J., 94: 1020-1023.
7. Porter, P.M., D.R. Hicks, W.E. Lueschen, J.H. Ford, D.D. Warnes and T.R. Hoverstad, 1997. Corn Responce to row widthand plant densityin the Norhern Corn Belt. J. Prod. Agric., 10: 293-300.
8. Larson, E.J. and M.D. Clegg, 1999. Using corn maturity to maintain grain yield in the presence of late- season drought. J. Prod. Agric., 12: 400-405.
9. Farnham, D.E., 2001. Row spacing, plant density and hybrid effects on corn grain yield and moisture. Agron. J., 93: 1049-1053.
10. Ulger, A.C., 1986. Response of Maize inbred Lines and Hybrids to Increasing Rates of Nitrogen Fertilizer. Dissertation, Hohenheim-Stutgart/West Germany.
11. Gozubenli, H., A.C. Ulger and O. Sener, 2001. The effect of different nitrogen doses on grain yield and yield-related characters of some maize genotypes grown as second-crop. J.Agric. Fac. Ç.Ü., 16: 39-48.
12. Thiraporn, R., G. Geisler and P. Stamp, 1983. Yield and relationships among yield components and N- and P-related traits in maize genotypes under tropical conditions. Z. Acker- und Pflanzenbau. J. Agron. Crop Sci., 152: 460-468.
13. Konuskan, O., 2000. Effects of plant density on yield and yield-related characters of some maize hybrids grown in hatay conditions as second crop. M.Sc. Thesis, Science Institute. M.K.U., pp: 71.
14. Gokmen, S., O. Sencar and M.A. Sakin, 2001. Response of popcorn (*Zea mays everta*) to nitrogen rates and plant densities. Turk. J. Agric. For., 25: 15-23.
15. Duncan, W.G., 1975. Maize in Crop Physiology-some Case Histories, (Ed. Evans, L.T.) Cambridge University Press. Cambridge. GB., pp: 23-50.
16. Turgut, I., 2000. Effects of Plant Populations and Nitrogen Doses on Fresh Ear Yield and Yield Components of Sweet Corn (*Zea mays saccharata* Sturt.). Grown Under Bursa Conditions. Turk. J. Agric. For., 24: 341-347.
17. Ulger, A.C., 1998. The Effects of different row and intra row spacings on grain yield and some agronomical characters of maize. J. Agric. C.U., 13: 95-104.
18. Aldrich, S.R., W.O. Scott and E.R. Leng, 1975. Modern Corn Production. A and L, Illinois. USA.
19. Rogers, I.S., G.J. Lomman, 1988. Effects of plant spacing on yield, size and kernell fill of sweetcorn. Aust. J. Exp. Agron., 28: 787-792.
20. Norwood, C.A., 2001. Dryland corn in Western Kansas: Effects of hybrid maturity, planting date and plant population. Agron. J., 93: 540-547.