Proceedings of 2010 International Conference on Agricultural and Animal Science (CAAS 2010)

Singapore, 26-28 February, 2010

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Published by

World Academic Union (World Academic Press)
113 Mill Lane
Wavertree Technology Park
Liverpool L13 4AH, England, UK

ACADEMIC
World Academic Union

www.WorldAcademicPress.com
Sale: Please contact publishing@WAU.org.uk or PublisherMail@Gmail.com

ISBN13: 978-1-84626-022-3

ISBN 978-1-84626-022-3
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Temperature Effect on Yield and Yield Components in Field -Grown Maize in Different Planting Densities

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Abstract. In order to evaluate the temperature effect on yield and yield components of maize in different planting densities in the field condition, two field experiments were conducted with a Randomized Complete Block Design on 19th April (as a main crop) and 18th June (as a second crop) 2008 in Agricultural Research Center of Golestan - Iran (36° 53' N, 54° 21' E). Each experiment included seven planting densities (0.16, 2.5, 4.5, 6.5, 8.5, 10.5 and 12.5 plants m^{-2}) with four replications. Both experiments were conducted without any water and nutrient limitations. All phenological events including planting date, emergence date, tasseling, silking, physiological maturity and harvesting time were recorded during the growing season. To evaluate temperature effect, from weather data, daily maximum and minimum temperature, cumulative mean temperature, days with temperature > 34 °C, and cumulative growth degree-day (GDD) were computed for different plant growth stages in each season. The result showed, in the second season, because of higher mean daily temperature (28.2 vs. 24.4°C) and more days with maximum temperature > 34 °C (38 vs. 17) the values of total dry matter (TDM), grain yield, ear per plant, W1000, harvest index, LAI, seed number per rows, and (cob+ husk) weight, were significantly less than the values of them in the first season (26.9, 43.1, 33, 9.7, 21.4, 14.7, 13.2 and 52.7 % respectively). ANOVA showed a significant interaction between season and density for 7 of 9 properties. Maximum grain yield observed in middle planting densities in the first season while, in the second season the grain yield was same in planting densities between 2.5 and 12.5 plant m^{-2}. This study found that corn should be planted in the first season for higher growth and yield with 6.5 plant m^{-2} and in the heat stress condition (in the second season) planting density should be reduced to 2.5 - 4.5 plants m^{-2}.

Key words: Maize, temperature, planting density, yield and yield components.

1. Introduction

Temperature is one of the most important factors that influence plants growth and yield. In the CERES-Maize model, in the DSSAT ver. (4.5), grain growth rate is related to temperature via a quadratic function of mean daily temperature and the potential growth rate related to 25°C (Jones et al., 2003). Stress before silking may cause ears to fail to develop while stress after pollination results in limitation of kernel numbers or kernel abortion (Frey, 1981). Lorgeou (1990), cited by Khabba et al. (2001), reported daily growth rate per kernel correlated with mean daily temperature, the optimum being observed at a mean temperature of 21°C. There are little information about temperature effect on growth and yield of maize in field condition. Muchow (1990) found that during five growing seasons in Northern Australia, the rate of grain growth increased and the duration of grain-filling was shorter as temperature increased. However, contrary to other reports for maize grown in controlled environments, yield unaffected by temperatures, when temperature ranged from 25.4 to 31.6 °C during the period from pollination to 80% maximum grain size. Planting density is a major factor in determining the degree of competition between plants. Yield per plant decreases as the

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planting density increases. Reduction in yield is mostly due to lower ears (barrenness), fewer kernels per ear, lower kernel weight, or a combination of these components (Hashemi-Dezfouli et al, 2005). Golestane Province is located in northern Iran near the Caspian Sea. It has a Mediterranean weather: cool in spring and warm in the summer. The average daily mean temperature in spring and summer are 20.8°C and 27.8°C respectively. The most daily mean T_{max} (34.6 °C), the most daily mean evaporation (7.1 mm) and the least precipitation (13.14 mm) occurred in the August during the last decade (Fig. 1).

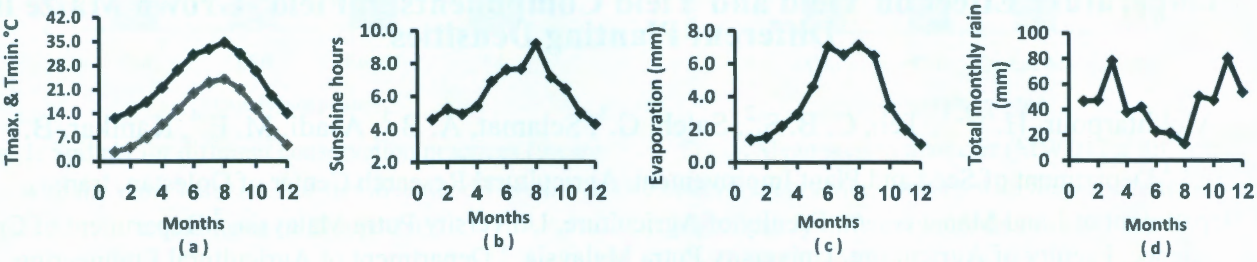

Fig. 1: The average of ten - year (1999 - 2008) monthly means, (Tmax and Tmin (a), sunshine hours (b), evaporation (c) and total monthly mean precipitation (d) in different months of year in Golestan- Iran.

Golestane's weather allows corn to be planted in a long period from mid April until early of July. Corn is usually planted in two seasons per year; mid-April as a main crop and mid-June as a second crop after wheat harvest. According to previous study in Golestan Province, the maximum plant yield (9-11 ton ha^{-1}) obtained in densities between 5.5 - 6.5 plant m^{-2} in the first and second season but during the last decade, the yield was reduced in summer planting dates because of high temperatures, so that in 1999 and 2000 the grain yield reduced to 4.7 ton ha^{-1}(Mokhtarpour and Mosavat, 2001). Preliminary evaluation of experimental fields and farmer's fields showed that the percent of barren stalks inside the canopy increased dramatically in summer planting dates. Based on this observation and the results of other studies that concluded in stress condition planting density should be reduced (Norwood and Currie, 1996; Larson and Clegg, 1999), it seems planting density should be decreased in stress condition. Therefore the objectives of this study were to determine if the effect of temperature on corn growth and yield would differ between the two seasons, as well as to different planting densities.

2. Materials and methods

In order to evaluate the temperature effect on yield and yield components of maize in different planting densities in the field condition, two field experiments were conducted with a Randomized Complete Block Design on 19th April (as a main crop) and 18th June (as a second crop) 2008 in Agricultural Research Center of Golestan - Iran (36° 53' N, 54° 21' E). Each experiment included seven planting densities (0.16, 2.5, 4.5, 6.5, 8.5, 10.5 and 12.5 plants m^{-2}) with four replications. The low planting density (0.16 plants m^{-2}) was to obtain the potential growth and yield of maize without competition by other maize plants, so single plants were planted with a 2.5 m distance of each other in the two seasons. In the main experiment, each plot contained four rows with seven meters in length. The distance between rows was 0.75 m. Both experiments were conducted without any water and nutrient limitations. All phenological events including planting date, emergence date, tasseling, silking, physiological maturity and harvesting time were recorded during the growing season. To evaluate temperature effect, from weather data, daily maximum and minimum temperature, cumulative mean temperature, days with temperature higher than 34 °C, and cumulative growth degree-day (GDD) were computed for different plant growth stages in each season. GDD calculated using following formula according to Tsuji et al., (1998) work; (Tmin + Tmax)/2 - T_{base}, where T_{max} and T_{min} are maximum and minimum daily air temperatures respectively, and the base temperature at which development ceased T_{base} was 8°C. In case where mean daily temperature exceeded 30°C, T_{mean}=30. Leaf area was measured using the equipment "Area Measurement System" (Delta-T Devices Ltd, Cambridge, UK). Plant number and ear number in all plots were counted to calculate number of ear per plant. To calculate total dry matter, yield, (stem + leaf weight + tassel), cob weight, husk weight, harvest index, and W1000, 5 m of two central rows considering border effect were harvested in each plots. After separating the different parts of the plants including (stem + leaf + tassel), cob, husk and grain, the fresh weight were measured and a sample of each part then dried to a constant weight at 75°C for about three days. Dry weights were recorded based on 14% humidity in each part. To analyze the data a combined analysis ANOVA was done using SAS software (Ver. 9.1, SAS Inst., NC) The least significant differences test (LSD) was used to compare the mean values in each trait.

3. Results and discussion

The results showed that the effect of season, planting densities and the interaction effect between them were significantly different at $p \leq 0.05$ in most traits (Table 1). The values of total dry matter (TDM), grain yield, ear per plant, W1000, harvest index, LAI, seed number per rows, and (cob+ husk) weight, were significantly less than the first season at $p \leq 0.05$ (26.9, 43.1, 33, 9.7, 21.4, 14.7, 13.2 and 52.7 % respectively) (Table 2). Low values in growth parameters for the second season was due to the higher temperature. In the first season, 17 days of total plant growth stages (15.88 %) experienced maximum temperature more than 34°C while in the second season maximum temperature in 38 days of total plant growth stages (38%) were more than 34°C that occurred in total plant growth stages especially 1-2 weeks before and after silking stage (Table 3). Jones and Kiniry (1986) reported that temperatures higher than 34°C damage photosynthesis apparatus and reduce dry matter accumulation.

Tabel 1. Analysis variance of some traits

S.O.V	df	Ms								
		Stem weight	LAI	TDM	Ear plant^{-1}	Seed row^{-1}	W1000	Grain weight	HI	(Cob+Husk) weight
Season	1	0.31^{ns}	4.78*	328.59**	1.7980**	436.52**	10858.26**	166.74**	1438.14**	33.30**
Block(Season)	6	1.28^{ns}	0.60^{ns}	3.17^{ns}	0.0006^{ns}	10.49^{ns}	1345.87^{ns}	0.60^{ns}	9.79^{ns}	0.06^{ns}
Planting density	6	82.49**	36.67**	362.70**	0.5872**	561.89**	1370.85^{ns}	57.12**	80.19**	7.09**
Season*density	6	25.21**	0.53^{ns}	58.76**	0.1612**	80.19**	2429.87^{ns}	8.62**	122.06**	1.49**
Error	36	1.22	0.58	3.27	0.0018	6.02	1051.19	0.51	4.82	0.07
Total	55									
CV, %		15.51	20.55	11.91	4.69	6.24	9.61	11.39	5.32	11.62

ns, *, **; not significant, significant in 5 %, and 1 % probability level respectively.

Table 2. The effect of season on some traits.

	Traits							
Seasons	Ear plant^{-1}	Seed row^{-1}	LAI	W1000 (g)	Grain (t ha^{-1})	TDM (t ha^{-1})	HI (%)	(Cob+Husk) (t ha^{-1})
Season 1 (S1)	1.09 A	42.07 A	4.01 A	286.04 A	7.99 A	17.97 A	46.13 A	2.92 A
Season 2 (S2)	0.73 B	36.48 B	3.42 B	258.19 B	4.54 B	13.13 B	36.22 B	1.38 B
Reduction (%), S2 vs S1.	33.02	13.28	14.71	9.73	43.17	26.93	21.48	52.73

Reduction in ear per plant and kernel per ear in the second season was consistent to the results by Frey (1981) who concluded that stress before silking may cause ears to fail to develop while stress after pollination results in limitation of kernel numbers or kernel abortion. Other researchers also showed that the kernel number is the most susceptible component to stress in the period between 2 weeks before to 2 to 3 weeks after silking (Cirilo and Andrade. 1994; Khabba et al, 2001). Increasing daily mean temperature in the second season in compare with the first season is another important reason to reduce the value of yield and yield component in the second season. Daily mean temperature for different plant growth stages showed in Table (3). Mean daily temperature from planting date to anthesis in the first and second season are 22.1 and 27.9°C respectively and its value for total plant growth stages is 24.4 and 28.2 for the first and second season. Lorgeou (1990), cited by Khabba et al. (2001), reported daily growth rate per kernel correlated with mean daily temperature, the optimum being observed at a mean temperature of 21°C. Thompson (1986) using long-term weather data concluded that higher mean seasonal temperature is correlated with lower grain-yield. However, contrary to the result of this study and other reports for maize grown in controlled environments, Muchow (1990) reported that, in the field condition during five growing seasons in Northern Australia maize yield unaffected by temperatures, when temperature ranged from 25.4 to 31.6 °C during the period from pollination to maturity. High temperature in the second season also caused the shortening of the period of plant growth (days to maturity in the first season was 107 days while in the second season was 100 days) (Table 3). In other words, reduction in ear per plant, kernel per ear, LAI, W1000 and HI are the mean reasons to reduce yield in the second season. Planting density affected LAI (Table 1) and the highest value of LAI (5.47-5.75) was obtained in planting densities between 8.5-12.5 plant m^{-2}.

Table 3. Number of days (No.D), Mean daily temp (MDT), ∑ Mean daily temp (∑ MDT), Day with Tmax > 34 °C (DTmax > 34 °C), and ∑ GDD, to reach to different phenological stages in two seasons.

Days to phenological stages	No.D		MDT		∑ MDT		∑GDD		D Tmax > 34 °C	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Days to emergence	8	5	19.4	25.6	155.1	128	88.9	88	2	0
Days to anthesis	65	60	22.1	27.9	1437.9	1676.1	917.9	1195.1	4	16
Anthesis to maturity	42	40	28	28.6	1175.5	1143.1	835.2	819.1	13	22
Days to maturity	107	100	24.4	28.2	2613.4	2818.2	1745.4	2004.2	17	38

S1, season 1., S2, Season 2.

Interaction effects between planting density and season in 7 of 9 traits were significantly different in 5 % of probability level (Table 1). In the first season, the maximum values of TDM (24603 - 25960 kg ha^{-1}) and stem weight (9681.3 - 10752 kg ha^{-1}) were observed in the middle densities (6.5 and 8.5 plants m^{-2}) while in the second season their maximum values (18432 – 18927 kg ha^{-1}), (11236.9 – 11879.2 kg ha^{-1}) were respectively observed in the high planting densities (10.5 and 12.5 plants m^{-2}) (Table 4). The number of ear per plant was reduced when the planting density increased (Table 4). In the first season, single plants produced two ears per plant, and in planting densities between 2.5 and 8.5 plants m^{-2}, one ear per plant produced. But in the second season single plants had one ear per plant, and with increasing plant density ear per plant decreased. Hashemi-Dezfouli et al., (2005) and Sarlangue et al., (2007) reported the same trend and concluded that with increasing planting density the number of bareness stalk increased. In the first season, the maximum number of seeds per row (52.32) was observed in second planting density (2.5 plants m^{-2}) while in the second season, its maximum value (53.75) was observed in the single plants (0.16 plants m^{-2}). The main reason was that the single plants in the first season produced two ears per plant while in the second season they produced one ear per plant (Table 4). Maximum value of harvest index (55.32 %) was observed in the single plants (0.16 plants m^{-2}) and its minimum value (40 – 42 %) was observed in planting densities between 2.5 – 8.5 plant m^{-2} in the first season, while in the second season, its minimum value (30.9 – 29.28 %) was obtained in the high plant densities (10.5 – 12.5 plants m^{-2}) (Table 4). Tollenaar et al. (2006) concluded that crowding stress affected dry matter accumulation, but it did not affect harvest index.

Table 4. The intraction effect between season and planting density on some traits.

Planting density (plant m^{-2})	Traits													
	Stem (t ha^{-1})		(Cob+Husk) (t ha^{-1})		TDM (t ha^{-1})		Ear $plant^{-1}$		Seeds row^{-1}		Grain (t ha^{-1})		Harvest index (%)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
0.16	0.34 CE	0.38 D	0.22 C	0.12 B	1.27 E	0.80 D	2.00 A	1.00 A	47.25 BC	53.75 A	0.70 E	0.36 B	55.32 A	42.13 A
2.5	6.58 DC	5.09 C	2.83 B	1.57 A	15.85 D	11.67 C	1.00 B	0.75 B	52.32 A	44.98 B	6.43 D	4.99 A	40.59 D	42.70 A
4.4	8.99 AB	6.86 B	3.86 A	1.54 A	22.07 BC	13.20 BC	1.00 B	0.756 B	48.67 B	35.59 C	9.21 B	4.78 A	41.83 CD	36.26 B
6.5	9.68 A	7.47 B	3.98 A	1.71 A	24.60 AB	14.44 B	1.00 B	0.790 B	43.78 C	33.47 DC	10.93 A	5.26 A	44.45 C	36.29 B
8.5	10.75 A	7.53 B	4.18 A	1.68 A	25.96 A	14.42 B	1.00 B	0.717 BC	39.34 D	31.87 DE	11.01 A	5.20 A	42.63 CD	35.98 B
10.5	7.46 BC	11.23 A	2.63 B	1.49 A	19.64 C	18.43 A	0.92 C	0.646 C	32.21 E	29.6 EF	9.54 B	5.70 A	48.60 B	30.92 C
12.5	5.58 D	11.87 A	2.71 B	1.52 A	16.40 D	18.92 A	0.76 D	0.518 D	30.93 E	26.13 F	8.10 C	5.52 A	49.43 B	29.28 C

Means with same letter in each column are not significantly different in 5 % probability level.

Maximum grain yield (10938.3 – 11018.8 kg ha^{-1}) was observed in the middle planting densities (6.5 and 8.5 plants m^{-2}) in the first season while in the second season the grain yield (4787 – 5701 kg ha^{-1}) was the same in planting densities between 2.5 and 12.5 plants m^{-2} (Table 4). In the first season, with increasing plant density yield per unit area increased until planting density at 8.5 plants per m^{-2} and after that start to decrease. But in the second season, yield per unit area in planting densities between 2.5 and 12.5 was not significantly different. Increasing plant density could not compensate for the yield reduction which was as a result of reduction in ear per plant and seeds per ear in higher planting densities. The result of this study is agreement with the results of Larson and Clegg (1999) and Norwood and Currie (1996) studies that found in stress condition planting density should be reduced in compare with no stress condition.

4. Conclusion

This study found that corn should be planted in the first season as main crop (mid-April) for higher corn growth and yield (43.3% yield reduction occurred in the second season) in Golestan, Iran with 6.5 plants m^{-2}. Because corn yield showed the same response to different planting densities between 2.5 – 12.5 plants m^{-2} in the second season, therefore in the heat stress condition (in the second season) planting density should be reduced to 2.5 – 4.5 plants m^{-2}.

5. Acknowledgment

We thank the Agricultural and Natural Resources Research Center, Golestan, Iran for their financial support.

6. References

[1] A. G. Cirilo, and F. H. Andrade. Sowing date and maize productivity: II. Kernel number determination. Crop Sci. 1994, 34:1246–1252.

[2] A. M. Hashemi, S. J. Herbert, and D. H. Putnam. Yield response of corn to crowding stress. Agron. J. 2005, 97:839–846.

[3] B. Badu-Apraku, R. B. Hunter, and M. Tollenaar.. Effect of temperature during grain filling on whole plant and grain yield in maize (Zea mays L.). Can. J. Plant Sci. 1983, 63: 357-363.

[4] C. A. Jones, and J. R. Kiniry,. CERES-Maize, a simulation model of maize growth and development. Texas A&M University Press, 1986.

[5] C. A. Norwood, and R.S. Currie, R.S. Tillage, planting date, and plant population effects on dryland corn. J. Prod. Agric. 1996, 9:119–122.

[6] E. J. Larson, M. D. Clegg. Using corn maturity to maintain grain yield in the presence of late-season drought. J. Prod. Agric.1999, 12:400–405.

[7] G. Y. Tsuji, G. Hoogenboom, and P. K. Thornton. Understanding options for agricultural production. Systems approaches for sustainable agricultural development. Kluwer Academic Publishers, Dordrecht, Netherlands. 1998.

[8] H. Mokhtarpour, and S. A. Mosavat. Investigating the reasons of corn yield reduction in 1998 and 1999 in Golestan Province. Agricultural Research Center of Golestan. Gorgan. Iran. 2001.

[9] J. W. Jones, G. Hoogenboom, C. H. Porter, K. J. Boote, W. D. Batchelor, L. A. Hunt, P.W. Wilkens, U. Singh, A. J. Gijsman, and J. T. Ritchi. The DSSAT cropping system model. Europ. J. Agronomy, 2003, 18: 235-265.

[10] L. M. Thompson. Climatic change, weather variability, and corn production. Agron. J. 1986, 78:649-653.

[11] M. Tollenaar, W. Deen, L. Echarte, and W. Liu. Effect of crowding stress on dry matter accumulation and harvest index in maize. Agron. J. 2006, 98:930-937.

[12] N. M. Frey. Dry matter accumulation in kernels of maize. Crop Sci. 1981, 21:118–122.

[13] R. C. Muchow. Effect of high temperature on grain-growth in field-grown maize. Field Crops Res. 1990, 23: 145-158.

[14] S. Khabba, J. F. Ledent, and A. Lahrouni. Maize ear temperature. Europ. J. Agronomy. 2001, 14: 197–208.

[15] T. Sarlangue, F. H. Andrade, P. Calviño, and L. Purcell. Why do maize hybrids respond differently to variations in plant density? Agron. J. 2007, 99:984–991.