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Research Article

Thermal requirement and productivity of *kharif* maize under different growing environments and planting density

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Abstract

A field experiment was conducted during *kharif* season of 2013 under rainfed situations on Vertisols of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (India), which is located in the northern transition zone of Karnataka at 15^{o}26' North latitude, 75^o 07' East longitude and at an altitude of 678 m above mean sea level. Among the five sowing dates (June I FN, June II FN, July I FN, July II FN and Aug I FN) tried, June I FN sowing recorded significantly higher grain yield (8055 kg ha-1), total dry matter production (3018.1g m^{-2}) and accumulated heat units (1597 GDD) to attain physiological maturity. Similarly, higher planting density of 1,11,111 per hectare has outperformed other planting densities (66, 666 and 83, 333 plants ha^{-1}) with respect to grain yield (7007 kg ha^{-1}),stover yield (108 q ha^{-1}) , accumulated heat units (1515 GDD) and TDMP (3168 g m^{-2}). The increase in planting density increased the grain yield and accumulated heat units (GDD).Sowing of *kharif* maize during June I FN with a planting density of 1,11,111 plants ha-1 gave significantly higher grain yield (8420 kg ha-1) of maize.

Introduction

Variability in plant development may be due to different management practices and different environmental conditions. Environmental requirements for the satisfactory growth and development for tropical crops have been less studied (Squire, 1990). Amongst environmental factors, temperature is considered a primary determinant of plant development. When a maize hybrid is grown in its region of adaptation, temperature variations are the primary cause of year-to-year variation in its development. It is for this reason that the maturity time of maize has been found to be closely related to the accumulation of thermal units. The heat unit concept assumes that a direct and linear relationship between growth and temperature is advantageous for the assessment of yield potential of a crop in different weather conditions. Growing Degree day (GDD) is one of the most important indices to study the heat unit concept. GDD (^{o}C day) is the departure from the mean daily temperature above the minimum threshold (base) temperature. This minimum threshold is the temperature below which no growth takes place.

Optimum time of sowing is one of the important factors which provide scope for better utilization of natural resources by the crop during its growing season. Suitable time of sowing enables the crop to take full advantage of favorable weather conditions during growing seasons. The variation in sowing date in maize modifies the radiative and thermal conditions during its growth. There are several evidences showing that, delay in sowing of maize beyond July results in yield reduction. In the event of late onset of monsoon rains and erratic rainfall farmers are forced to take-up sowing late i.e., beyond 15th July: and the sowing may even be extended to the end of August month. Shift in sowing dates directly influence both thermo and photoperiod, and consequently a great bearing on the phasic development and partitioning of dry matter. Similarly, an optimum plant population for maximum economic yield exists for all crop species and varies with cultivar and environment (Bruns and Abbas, 2005). New generations of maize hybrids are characterized by a better ability of plants to be grown in denser stand, as they were selected under such conditions.

In northern transitional zone of Karnataka under medium black and red soils with an average rainfall of around 800 mm, maize yields are higher when sown with the onset of monsoon. However, during recent years after the onset of monsoon, rains are delayed with dry spells leading to delayed sowing resulting in poor growth and yield. Hence, the present study was undertaken to know the heat unit (thermal) requirements, yield and dry matter production of maize grown under different growing environments and planting densities.

Materials and Methods

A field experiment was conducted during *kharif* season of 2013 under rainfed situations on Vertisols of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (India),which is located in the northern transition zone of Karnataka at 15^{o}26' North latitude, 75^{o} 07' East longitude and at an altitude of 678 m above mean sea level. The total amount of rainfall received during 2013 was 740.4 mm. The maize crop was sown in five dates of sowing (June I FN, June II FN, July I FN, July II FN and Aug I FN) with three planting densities (6.66, 8.33 and 11.11 plants m^{-2}) with cultivar *Dekalb* Super 900M. The crop was fertilized with recommended dose of fertilizer (100:50:50 kg N, P_2O_5 and K_2O per hectare). 50 percent of nitrogen and full dose of phosphorus and potash fertilizers were applied at the time of sowing and remaining 50 per cent of nitrogen was applied 30 days after sowing. Other cultural and plant protection measures were followed as per the recommended package of practices. For higher and lower densities than normal density (83,333 plants/ha) were supplied with proportionate increase and decrease in recommended dose of fertilizer. The weather data during the experimental period were recorded from the meteorological observatory located nearby the experimental plot at MARS, University of Agricultural sciences, Dharwad. Growing degree day was calculated using the standard method as mentioned below

Growing Degree Days (GDD)

$$GDD = \sum \left(\frac{Tmax + Tmin}{2} - Tb \right)$$

Where, Tmax = maximum Temperature, Tmin= minimum temperature and Tb = Base Temperature below which crop growth cease, Tb for: Maize: 10 ^{0}C. Data was statistically analyzed in MS-Excel using split plot design.

Results and Discussion

Results revealed that both sowing date and planting density significantly influenced Growing Degree Day (GDD), the grain yield, stover yield, and total dry matter production of maize. Accumulated thermal units (Growing degree days) were found to be significant at maturity of maize for different sowing dates (Table 1).

Table 1: Accumulated heat units (GDD) of maize as influenced by different sowing dates and planting densities

Planting densities/ Sowing dates	11.11 plants per m^{-2}	8.33 plants per m^{-2}	6.66 plants per m^{-2}	Mean accumulated GDD for sowing dates
June –I fortnight	1609	1603	1580	**1597**
June –II fortnight	1595	1550	1540	**1562**
July –I fortnight	1517	1520	1490	**1509**
July –II fortnight	1463	1447	1400	**1437**
August–I fortnight	1393	1402	1370	**1388**
Mean accumulated GDD for planting densities	**1515**	**1504**	**1476**	
SEm±	**CD(0.05)**	**SOURCE**		
29.6	96	Between sowing dates (Main)		
9.8	29	Between planting densities (Sub)		
		Interactions		
22.0	NS	Between sub means at the same main		
34.6	NS	Between main means at the same are different sub treatments		

Among the five sowing dates tried, significantly higher GDD from sowing to maturity were recorded in June 1st FN sowing (1597 GDD). GDD required for maturity reduced with delayed sowing. On an average it reduced from 1597 to 1388 GDD with delay in sowing. The requirement of GDD was higher for normal growing condition than the late sowing condition. This was due to longer period for all the phenological stages in the normal growing condition. Late sowing decreased the duration of phenology as compared to normal sowing due to fluctuated unfavorable high temperature during the growing period. So, the requirement of thermal units decreased with late sowing. Similar results were recorded by Dahiya and Narwal (1989) and Leelarani *et al*. (2013).

Among the five sowing dates tried, normal sowing (June 1st FN) recorded significantly higher grain yield (8055 kg ha^{-1}) than subsequent dates of sowing because of higher accumulation of heat units (1597 GDD) and better utilization of available favourable environmental conditions. Delay in sowing resulted in reduction of grain yield which might be due to minimum accumulation of heat units and also the reduced growth. The least grain yield of maize was recorded with August I FN sowing (4662 kg ha^{-1}) due to least accumulated heat units (1388 GDD). Among different dates of sowing, early sowing on June 1st FN outperformed all the other dates. If the sowing was delayed upto August 1st FN, there was a yield reduction upto to 42.1 % (Table 2). Similarly, higher stover yield (99 to 100.8 q ha-1) were recorded with early sowing dates i.e from June I FN to July I FN sowing and least (82.4 q ha^{-1}) was recorded with late sowing i.e August I FN sowing (Table 3). The results are in conformity with the findings of Hemalatha et al. (2013).

Table 2: Grain yield (kg ha^{-1}) of maize as influenced by different sowing dates and planting densities

Planting densities/ Sowing dates	**11.11 plants per m^{-2}**	**8.33 plants per m^{-2}**	**6.66 plants per m^{-2}**	**Mean Grain yield (kg ha^{-1}) for sowing dates**
June –I fortnight	8420	8156	7589	**8055**
June –II fortnight	7466	7301	6361	**7043**
July –I fortnight	7444	7021	6082	**6849**
July –II fortnight	6235	5175	3912	**5107**
August–I fortnight	5472	3732	4782	**4662**
Mean grain yield (kg ha^{-1}) for planting densities	**7007**	**6277**	**5745**	
SEm±	**CD(0.05)**	**SOURCE**		
250	816	Between sowing dates (Main)		
147	434	Between planting densities (Sub)		
		Interactions		
329	971	Between sub means at the same main		
367	1084	Between main means at the same are different sub treatments		

Similarly, among the three planting densities tried, the higher one i.e. 11.11 plants per m^{-2} outperformed all the other densities. Significantly higher grain yield (7007 kg ha^{-1}), stover yield (82.4 q ha^{-1}) and GDD (1515) of maize were recorded with planting density of 11.11 plants per m^{-2}. The lowest grain yield (5745 kg ha^{-1}) and GDD (1476) of maize were recorded with the lower planting density of 6.66 plants per m^{-2}. These results are inconformity with those of Bisht *et al.* (2013) and Parthasarathi *et al.* (2012)

As per as, total dry matter production per square metre at physiological maturity was concerned, among five dates of sowing tried, early sowing on June 1st FN outperformed all the other sowing dates with respect to total dry matter production (TDMP) per square metre (3018 g).It reduced with delay in sowing. Least total dry matter production per square metre (2314.8 g) was recorded in August I FN sowing. Among the three planting densities tried, 11.11 plants per m^{-2}outperformed all the other densities. Significantly higher TDMP per square metre (3167.8 g) of maize was recorded with planting density of 11.11 plants per m^{-2}. The lowest TDMP (2335.8 g) of maize was recorded with the planting density of 6.66 plants per m^{-2} (Table 4). As per as interaction effects were concerned, sowing of maize during June I FN with a planting density of 11.11 plants per m^{-2},which gave significantly higher grain yield (8420 kg ha^{-1}) of maize found superior over other treatment combinations.

Table 3: Stover yield (q ha^{-1}) of maize as influenced by different sowing dates and planting densities

Planting densities/ Sowing dates	**11.11 plants per m^{-2}**	**8.33 plants per m^{-2}**	**6.66 plants per m^{-2}**	**Mean stover yield (q ha^{-1}) for sowing dates**
June –I fortnight	112.0	107.0	82.0	**100.3**
June –II fortnight	111.9	109.5	76.7	**99.4**
July –I fortnight	115.9	106.5	80.0	**100.8**
July –II fortnight	108.3	79.2	70.9	**86.1**
August–I fortnight	92.1	82.6	72.7	**82.4**
Mean stover yield (q ha^{-1}) for planting densities	**108.0**	**97.0**	**76.4**	
SEm±	**CD(0.05)**	**SOURCE**		
2.41	7.8	Between sowing dates (Main)		
1.45	4.2	Between planting densities (Sub)		
		Interactions		
3.24	9.5	Between sub means at the same main		
3.58	10.5	Between main means at the same are different sub treatments		

Table 4: Total dry matter production (g m^{-2}) of maize at physiological maturity as influenced by different sowing dates and planting densities

Planting densities/ Sowing dates	**11.11 plants per m^{-2}**	**8.33 plants per m^{-2}**	**6.66 plants per m^{-2}**	**Mean total dry matter production (g m^{-2}) for sowing dates**
June –I fortnight	3757.7	2864.8	2431.7	**3018.1**
June –II fortnight	3370.8	2746.4	2707.0	**2941.4**
July –I fortnight	3155.4	2623.9	2218.5	**2665.9**
July –II fortnight	2722.7	2725.0	2439.6	**2629.1**
August–I fortnight	2832.4	2229.5	1882.6	**2314.8**
Mean total dry matter production (g m^{-2}) for planting densities	**3167.8**	**2637.9**	**2335.8**	
SEm±	**CD(0.05)**	**SOURCE**		
142.35	464.2	Between sowing dates (Main)		
64.03	188.8	Between planting densities (Sub)		
		Interactions		
143.18	NS	Between sub means at the same main		
184.20	NS	Between main means at the same are different sub treatments		

Conclusion

Optimum time of sowing is one of the important factors which provide score for better utilization of natural resources by the crop during its crop to take full advantage of favourable weather conditions during growing season.The shifting of sowing dates corresponds to fluctuations in temperature lead to shortening of the growth periods. A progressive delay in sowing caused a decrease in grain yield,stover yield ,total dry matter production and accumulated heat units (GDD). Similarly, an increase in grain and stover yields of maize was found with increase in plant density. Also, the increase in plant density recorded more accumulated heat units (GDD).

References

Bisht, A. S., Amit, B. and Singh, V., 2013, Influence of plant density and integrated nutrient management on N, P and K contents and uptake of quality protein maize. *Madras Agric. J.*, 100(1-3) : 110-112.

Bruns, H.A, Abbas, H.K., 2005. Ultra-High plant populations and nitrogen fertility effects on corn in the Mississippi Valley. *Agron*. *J*., 97(4): 1136.

Dahiya, D. S and Narwal, S. S., 1989, Effect of sowing dates on phenology and growing degree requirement of winter maize (*Zea mays* L.). *Indian J. Agric. Sci*., 59(9):589-592.

Hemalatha, S., Sreelatha, D., Anuradha, M. and Sai Kumar, R., 2013, Crop weather relations in maize (*Zea mays* L.). *J. Agrometeorol*., 15(2):165-166.

Leelarani, P., Sreenivas, G. and Rajiv Reddy, D., 2013, Evaluating contribution of weather to growth and yield of *kharif* maize (*Zea mays* L.) under irrigated conditions. *J. Agrometeorol*., 15(2):156-158.

Parthasarathi, T., Vanitha, K. and Velu, G., 2012, Physiological effects of maize crop under altered plant populations and soil moisture regimes. *J. Agric. Sci. & Tech.*, 1(3) : 10-18.

Squire, G.R. 1990. The Physiology of Tropical Crop Production. *CAB International*, Wallingford, pp. 180-215.