African Journal of Biotechnology Vol. 11(61), pp. 12450-12453, 31 uly, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB12.201
ISSN 1684–5315 ©2012 Academic Journals

Full Length Research Paper

Effects of sowing date on the growth and yield of maize cultivars (*Zea mays* L.) and the growth temperature requirements

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Accepted 11 June, 2012

A field experiment was conducted to analyze the relationship between growing degree days, yield and yield components of maize cultivars. Five maize cultivars (SC 108, SC 301, SC 604, SC 704 and TVG) were sown on four different dates during summer in a randomized complete block design with split plot arrangements with three replications. Maize cultivars exhibited significant differences on yield, weight of 100 seeds, biological yield and harvest index. The best hybrid SC 704 accumulated growing degree days (GDD) and was the highest for seed yield and all yield components. The plant sown on 5th August, accumulated suitable GDD and produced the highest seed yield, biological yield and harvest index. Generally, 5th August plantation accumulated more suitable GDD in comparison with the other sowing dates (6th July, 21st July and 20th August), as such, it exhibited higher seed yield, biological yield and harvest index. The results show that SC 704 had the highest biological yield, seed yield and harvest index. This hybrid received the highest quantity of GDD as compared to other cultivars thus, suggesting the use of SC 704 and sowing on the 5th of August in Sistan region.

Key words: Growing degree days, harvest index, seed and biological yield, sowing date.

INTRODUCTION

Growth and development are different concepts although they have related stages. Plant growth refers to irreversible increase in organ or whole plant size (length, area, volume and weight), while plant development refers to processes related to cell differentiation, organ initiation, member appearance, and extends to plant senescence (Streck et al., 2003). Selection of adapted genotypes and field plant management practices such as fertilization, pest's control and irrigation arrangement was reported by Streck et al. (2003). Temperature is a major environmental agent that determines the rate of plant growth and development. Different genotypes may behave differently under similar environmental conditions. Maize (*Zea mays* L.) development is primarily driven by temperature, with air temperature being theoretical to enhance maize development from emergence to physiological maturity (Cutforth and Shaykewich, 1990).

Muchow (1990) showed that seed growth may be directly influenced by air temperature. Different sowing dates might cause different environmental conditions from emergence to seed filling. The most common temperature index used to estimate plant development is growing degree days (GDD), or thermal unit (TU). The accumulation of GDD determines the maturity of plant, yield and yield components. Sur and Sharma (1999) reported that the full GDD decreased from 1731 to 1621 with delay in sowing, as the later sown plant experienced lower temperature during the seed filling period. Akasha (1968) showed that high temperature reduced the number of tillers and seed weight, because the period between anthesis and senescence was shortened by relatively higher temperature. Fischer (1985) showed that the thermal time requirement needed by a specific growth stage is more or less constant. Temperature changes in the field can be created by planting at different dates in a season, so that the plant will grow at different temperature. The present experiment was considered to investigate relationship of GDD with yield and yield components in different maize cultivars. Hongyong et al. (2007) concluded that seed yield of summer maize were

Table 1. Soil characteristics of the experiment area during the 2000 growing season (Agricultural Research Center of Sistan).

Year	Depth of soil (cm)	PH	Ec (mmohs/cm)	N (%)	P(ppm)	K (ppm)	Sand	Silt	Clay
2000	0-30	7.8	3.3	0.06	12	130	71	14	15

Table 2. Mean monthly temperature (°C) recorded during summer 2000.

Month	MMT (°C)	MmT (°C)	MM (°C)	AM (°C)	Am (°C)
July	42.2	28.5	35.4	48	26
August	40.8	27.8	34.3	44.2	23
September	37.9	23.3	30.6	43.6	15
October	32.8	16.3	24.6	40.8	9
November	27	9.8	18.4	30.6	5
December	21.5	5.3	13.4	25	-0.8

MMT, Mean of maximum temperature; MmT, mean of minimum temperature; MM, monthly mean; AM, absolute maximum; Am, absolute minimum.

increased with delay in harvest. Differences in temperature for growth, development and maturity were observed by sowing maize cultivars at different dates during summer.

MATERIALS AND METHODS

Field experiments were conducted in summer 2000 at the University of Zabol, Iran. The experimental farm is located at 30° 54′N; 61° 41′E at an altitude of 483 m above sea level in Sistan Region; Sistan region is located in Southeast of Iran and has arid type of climate.

Seed beds were prepared by plowing the soil 2 times. Five maize cultivars (SC 108, SC 301, SC 604, SC 704 and TVG) and four planting dates (6th, 21th July, 5th and 20th August) were arranged in a randomized complete block design in split plot arrangements with three replications. Planting dates were established in main plots and the different genotypes corresponded to subplots. The experiment was carried out during 2000 growing season on a sandy loam soil (Table 1). Similar dose of fertilizer, 290 kg.ha^{-1} N of urea source, 65 kg.ha^{-1} P_2O_5 of super phosphates triple and 200 kg.ha^{-1} K_2O potassium sulphate per hectare was applied in the soil during seedbed preparation. The line-to-line distance was maintained at 60 cm and crop-to-crop distance at 20 cm in net plot size of 7 x 4 m. Seeds were sown with a dibbler, sowing two seeds per hill. After emergence, one plant per hill was maintained. Weeds were kept under control by hand weeding throughout the plant life cycle. The cumulate GDD from emergence till maturity was calculated for each sowing date from weather data (Table 2) recorded throughout plant life cycle by the equation of Dwyer and Stewart (1986). GDD were calculated throughout the season for each planting date. The formula GDD = [(Tmin + Tmax)/2-10°C] was used. Tmax and Tmin were daily maximum and minimum air temperatures in degree centigrade. Base temperature for maize development was 10°C. At maturity, the two central rows were harvested. The seed weight was determined with an electronic scale. Seed and biological yield per plot were recorded and converted into kg ha^{-1}. The recorded data during the study were subjected to Fisher's analysis of variance technique (ANOVA). Treatment means were compared for significance using Duncan's multiple range test at 5% level of probability (Steel and Torrie, 1980).

RESULTS

During summer, SC 704 accumulated the maximum (1566) GDD and was not significantly different as compared to TVG hybrid (1566), while SC 108 and SC 301 had the minimum (1448). Similarly, planting dates had statistically significant differences for GDD accumulation, the 6th July planting accumulated the maximum (1743) though, progressively decreased to minimum (1252) with late planting (Table 3).

The data presented in Table 3 shows that the differences for 100 seed weight (HSW) of the cultivars under evaluation were statistically different. TVG presented the maximum HSW (37.85 g), which differed significantly from all the other cultivars. On the other hand, SC 108 produced the minimum HSW (28.85 g). The planting dates also exhibited significant effects on HSW (Table 3). The maximum HSW was produced by plants planted on 6th of July (34.48 g) which was statistically equivalent to all the other planting dates, except 20th August (27.26 g). During summer season, the cultivars under evaluation differed significantly from each other for seed yield (GY) (Table 3). The highest GY was obtained from the hybrid SC 704 (8300 kg ha^{-1}), while the minimum was produced by the hybrid SC 108 (3800 kg ha^{-1}). GY was also significantly affected by the planting date (Table 3). The highest GY was observed in the plant planted on the 5th of August (8840 kg ha^{-1}) which was statistically similar to that of 21th July (6760 kg ha^{-1}) and 20th August (6170 kg ha^{-1}). The lowest GY was recorded in the case of the plant planted on 6th of July (2300 kg ha^{-1}). Cultivars under evaluation differed significantly from each other for biological yield (BY) (Table 3). Highest values of BY was obtained from the hybrid SC 704 (20340 kg ha^{-1}) which was similar to SC 604 (18210 kg ha^{-1}). The minimum BY was make by the hybrid SC 108 (8190 kg ha^{-1}). As in the other measured parameters, BY

Table 3. GDD, yield and yield components of maize cultivars during summer.

Parameter	DDPCA	DDCAEA	DDEAM	GDD	HSW	BY(kg ha^{-1})	GY(kg ha^{-1})	HI (%)
Cultivars								
SC 108	714^{b}	163^{a}	571^{a}	1448^{b}	28.85^{d}	8190^{d}	3800^{c}	41.98^{a}
SC 301	805^{ab}	146^{ab}	537^{a}	1488^{b}	30.91^{c}	12760^{c}	4320^{c}	30.5^{b}
SC 604	888^{a}	142^{ab}	469^{ab}	1499^{b}	31.18^{c}	18210^{a}	6770^{b}	34.41^{b}
SC 704	952^{a}	175^{a}	439^{b}	1566^{a}	33.57^{b}	20340^{a}	8300^{a}	39.4^{a}
TVG	952^{a}	175^{a}	439^{b}	1566^{a}	37.85^{a}	17040^{b}	6900^{b}	39.34^{a}
SE	10.5	2.4	3.1	11.6	3.6	1.38	1.48	27.52
Sowing dates								
6th July	952^{a}	176^{ab}	615^{a}	1743^{a}	34.48^{a}	8080^{b}	2300^{b}	26.42^{b}
21th July	892^{a}	214^{a}	531^{ab}	1637^{a}	34.37^{a}	16820^{a}	6760^{a}	38.6^{a}
5th August	793^{ab}	142^{ab}	487^{ab}	1422^{ab}	33.77^{a}	20370^{a}	8840^{a}	45.26^{a}
20th August	811^{a}	110^{b}	331^{b}	1252^{b}	27.26^{b}	15960^{a}	6170^{a}	38.22^{a}
SE	10.5	2.4	3.1	11.6	3.6	1.38	1.48	27.52

GDD, Growing degree days; DDPCA, degree days from planting until cluster appearance; DDCAEA, degree days from cluster appearance until ear appearance; DDEAM, degree days from ear appearance until maturity; HSW, hundred seed weight; BY, biological yield; GY, seed yield; HI, harvest index. *Means followed by the same letter (s) within a column are not statistically different at the p = 0.05% level.

was also significantly affected by the planting date. Highest value of BY was observed in the plant planted on the 5th of August (20370 kg ha^{-1}), which was significantly equal to the planting date of 21th July (16820 kg ha^{-1}) and 20th August (15960 kg ha^{-1}). Lowest BY was recorded in the plant planted on the 6th of July (8080 kg ha^{-1}).

The plant planted on the 5th of August produced the maximum (45.26%) harvest index (HI) which was similar to planting date of 21th July (38.6%) and 20th August (38.22%). Minimum HI was observed for the plant that was planted on the 6th of July (26.42%) and it was statistically different from all the other planting dates (Table 3). The data presented in Table 3 shows that the differences for HI of the cultivars under evaluation were statistically different. Among the cultivars, SC 108 (41.98%) presented the maximum HI, which is similar to SC 704 (39.4%) and TVG (39.3%), but significantly different from the other two cultivars. The hybrid SC 301 produced the minimum (30.5%) HI.

DISCUSSION

Environmental factors, especially temperature, are the key agents which influence plant growth and development. Significant differences among different cultivars for GDD explained that different cultivars have varying maturity periods. Environmental factors, especially temperature during the period of seed development and maturation, might have affected yield and yield components. In the present experiment, the maximum seed yield was observed in the plant that was planted late in summer, which progressively decreased to the minimum when the temperature increased (6th July). The results of the present study show that when the temperature decreased (20th August) or increased (6th July) towards the maturity of the plant, the biological and seed yield decreased. Differences among different planting dates might be due to the different climatic conditions which are based on high temperature during the plant life cycle. The present study shows that maize cultivars produced different 100 seed weight; the result also show that the cultivars which remained for longer duration in the field produced higher seed weight as compared to the cultivars which remained for shorter period of time. Andrade (1995) reported that seed weight decreased due to the change in sowing dates. The differences in seed weight might be due to the environmental conditions, mostly observed during the plant life cycle.

Killi and Altanbay (2005) observed that seed weight was significantly affected by the planting dates. The plants planted during the early part of the year (February-April) passed through lower temperature during early phases and completed their life cycle taking longer period, and they had higher seed weight, and the plants planted during the later section of the year, July-August, had higher temperature during the early phases and completed their life cycle rapidly, and therefore had lower seed weight.

The seed yield is the function of combined effect of all the yield components under the influence of a particular set of environmental conditions. The seed yield increased little by little with the delay in planting date; the lowest seed yield was obtained at early planting date and in delay planting date, seed yield was decreased. The delay in planting gradually decreased the yield because of decrease in temperature at the end of the season.

Conclusion

The results show that maize sown in 5th August was significantly better as compared to July sowing for the studied parameters of growth and yield. The degree day required by maize to reach maturity was dependant on temperature and date of sowing. It is therefore better to sow the plant by first of August at the environmental conditions of Sistan region, because early sowing date and/or late sowing date can result in less yield. This lower yield can be seen in an unfavorable temperature condition. The results show that SC 704 has the highest biological yield, seed yield and harvest index. This hybrid had the highest GDD as compared to other cultivars. Thus, suggesting the use of SC 704 and sowing on the 5th of August in Sistan region.

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