MAIZE PLANTING WINDOW: THE FLORAL, SEED YIELD AND SEED QUALITY IMPACTS

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Abstract: The present investigation evaluated the effect of planting dates on floral traits and seed yield in hybrid seed production of maize conducted during *Kharif*, 2012. The female (BML 6) and male (BML 7) parents of DHM 117 were planted at fortnightly intervals (from 1st June to 15th September) in 4:1 row ratio in RBD with three replications. The results showed that first pollen shed (57.3 days), 50 % pollen shed (60.7 days),first silking (54.3 days) and 50 % silking (59.7 days) were early when maize was sown during August second fortnight, while high pollen viability (97.52 per cent) was recorded during June second fortnight. Sowing in June second fortnight recorded significantly high number of seeds row^{-1} (30.1) and cob yield plant^{-1} (114.74 g). Sowing in August first fortnight recorded significantly high seed yield plant^{-1} (88.11 g). The germination per cent (99 per cent) was high during the second fortnight of June and root length (15.3 cm), shoot length (10.7 cm) and total seedling length (26.0 cm) was comparatively more during June first fortnight. It was determined that, June 15th and August 1st sowings were better for achieving maximum synchronization of male and female lines and also realizing good seed yield

Keywords: Floral behaviour, Maize, Seed quality, Seed yield and Sowing dates

Introduction: Maize (*Zea mays* L., 2n=24) occupies third position among the cereal crops after rice and wheat in world. It is a versatile crop with wider adaptability in varied agro-ecologies. Yield and the development of seed depend on genetic, environmental and agronomic factors as well as the interaction between them (Sidlauskas and Bernotas, 2003). Therefore, there is a scope to increase the yield level of maize by using hybrids and by adopting proper management practices such as date of seeding, seed rate, irrigation, fertilizer application and other cultural operations. Successful seed production of maize requires an understanding of various management practices as well as environmental conditions that affect crop performance (Eckert, 1995). Selection of appropriate planting window is the non monetary and free input in seed production. Environmental changes (sunshine, temperature and relative humidity) associated with different sowing dates, have a modifying effect on the growth and development of maize. Each hybrid has an optimum sowing date and greater the deviation from this optimum (early or late sowing), the greater the yield loss (Sarvari and Futo, 2000; Berzsenyi and Lap, 2001). Planting date was reported to affect the growth and yield of maize significantly. Proper selection of sowing date can optimize maize yield. In India less work has been done on the effect of sowing date on performance of maize. Therefore, present work was carried out to identify the possible causes of yield differences in different sowing dates and also to study the effect of sowing dates on floral behaviour, seed yield and seed quality of maize.

Materials And Methods:

Scope of the Study: The present experiment was carried out at Seed Research and Technology Centre, Rajendranagar, Hyderabad during Kharif, 2012-2013. The parental lines of recently released maize hybrid, DHM 117 (Female: BML 6 and Male: BML 7) were sown in different planting dates with fortnightly intervals i.e. from June 1st to September 1st in three replications at 4:1 (female: male) row ratio in an equal plot size of 49.25 m2. All the recommended agronomic practices were followed to raise a healthy crop.

Data Collection: The meteorological data (temperature, rainfall, relative humidity and sunshine hours) during planting period at fortnightly interval were collected and presented in Table 1. Observations on floral behaviour were calculated and the averages were expressed in days. Days to first pollen shed and 50 % pollen shed: The date on which the first tassel shed its pollen and 50 per cent pollen shed in 50 % of male plant population , respectively was recorded and days were calculated from the date of sowing.Days to first silking and 50 % silking: Number of days taken for the emergence of first silk, 50 % emergence of silk in 50 % of female plants, respectively from the female parent was recorded and days were calculated from the date of sowing.

Pollen viability (%): Pollen grains were collected at two intervals i.e. at 9 A.M and 2 P.M and were tested for pollen viability using iodine-potassium iodide solution (I-KI) (Charles and Harris, 1972). This solution was prepared using 1 g potassium iodide (KI) + 0.5 g iodine (I) dissolved in 100 ml distilled water. The pollen counts were made few minutes after pollen grains were placed on IKI solution under low power (10X) of a microscope. The viable pollen turns to dark blue colour, where as non viable pollen remain yellow in colour. Three sides were prepared for each replication and for each slide three microscopic fields were identified and the total number of viable and non viable pollen grains (in each field) was recorded and percentage is calculated. Various seed yield parameters like number of rows per cob, number of seeds per cob, seed yield per plant (g), cob yield per plant (g), 100 seed weight (g) and shelling percentage were calculated on ten randomly selected plants after harvest. Seeds were cleaned, dried and analyzed for various seed quality parameters like germination percentage by between paper method as per the procedure described by ISTA (1985), root length (cm), shoot length (cm), total seedling length (cm) and seedling vigour indices I and II (Abdul-Baki and Anderson, 1973).

Data Analysis: Analysis of variance (ANOVA) was used to compare differences between the various planting dates. The significant difference of sowing dates means were determined using least significance difference (LSD) at both 5% and 1 % level of probability (Steel and Torrie, 1980). The data was statistically analyzed using randomized block design as per procedure given by Panse and Sukhatme (1985).

Results And Discussion:

Floral Behaviour: The days of planting differed significantly for days to first pollen shed, days to 50 per cent pollen shed, days to first silking, days to 50 per cent silking and pollen viability at both 5 % and 1 % levels of significance (Table 2). The first pollen shed was early in August second fortnight sowing (57.3 days) followed by June second fortnight (60.7 days) and were significantly different from each other. Similarly, 50 per cent pollen shed was observed early in August second fortnight sowing (60.7 days) and was significantly different from June second fortnight (64.7 days). Comparatively, high temperature (32.50 °C), low relative humidity (60.30 per cent) and very less rainfall (0.3 mm) conditions prevailed during the June first fortnight sowing causing poor growth of the plants. As the temperature has reached high limits for the crop, the rate of food used by respiration might have exceeded the rate at which food was manufactured by photosynthesis causing delay in growth habit of the crop. In common, pollen viability was more at 9 AM (95.2 percent) than at 2 PM (91.8 per cent). Generally dehiscence normally occurs in mid-morning and as the temperature is typically increasing, relative humidity decreasing, and radiation load increasing pollen loses viability quickly. Hence, decrease in pollen viability at 2 PM was observed. Sowing in June second fortnight recorded higher pollen viability (97.5 per cent) followed by August second fortnight (97.3 per cent) sowing and was statistically on par with each other and with other sowing dates except July sowings (Fig 1). Pollen viability was more in early plantings (June) and slowly decreased for July sowings and further increased during late sowing (August and September). Changes that occurred in the weather conditions i.e. high rainfall of 16.6 mm coupled with low sunshine hours (6.3) might have contributed to low pollen viability for July sowings. In contrast, Schoper *et al*. (1986) reported that high temperatures had negative effect on pollen viability in maize. Similarly, Vara Prasad *et al*. (2006) also reported that growing grain sorghum at temperatures beyond 36 °C significantly decreased pollen production and pollen viability. Lower pollen viability at high temperatures could be related to degeneration of tapetum layer (Suzuki *et al*., 2001), and/or decreased carbohydrate metabolism (Datta *et al*., 2001) and this could significantly influence nourishment of pollen mother cells thereby leading to infertile pollen. Sowing in August second fortnight recorded significantly higher pollen viability at 2 PM (96.5 per cent) followed by June first fortnight (96.3 per cent), September first fortnight (94.6 per cent) sowing and June second fort night sowing (93.9 per cent) and were significantly different from pollen viability recorded in July and first fort night of August. Wide variations noticed in minimum and maximum temperatures during July and first fortnight of August might have led to decreased pollen viability. Pressman *et al*. (2002) reported that the effect of heat stress on pollen viability was associated with carbohydrate metabolism during anther development. Under optimal temperature soluble sugar concentration gradually increased in pollen. Continuous high temperature prevented the increase in starch concentration and led to decrease in soluble sugar in mature pollen. These reasons possibly caused the decrease in pollen viability. It has been concluded that continuous high temperature reduced the total number of pollen, pollen germination and viability.First silking was early in August second fortnight sowing (54.3 days) followed by June second fortnight (56.7 days) whereas, 50 per cent silking was early in August second fortnight sowing (59.7 days) and was significantly different from September first fortnight (64.3 days). During the August second fortnight sowing, maize crop was subjected to optimum temperature (26.31 ºC), comparatively high relative humidity (85.63 per cent) and high rainfall (4.6 mm), which enhances the crop vegetative growth, so that the plants may reach the reproductive phase very quickly. This was supported by Tamura *et al*. (1989) who reported that environmental parameters like temperature and rainfall had a significant effect on flowering behaviour of maize where in development of silk and air temperature followed a sigmoid curve and days to flowering had a negative correlation with temperature. William *et al*.

(1977) reported that differences in development rate from time of planting to half-silk (when 50 per cent of plants have silked) varied by location and planting date within a location.

Seed Yield: The yield and yield attributing characters such as number of rows per cob, cob yield per plant, seed yield per plant differed significantly with different dates of sowing at 5 % level of significance (Table 3). Non significant difference in number of rows per cob was noticed with dates of sowing except when the crop was sown in July which recorded less number of rows per cob. High rainfall and low bright sunshine hours must have indirectly contributed to less number of rows per cob. This was further confirmed by low pollen viability and improper synchronization between male and female parents which might have contributed to decrease in yield attributing characters. The number of rows per cob was more in September first fortnight sowing (15.6) followed by June second fortnight (15.5) and August second fort night sowing (15.4) and was significantly different from July sowings. Higher number of rows per cob could be due to the correct synchronization between the male and female parents, high pollen viability and moderate temperatures (about 26 ºC) during these planting dates. Similar results had been obtained by Green *et al*. (1985) who reported that a delay in planting date beyond a given optimum date resulted in a progressive reduction in the yield and yield components of the crop because of increased proportion of the available solar radiation was not intercepted by the crop canopy. Sowing in June second fortnight recorded significantly high number of seeds per row (30.1) and was different from other sowing dates like June first fortnight (26.5) and August first fortnight (25.5) sowing. The reason might be due to high pollen viability and proper synchronization between male and female parents which could have resulted in more number of seeds per row during June second fortnight sowing. Otegui and Melon (1997) found that variation in planting dates influenced the number of grains per ear and number of cobs per plant. The authors reported that higher cob number per plant for maize planted earlier in the season than maize planted later in the season. The increase in seeds per cob or seeds per row at optimum planting date was in contrast with results of Harris *et al*. (1984) who found that variation in planting date had negligible influence on the number of seeds per cob. Significantly higher cob yield per plant was recorded for June second fortnight sowing (114.74 g) followed by September first fortnight (109.54 g), August first fortnight (104.85 g) and June first fortnight (104.61 g) and were significantly different from other sowing dates. The decrease in cob yield per plant during July first fortnight sowing may be due to less crop growth as depicted in plant height, leaf area and other leaf characters, there by significantly reducing the amount of photosynthates that can be translocated from source (leaves) to sink (seeds) and thus retarded the growth and development of cobs. Previous investigations on the effect of planting date on grain yield and yield components have found a positive correlation between cob weight, number of seeds per row and seed yield (Ahmadi *et al*., 1993). Otequi *et al*. (1995) reported that optimum planting date resulted in higher grain yield than early and late planting dates because of higher cob number and greater seed number per cob. This could be attributed to the fact that there was enough rainfall and temperatures during the crop growth period at the specific location.Seed yield per plant is an important criterion which is based on the synchronization of female and male parents. Non significant differences were noticed in seed yield per plant between June, August first fortnight and September first fortnight sowing. Sowing in August first fortnight recorded significantly high seed yield per plant (88.11 g) followed by June first fortnight (87.10 g) and June second fortnight (86.52 g). It was noticed that delay in sowings from June second fort night to July first fortnight decreased total seed yield per plant by 32 per cent. June sowings were more appropriate than the July sowings because there was a drastic reduction in the seed yield during July first fort night sowing (58.64 g) and July second fort night sowing (70.04 g). There are several reasons for such inconsistencies and unexpected results. First, the soil conditions at different planting dates will inevitably be different and unfavorable conditions (excess or deficiency of soil moisture and soil nutrients etc.) can occur at almost any point during the normal planting dates. Consequently, the observed differences in the performance of crops sown on different dates are commonly a reflection of differences in established plant density. Secondly, crops sown at different dates pass through each developmental stage at slightly different times and, therefore, under different environmental conditions (especially photoperiod and temperature); thus any one of the developmental stages which determine the components of yield could conceivably occur under more or less favorable conditions in late-sown crops. These findings were supported by Rastegar (2004) who reported that delay in sowing from April 25th to June 9th decreased total yield of corn by 38 per cent. Lobell and Asner (2003) evaluated maize and soybean production relative to climatic variation in the United States, reported a 17 percent reduction in yield for every 1 ºC rise in temperature, but this response is unlikely because the confounding effect of rainfall was not considered. Also, Kresovic *et al*. (1997) in sweet corn suggested that delay in sowing from June 21st to July 11th decreased total yield of corn as second crop. The results obtained concur partly with observations made by Namakka *et al.* (2008) who reported that the total yield decreased with delay in sowing of maize.

Seed Quality Characters: Good quality seed is the most important basic input and is characterized in terms of germination and vigour. Seed quality characters such as germination percentage, root length, shoot length, total seedling length and seedling vigour index II were significantly different for dates of sowing at 5 per cent level of significance (Table 4). High germination per cent (99 per cent) was recorded during the second fortnight of June followed by first fortnight of June (97 per cent) and significantly differ from first fortnight of July and August sowings. The variation between the germination percentages of different sowing dates might be due to variation in environmental conditions during seed filling stage which leads to prevention of expression of seed quality characters. The seedling vigour index was the one of the most important vigour parameter to know the potentiality of the seed. Maize sown during the June first fortnight (2519) recorded highest seedling vigour index I and was on par with August sowings (2234 and 2458). Sowing in first fortnight of August was found superior for majority of seed quality characters like shoot length (11.6 cm), total seedling length (25.1 cm) and seedling vigour index I (2234) while sowing in second fortnight of June exhibited superiority for seedling dry weight (0.32 g), seedling vigour index I (2324) and seedling vigour index II (31.39).

Conclusion: Thus, based on the results obtained, it may be concluded that sowing date significantly influenced the floral behaviour, yield attributing characters and seed quality parameters in maize seed production. Sowing of maize hybrid in June second fortnight and August first fortnight was found optimum and highly munerative as it recorded maximum synchronization between male and female lines, recorded high seed yield and yield attributing characters besides good germination and seedling vigour index.

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Fortnightly distribution of mean maximum, mean minimum, mean temperature (°C), rainfall (mm), relative humidity (%) and sunshine (hours) during crop growth period from June to September first fortnight.

Date of Sowing	Min. temp. (° C)	Max temp. (° C)	Mean temp. (° C)	Relative humidity (%)	Rainfall (mm)	Sunshine (Hours)
Jun first fortnight	27.0	38.0	32.50	60.30	0.3	7.4
Jun second fortnight	24.0	32.2	28.10	82.90	9.0	3.6
Jul first fortnight	23.4	31.2	27.30	80.60	4.0	4.6
Jul second fortnight	22.8	29.2	26.00	73.10	12.6	1.7
Aug First fortnight	22.5	30.2	26.35	87.27	1.7	5.5
Aug second fortnight	22.5	30.1	26.31	85.63	4.6	4.5
Sep first fortnight	22.2	29.3	25.70	88.90	4.7	4.6

Table 2: Flowering behaviour of the parental lines of maize hybrid, DHM 117 during *Kharif*, 2012

Date of Sowing	Days to first tasseling	Days to 50 % tasseling	Days to first silking	Days to 50 % silking	Pollen Viability (%)	
					9 AM	2 PM
01-06-2012	66.3	68.0	59.3	70.7	96.7	96.3
15-06-2012	60.7	64.7	56.7	72.3	97.5	93.9
01-07-2012	65.3	69.7	67.5	70.0	93.2	85.6
15-07-2012	65.7	68.0	61.5	69.3	90.7	83.1
01-08-2012	62.7	75.3	59.7	71.3	95.4	92.6
15-08-2012	57.3	60.7	54.3	59.7	97.3	96.5
01-09-2012	62.7	66.0	59.3	64.3	95.2	94.6
Gr. Mean	62.95	67.47	59.66	68.23	95.15	91.80
S. Em +	0.926	0.792	1.011	0.640	0.910	1.165
S. Ed	1.309	1.120	1.429	0.905	1.287	1.648
C.D. (0.05)	2.854	2.441	3.115	1.974	2.805	3.592
C.V. (%)	2.547	2.033	2.933	1.625	1.657	2.198

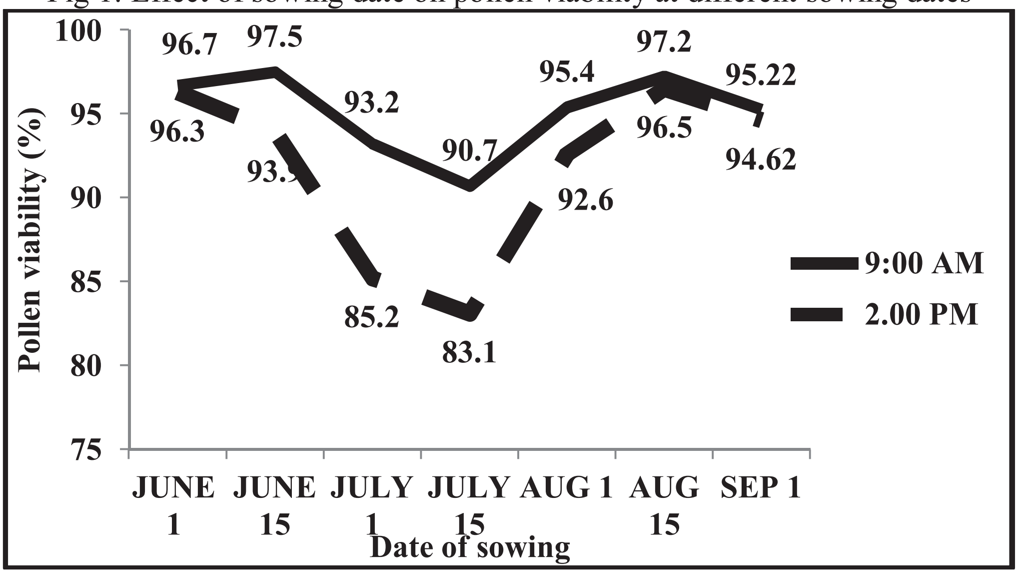
Table 3: Yield and yield components of maize hybrid, DHM 117 during *Kharif*, 2012

Date of Sowing	No. of rows per cob	No. of seeds per row	Cob yield per plant (g)	Seed yield per plant (g)	Shelling percentage (%)	100 seed weight (g)
01-06-2012	14.8	26.5	104.61	87.10	83.2	24.31
15-06-2012	15.5	30.1	114.74	86.52	82.0	24.63
01-07-2012	14.5	23.4	73.34	58.64	79.8	20.63
15-07-2012	14.6	23.8	88.02	70.04	79.5	21.91
01-08-2012	14.9	24.6	104.85	88.11	84.1	25.26
15-08-2012	15.4	25.5	98.24	73.03	74.5	23.77
01-09-2012	15.6	24.2	109.54	79.25	72.4	25.05
Gr. Mean	15.04	25.43	99.05	77.52	79.36	23.65
S. Em +	0.300	0.806	3.946	3.740	3.686	1.594
S. Ed	0.424	1.140	5.579	5.289	5.212	2.254
C.D. (0.05)	0.925	2.486	12.162	11.529	11.363	4.914
C.V. (%)	3.453	5.491	6.900	8.356	8.045	11.675

Table 4: Seed quality characters of maize hybrid, DHM 117 during *Kharif*, 2012

Date of Sowing	Germination percentage	Root length (cm)	Shoot length (cm)	Total seedling length (cm)	Seedling dry weight (g)	SVI I	SVI II
01-06-2012	97	15.3	10.7	26.0	0.29	2519	28.18
15-06-2012	99	13.7	9.6	23.4	0.32	2324	31.39
01-07-2012	80	14.2	9.8	24.1	0.16	1909	12.51
15-07-2012	90	13.0	10.3	23.3	0.18	2108	16.06
01-08-2012	89	13.6	11.6	25.1	0.16	2234	14.06
15-08-2012	93	15.4	11.0	26.5	0.27	2458	24.60
01-09-2012	91	12.95	8.6	21.5	0.27	1962	24.45
Gr. Mean	91.2	14.02	10.21	24.27	0.23	2216.3	21.604
S. Em +	2.806	0.422	0.422	0.685	0.019	106.991	1.5981
S. Ed	3.967	0.597	0.596	0.968	0.027	151.285	2.25971
C.D. (0.05)	8.648	1.301	1.300	2.111	0.059	329.801	4.92617
C.V. (%)	5.329	5.213	7.148	4.886	14.185	8.36112	12.8119

Fig 1: Effect of sowing date on pollen viability at different sowing dates



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