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Performance of Maize (*Zea mays* L.) Hybrids with Respect to Growth Parameters and Phenological Stages under Different Sowing Dates in Kharif Season

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A B S T R A C T

The experiment consisting of four dates of sowing (15th June, 25th June, 5th July and 15th July) in main plot and five maize (*Zea mays* L.) hybrids of different maturity group namely, HQPM-1 (long), HM-4 (medium), HM-5 (long), HM-6 (early) and HM-7 (extra early) in sub plot was replicated three times in split plot design. Ten days advance, normal and 10 days delay sowing being at par recorded significantly higher plant height, dry matter, crop growth rate, as compared to delay in sowing by 20 days from normal sowing. Plant population and relative growth rate did not differ significantly due to date of sowing. Among hybrids, HM-5 recorded highest dry matter followed by HQPM-1, HM-4, HM-6 and lowest in case of HM-7. HM-5 recorded higher crop growth rate from 60 DAS to maturity. Days to 50 % tasseling, 50 % silking and maturity were delayed in last date of sowing. HQPM-1 recorded highest plant height at harvest followed by HM-4, HM-7, HM-6 and lowest in HM-5. HM-6 and HM-7 recorded lowest crop growth rate between 60 DAS to harvest. HM-7 and HM-6 took lower number of days to attain 50 % tasseling, 50 % silking and maturity stage. HQPM-1 and HM-5 being at par took higher number of days to 50 % tasseling, 50 % silking and maturity as compared to HM-4.

Introduction

Globally, maize (*Zea mays* L.) is referred as 'Miracle crop' or 'Queen of the Cereals' due to its high productivity potential compared to other Gramineae family members. Maize is the third most important food grain in India after wheat and rice. In India, about 28% of maize produced is used for food purpose, 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry (e.g. starch and oil production) and 1% as seed (Anonymous, 2007). In India, during 2012-13 maize was grown over an area of 8.7 million ha with production and productivity of 21.76 million tonnes and 2510 kg/ha, respectively (USDA, 2012). Maize was grown in Haryana during 2012 over an area of 20,000 ha with productivity of 2610 kg/ha (Anonymous, 2012). However its area fluctuates between 10,000-20,000 ha. The main reasons for fluctuation in acreage and production of this crop during *kharif* season are: deficit or excess moisture, prevailing high temperatures, cloudiness which favour incidence of insect pests, weeds, diseases and

restricts sunshine hours for photosynthesis, rainfall which washes off the pollens and leaches the fertilizers nutrients. The productivity level of maize can be increased further due to the availability of single cross hybrids of different maturity durations which are best suited to different climatic conditions and soil types.

Two important components of maize cropping systems are plant variety and planting date. Proper selection of these components can help in improving maize yields. Maize grain yield potential has dramatically increased during the last 50 years especially in the temperate regions of the world (Russel, 1991 and Tollenaar *et al.,* 1994). This yield enhancement can be attributed largely to the release of genetically superior hybrids, reduction of row spacing, higher plant densities, increased use of chemical fertilizers, improved cultural practices and better weed and pest management (Carlon and Russel, 1987 and Dwyer *et al.,* 1991). Planting date is one of the most important aspects of management in agricultural system, which can affect yield through influencing emergence date, plant density, normal growth, pollination and maturity date. Delaying planting date ends in decreased in maize grain yields (Panahi *et al.,* 2010). Contarero *et al.,* (2000) reported that delayed sowing reduced number of ears, number of grains per ear and grain yield of maize crop. Khan *et al.,* (2002) reported that delaying planting date would lead to a lesser number of grain row in the maize and also a lesser number of grains in the rows.

Today, the challenge for maize growers is to find the narrow window between planting too early and planting too late. Farmers who plant maize early are concerned about high temperature and early plant growth. On the other hand, farmers who plant late are concerned about different maturity hybrids, and how the late planting will affect the final grain yield and grain moisture. Hence, it was realized to evaluate promising maize hybrids under different dates of sowing for Haryana condition to boost maize production.

Materials and Methods

The field experiment was conducted during 2012-13 at Regional Research Station, Karnal, CCSHAU, Haryana, situated in semi-arid, sub-tropics at 29°43'N latitude and 76°58'E longitude at an altitude of 245 meters above the mean sea level. The soil of experimental field was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The experiment consisted of four dates of sowing (15^{th} June -10 days before normal date of sowing**,** 25^{th} June -Normal date of sowing, 5^{th} July -10 days after normal date of sowing and 15^{th} July -20 days after normal date of sowing) in main plot and five hybrids of different maturity groups [HQPM-1 Late maturity, HM-5 (Late maturity), HM-4 (Medium maturity), HM-6 (Early maturity), HM-7 (Extra early maturity)] in sub plots was replicated three times in split plot design. All the cultural practices were followed from sowing till harvesting as per the recommended package and practices of CCSHAU, Hisar.

Plant stand (000 /ha), plant height (cm), dry matter accumulation (g/plant), crop growth rate (g/m^2/day), relative growth rate (g/g/day) and phenological stages were calculated for all the treatments. All the experimental data were statistically analyzed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1978). The significance of treatment effects was tested with the help of 'F' (variance ratio) test. Appropriate standard errors along with critical differences (CD at 5%) were recorded for differentiating the treatment effects.

Results and Discussion

Growth studies: Effect on growth parameters

The data indicated that sowing dates and hybrids did not show significant effect on plant stand at 15, 30, 45, 60 days after sowing (DAS) and at harvest. There was marginal reduction in plant stand with the advancement of crop growth. Similar plant stand in all the dates of sowing was due to assured germination, manual sowing of seed by dibbling method at proper soil environment and assured irrigation facilities throughout the crop growth period (Table 1). Similarly, Anonymous (2012) and Singh *et al.,* (1992) also showed no difference in plant stand under different dates of sowing in maize crop. In general, plant height increased with advancement of crop growth. The magnitude of increase was nearly two times between 15 and 30 DAS, 3 times between 30 and 45 DAS and the increase was marginal between 60 DAS and at harvest irrespective of the dates of sowing and hybrids. The 10 days advance, normal and 10 days delayed sowing being at par registered significantly higher plant height at all crop growth stages over the delayed sowings by 20 days after normal sowing dates. It was mainly due to prevailing high maximum and minimum temperature, which resulted in quick growth of the plants in early dates of sowing since temperature plays a key role in the physiological and morphological development of the crops (Table 2). Similar results had been reported by Panahi *et al.,* (2010) and Azadbakht *et al.,* (2012). Plant height also varied significantly due to hybrids at all the growth stages. At all crop growth stages HQPM-1, HM-4, HM-6, HM-7 being at par had significantly higher plant height as compared to hybrid HM-5. Difference in plant height of different hybrids had been reported by Beiragi *et al.,* (2011). Dry matter increased as the crop growth advanced and the magnitude of increase was nearly five times between 15 to 30 DAS, two times between 30 to 45 DAS and it was at slower rate between 60 DAS to at harvest stage. 10 days advance, normal and 10 days delayed sowing being at par accumulated significantly higher dry matter at all crop growth stages over the delayed sowings by 20 days after normal sowings. It was attributed to prevailing high maximum and minimum temperature which resulted in quick growth of the plants resulting in higher plant height, leaf area and leaf number and ultimately higher dry matter accumulation in early dates of sowing.

Dry matter accumulation differed significantly due to different hybrids at all the crop growth stages. At 15 DAS, HM-7 recorded significantly highest dry matter among all the hybrids and the next in order were HM-6, HQPM-1, HM-5and HM-4. Significantly lower dry matter was recorded in hybrids HM-4. Hybrid HQPM-1, HM-4, HM-6 and HM-7 accumulated more dry matter at 30 and 45 DAS as compared to HM-5. At 60 DAS and final harvest stage, HM-5 accumulated highest dry matter followed by HQPM-5, HM-4, HM-6 and lowest in HM-7 (Table 3). The variation in dry matter of different hybrids at different growth stages was attributed to variation in plant height and speed of growth at that time. Variation in dry matter of hybrids had also been reported by Sangoi and Salvador (1998).

The CGR increased up to 60 DAS and thereafter it showed a declining trend in different dates of sowing and hybrids (Table 4). CGR was comparatively higher in first three dates of sowing at all the crop growth stages as compared to delayed sowing by 20 days after normal sowing dates. Hybrid HM-7 (0.134 $g/m^2/day$) recorded higher whereas HM-5 (0.103$g/m^2/day$) recorded lower CGR during initial growth period as compared to other hybrids. HM-5 recorded higher CGR

from 45 DAS onward up to harvest. HM-6 (0.072 g/m^2/day) and HM-7 (0.077 g/m^2/day) recorded lowest CGR between 60 DAS to harvest. The variation in RGR at different growth stages was due to higher accumulation of dry matter at those stages. Similar results have been reported by Dahmardeh (2010).

RGR did not differ significantly on account of dates of sowing. Hybrids differed significantly in terms of RGR at 15-30 DAS, 45-60 DAS and 60 DAS-harvest. HM-4 recorded higher value of RGR in initial growth stages as compared to rest of the hybrids. The hybrids HM-5, HM-6 and HM-7 were found at par in term of RGR during initial growth stages. Variation in RGR in different hybrids was attributed to difference in speed of growth of hybrids at that time (Table 5).

Phenological studies: Effect on phenological development

The perusal of data presented in Table 6 indicated that days to 50 % tasseling differed significantly due to dates of planting and hybrids. Days taken to 50 % tasseling were delayed with delay in sowing by 20 days from normal sowing time as compared to 10 days advance, normal and 10 days delayed sowing and the later three being at par.

Among hybrids, HM-7 (50.8 days) and HM-6 (51.6 days) took lesser number of days to attain 50 % tasseling stage. HQPM-1 (55.8 days) and HM-5 (55.7 days) being at par took higher number of days to 50 % tasseling as compared to HM-4 (54.3 days). Days to 50 % silking also varied significantly due to dates of planting and hybrids. The 50 % silking was delayed with delay in sowing by 20 days from normal sowing time as compared to 10 days advance, normal and 10 days delayed sowing and the later three dates being at par. Among hybrids, HM-7 (53.3 days) and HM-6 (54.2 days) took lower number of days to attain 50 % silking stage. HQPM-1 (58.3 days) and HM-5 (58.1 days) being at par took higher number of days to 50 % silking as compared to HM-4 (56.7 days).

Table.1 Effect of dates of sowing and maize hybrids on plant stand (000/ha)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Dates of sowing					
15th June	61.1	60.7	60.2	59.9	59.6
25th June	61.3	60.9	60.4	60.1	59.8
5th July	60.9	60.5	60.0	59.7	59.4.
15th July	60.9	60.5	60.0	59.7	59.4
SEm±	0.2	0.2	0.2	0.2	0.2
CD (P=0.05)	NS	NS	NS	NS	NS
Hybrids					
HQPM-1	61.3	60.9	60.4	60.1	59.8
HM-4	60.8	60.4	59.9	59.6	59.3
HM-5	60.8	60.4	59.9	59.6	59.3
HM-6	61.1	60.7	60.1	59.9	59.6
HM-7	61.3	60.9	60.4	60.1	59.7
SEm±	0.2	0.2	0.2	0.2	0.2
CD (P=0.05)	NS	NS	NS	NS	NS

Table.2 Effect of dates of sowing and maize hybrids on plant height (cm)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Dates of sowing					
15th June	23.2	51.1	155.1	185.7	191.5
25th June	23.0	50.7	153.6	183.4	188.8
5th July	22.3	49.6	151.8	181.3	186.5
15th July	18.8	35.5	118.7	145.8	153.8
SEm±	0.4	0.7	2.3	3.0	2.4
CD (P=0.05)	1.2	2.3	7.9	10.5	8.3
Hybrids					
HQPM-1	22.5	48.8	146.5	180.3	185.4
HM-4	22.2	48.2	149.2	178.4	183.8
HM-5	20.1	42.4	137.0	159.3	167.4
HM-6	22.3	47.3	144.9	176.6	181.9
HM-7	22.1	47.0	146.6	175.8	182.3
SEm±	0.5	1.2	2.4	2.2	2.3
CD (P=0.05)	1.3	3.4	7.1	6.3	6.6

Table.3 Effect of dates of sowing and maize hybrids on dry matter (g/plant)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Dates of sowing					
15th June	7.4	37.7	79.6	122.3	153.7
25th June	7.3	37.0	78.2	121.0	152.2
5th July	7.2	36.4	77.4	119.8	150.0
15th July	5.7	29.3	62.7	99.7	120.1
SEm±	0.05	0.5	1.2	1.3	1.6
CD (P=0.05)	0.16	1.6	4.1	4.4	5.6
Hybrids					
HQPM-1	6.5	35.8	76.4	134.0	167.9
HM-4	5.8	35.3	76.0	107.8	139.1
HM-5	6.5	29.6	63.5	133.5	172.2
HM-6	7.6	36.3	76.3	102.4	122.6
HM-7	8.1	38.3	80.2	100.7	118.2
SEm±	0.12	0.6	1.3	1.1	1.3
CD (P=0.05)	0.36	1.8	3.7	3.1	3.9

Table.4 Effect of dates of sowing and maize hybrids on crop growth rate (g/m2/day)

Treatments	15-30 DAS	30-45 DAS	45-60DAS	60 DAS-At harvest
Dates of sowing				
15th June	0.134	0.186	0.189	0.095
25th June	0.132	0.184	0.190	0.094
5th July	0.130	0.182	0.188	0.086
15th July	0.105	0.148	0.165	0.050
SEm±	0.002	0.004	0.005	0.002
CD (P=0.05)	0.007	0.012	0.017	0.006
Hybrids				
HQPM-1	0.130	0.181	0.256	0.080
HM-4	0.131	0.180	0.142	0.090
HM-5	0.103	0.151	0.311	0.088
HM-6	0.128	0.178	0.116	0.072
HM-7	0.134	0.186	0.091	0.077
SEm±	0.002	0.004	0.005	0.003
CD (P=0.05)	0.008	0.010	0.018	0.008

Table.5 Effect of dates of sowing and maize hybrids on relative growth rate (g/g/day)

Treatments	15-30 DAS	30-45 DAS	45-60DAS	60 DAS-At harvest
Dates of sowing				
15th June	0.047	0.022	0.012	0.005
25th June	0.047	0.022	0.012	0.005
5th July	0.047	0.022	0.013	0.004
15th July	0.047	0.022	0.013	0.003
SEm±	0.0004	0.0002	0.0005	0.009
CD (P=0.05)	NS	NS	NS	NS
Hybrids				
HQPM-1	0.049	0.022	0.016	0.003
HM-4	0.053	0.022	0.010	0.005
HM-5	0.044	0.022	0.022	0.004
HM-6	0.045	0.022	0.009	0.003
HM-7	0.045	0.021	0.007	0.004
SEm±	0.0007	0.0002	0.0005	0.0001
CD (P=0.05)	0.002	0.001	0.002	0.0002

Table.6 Effect of dates of sowing and maize hybrids on days to 50 % tasseling, days to 50 % silking and days to maturity

Treatments	Days to 50 % tasseling	Days to 50 % silking	Days to maturity
Dates of sowing			
15th June	52.6	54.4	82.0
25th June	53.1	55.1	82.1
5th July	53.7	56.7	83.0
15th July	55.4	58.4	86.1
SEm±	0.3	0.3	0.5
CD (P=0.05)	1.0	1.0	1.7
Hybrids			
HQPM-1	55.8	58.3	88.7
HM-4	54.3	56.7	83.6
HM-5	55.7	58.1	89.6
HM-6	51.6	54.2	79.3
HM-7	50.8	53.3	75.5
SEm±	0.2	0.2	0.4
CD (P=0.05)	0.7	0.7	1.1

Days to maturity varied significantly due to dates of planting and hybrids. Days taken to maturity were delayed with delay in sowing by 20 days from normal sowing time as compared to 10 days advance, normal and 10 days delayed sowing and the later three being at par. Among hybrids, HM-7 (75.5 days) and HM-6 (79.3 days) took lesser number of days to attain maturity stage, whereas HQPM-1 (88.7 days) and HM-5 (89.6 days) being at par took maximum number of days to maturity as compared to hybrid HM-4 (83.6 days).

The data thus revealed that days to attain different phonological stage i.e. 50% tasseling, 50% silking and maturity were similar in normal date of sowing, 10 days advanced and 10 days delayed sowing. Days to different phonological stages were delayed in 4th date of sowing i.e. 20 days delayed from normal date. The earliness in attaining different phenological stage in first three dates of sowing might be due to prevailing high temperature and humidity, which resulted in fast growth of maize crop. The growth rate was slow in 4th date of sowing which resulted in delay in attaining the different phenological stages because of fall in ambient temperature. These finding are in accordance with Badu-Apraku *et al.,* (1983), Ahmed *et al.,* (2000), Williams (2008), Casini (2012) and Amjadian *et al.,* (2013). Similarly variation in phenological stages of hybrids had also been reported by Kagasago (2006) and Tsimba *et al.,* (2013).

In conclusion, based on one year experiment it is concluded that optimum dates of maize sowing in Haryana was June 15 to July 5 as it utilized prevailing weather condition especially temperature for *kharif* season. If there is any deviation from normal onset of monsoon, sowing by 10 days advance and 10 days delay from normal date had no adverse effect on grain yield. Among hybrids HM-7 (extra early), HM-6 (early), HM-4 (medium) and HQPM-1 and HM-5 (long duration) can be grown successfully from June 15 to July 5. HM-5 was found best yielder among all the hybrids under all the dates of sowing.

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