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EFFECT OF SOWING DATES ON GROWTH, PHENOLOGY AND AGRO METEROLOGICAL INDICES FOR MAIZE VARIETIES

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ABSTRACT

An experiment was conducted during *Kharif* season of 2013 at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur to evaluate the effect of sowing dates on growth indices, phenology and agro meterological indices for different maize varieties. Treatments consist of three dates of sowing (June 15, June 30 and July 15) with five maize varieties (HQPM-1, PEHM-2, Pratap Makka-5, Pratap QPM-1 and BIO-9637). The experiment conducted in Split Plot Design (SPD) with four replications. The crop sown on June 15 required significantly higher number of days and accumulated GDD to attain various phenophases compared to June 30 and July 15 sown crops. Higher heat use efficiency, dry matter accumulation and LAI were recorded with the crop sown on June 30 and decreased with delay in sowing. June 30 sown crop recorded grain yield (50.87 q ha^{-1}) significantly higher under June 15 and July 15 sown crops. BIO-9637 required maximum accumulated growing degree days (GDD) to attain different phenological stages of maize except knee high stage. Among the varieties, BIO-9637 recorded grain yield (51.78 q ha^{-1}) significantly higher over HQPM-1, PEHM-2, Pratap QPM-1 and Pratap Makka-5.

INTRODUCTION

Maize is the third most important cereal crop of world and India after wheat and Rice. Maize has been an important cereal crop sowing to its highest production potential and adaptability to wide range of environment hence called as 'Queen of Cereals' (Choudhari and Channappagouda, 2015).

In world maize is cultivated in 146 Mha with production of 685 million tonnes and an average production of 4.7t/ha. In India, maize is cultivated in 8.67 mha with a production of 22.26 mt with an average productivity of 2566 kg/ha, contributing nearly 8% in the national food basket (DACNET, 2014).

It provides food, feed, fodder and serves as a sources of basic raw material for the number of industrial products *viz.*, starch, protein, oil, alcoholic beverages, food sweeteners, cosmetics, more recently as bio-fuel etc. No other cereal is being used as many ways as maize. Maize grain has elevated nutritive value as it contains about 72 % starch, 10 % protein, 4.8 % oil, 5.8 % fiber and 3 % sugar (Rafiq *et al.*, 2010). Maize is grown during South West monsoon season (June-September). As the crop is predominantly grown under rain fed conditions, it is subjected to both biotic and abiotic stresses which are largely influenced by distribution and quantity of rainfall. Weather is one of the key components influencing its production and productivity. Climate variability has a direct, often adverse, effect on the quantity and quality of agricultural production. Temperature, rainfall, humidity, sunshine (day length) are important climatic elements that affect crop production (Sowunmi and Kintola, 2010).

In agriculture, heat units are often expressed as growing degree days (GDD). Sometimes growing degree days are called growing degree units (GDU), but the two terms are identical. Calculating GDD for a specific day uses a simple formula that involves subtracting a base or threshold temperature from the average temperature for the day. The base temperature is the threshold temperature for which plant growth begins. Plant species differ for base temperature. The base temperature for corn is 10ºC (Rao, 2008).

If the crop is sown on several dates of sowing and irrigation is provided on various crop growth stages which are crucial for the growth and development of the crop the results may provide information sufficient to find out the best option with logical understanding (Sharangi and Roychowdhury, 2014). Having these in view it was considered to take the experiment to determine optimum sowing date as well as effect on growth, phenology and agro meterological indices for maize varieties.

MATERIALS AND METHODS

An experiment was conducted during *Kharif* season 2013 at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, situated at South-Eastern part of Rajasthan at an altitude of 582.17 m above mean sea level, at 24º35′ N latitude and 73º42′ E longitude. The region falls under agro-climatic zone IV A "Sub-humid Southern Plain and Aravali Hills" of Rajasthan and agro climatic zone VIII (Central plateau and hills) of India. The annual rainfall was 600.8 mm with maximum and minimum temperatures ranged between 27.1 to 34.7 and 21.4 to 25.8ºC, respectively. The soil of experimental site was clay loam in texture, slight alkaline in reaction (pH 7.9), medium in available nitrogen (250.4 kg ha^{-1}) and phosphorus (22.5 kg ha^{-1}) and high in available potassium (296.8 kg ha^{-1}). The experiment comprised of 15 treatment combinations, consist of three sowing dates (June 15, June 30 and July 15) and five maize varieties (HQPM-1, PEHM-2, Pratap Makka-5, Pratap QPM-1 and BIO-9637). The experiment was laid out in Split Plot Design (SPD) taking dates of sowing in main plots and varieties in sub plot treatments and replicated four times. The line-to-line distance was kept as 60 cm with plant to plant distance of 25 cm with a seed rate of 25 kg ha^{-1}. Normally 100 kg ha^{-1} nitrogen and 40 kg ha^{-1} phosphorus were applied through urea and DAP**,** half dose of the nitrogen and full dose of phosphorus was applied at the time of sowing and remaining quantity of nitrogen was applied in two splits viz., knee high and tassel initiation stage. All data are presented as mean values of four replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth indices

Data Table 1 indicate that the maximum dry matter accumulation $plant^{-1}$ was produced in June 30 sown crop at 30, 60 DAS and at harvest which was significantly superior over June 15 sown crop by 27.1, 14.7 and 9.7 per cent, respectively but at par with July 15 sown crop. Date of sowing did not influence dry matter accumulation $plant^{-1}$ at 15, 45 and 75 DAS. At 15 DAS, the maximum leaf area index (0.09) recorded in June 30 sown crop which was significantly higher over June 15 and July 15 sown crops by 50 and 12.5 per cent, respectively. At 45 DAS, the maximum leaf area index (2.89) was recorded in June 30 sown crop which was significantly higher over June 15 sown crop by 16.5 per cent. The higher leaf area development which is potential site of photosynthesis was largely responsible for increased biomass production in the crop sown on June 30. This might have been resulted in more synthesis of photosynthates, major portion of which was utilized for increasing leaf area and ultimately dry matter accumulation. Plant growth is strongly related to genetic characteristics of the plant and influenced by environmental conditions during the plant growth and development. In the present study higher leaf area index and dry matter accumulation obtained under June 30 sown crop probably caused by interaction of environmental factors (temperature, rainfall and relative humidity etc). The results are in close conformity with the findings of Hara (2003) and Parashar (2011).

The maximum dry matter accumulation $plant^{-1}$ was recorded by Pratap makka-5 at 30 DAS (3.27 g), 45 DAS (39.04 g) and harvest (157.13 g) which was significantly superior over PEHM-2, HQPM-1 and Pratap QPM-1 by 6.2, 9.4, 10 per cent at 30 DAS, 8.1, 12.2 and 14.2 per cent at 45 DAS and 4, 5.3 and 6.1 per cent at harvest, respectively but at par with BIO-9637. The maximum leaf area index was recorded in Pratap Makka-5 which was significantly superior over PEHM-2, HQPM-1 and Pratap QPM-1 by 12.5, 28.6 and 50 per cent at 15 DAS and 8.2, 13.1 and 15.3 per cent at 75 DAS, respectively but at par with BIO-9637.

Yield

An assessment of data (Table 4) indicates that the highest grain yield (50.87 q ha^{-1}) was obtained under June 30 sown crop which was significantly superior over June 15 and July 15 sown crops. Grain yield was reduced due to both early and delay in sowing beyond June 30. Reduction in the crop yield might be due to adverse effects of weather parameters particularly rainfall, temperature and relative humidity on the growth and development of the crop. Generally, environmental variable may over ride genetic influences and as such variations in meteorological parameters at different date of sowing exert their influence on the plant growth and ultimately yield. The early attainment of flowering under early and delayed sowing *i.e.* June 15 and July 15 brought about significant reduction in

Table 1: Effect of date of sowing and varieties on dry matter accumulation and leaf area index of maize

Treatment	Dry Matter Accumulation (g $plant^{-1}$)						Leaf Area Index				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Harvest	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Date of sowing											
June 15	1.57	2.69	35.20	73.46	134.44	144.65	0.06	0.31	1.88	3.07	2.70
June 30	1.65	3.42	37.32	84.83	143.15	158.71	0.09	0.35	2.19	3.21	2.89
July 15	1.61	3.19	36.19	81.04	141.06	153.68	0.08	0.33	2.02	3.09	2.84
SEm ±	0.03	0.07	0.82	1.80	3.20	3.23	0.002	0.01	0.05	0.08	0.07
CD (p=0.05)	NS	0.24	NS	6.23	NS	11.18	0.007	NS	0.19	NS	NS
Varieties											
HQPM-1	1.57	2.99	34.81	80.54	139.61	149.11	0.07	0.31	1.94	3.07	2.67
PEHM-2	1.60	3.08	36.11	78.65	139.91	151.03	0.08	0.34	2.06	3.10	2.79
Pratap Makka-5	1.68	3.27	39.04	83.10	142.89	157.13	0.09	0.36	2.13	3.24	3.02
Pratap QPM-1	1.55	2.97	34.24	76.04	135.30	148.04	0.06	0.29	1.91	3.04	2.62
BIO-9637	1.65	3.19	36.98	80.56	140.05	156.45	0.09	0.35	2.11	3.17	2.95
SEm ±	0.03	0.05	0.78	0.90	1.56	1.51	0.003	0.01	0.03	0.05	0.05
CD (p=0.05)	0.09	0.15	2.23	2.60	4.49	4.34	0.008	0.04	0.10	NS	0.15

NS – Not significant

Table 2: Effect of date of sowing and varieties on days taken to attain phenological stages of maize

Treatment	Phenological stages (days)									
	Emergence	5th leaf	Knee high	1st tassel initiation	50% Tasseling	1st Silk initiation	50% silking	Milking	Dough	Maturity
Date of sowing										
June 15	5.1	10.2	32.7	50.9	53.6	54.5	55.7	68.8	80.9	85.4
June 30	4.0	10.0	29.1	48.8	52.6	51.5	54.3	65.5	81.4	90.0
July 15	5.0	12.1	25.1	48.4	53.9	51.4	55.8	66.7	83.5	92.2
SEm ±	0.14	0.19	0.56	1.09	0.75	1.11	1.12	1.46	1.02	0.81
CD (p=0.05)	0.50	0.66	1.94	NS	NS	NS	NS	NS	NS	2.81
Varieties										
HQPM-1	4.7	10.7	29.1	51.1	55.5	53.9	57.6	68.1	84.0	91.7
PEHM-2	4.6	10.7	28.8	46.8	51.5	52.0	55.0	65.9	81.9	87.1
Pratap Makka-5	4.7	10.8	28.1	46.3	50.2	48.8	52.4	64.9	78.5	83.6
Pratap QPM-1	4.6	10.7	29.4	50.3	54.0	52.3	54.6	67.4	82.2	90.3
BIO-9637	4.9	11.0	29.3	52.4	55.5	55.3	56.7	68.5	82.9	93.3
SEm ±	0.10	0.12	0.47	0.46	0.59	0.63	0.59	0.86	0.72	0.49
CD (p=0.05)	NS	NS	NS	1.33	1.71	1.82	1.70	2.48	2.07	1.41

NS – Not significant

Table 3: Effect of date of sowing and varieties on growing degree day (°C day) during different phenological stages of maize

Treatment	GDD (°C day)								
	5th leaf	Knee high	1st Tassel initiation	50% Tasseling	1st Silk initiation	50% silking	Milking	Dough	Maturity
Date of sowing									
June 15	199	598	909	957	973	991	1205	1419	1489
June 30	187	509	844	894	900	914	1103.	1375	1521
July 15	208	415	791	896	849	954	1112	1394	1517
SEm ±	3	9	13	13	17	21	25	21	15
CD (p=0.05)	11	31	45	45	60	NS	86	NS	NS
Varieties									
HQPM-1	196	515	878	949	936	985	1159	1425	1540
PEHM-2	196	504	813	886	892	943	1123	1397	1483
Pratap Makka-5	198	485	807	867	846	896	1106	1330	1425
Pratap QPM-1	196	519	849	927	908	919	1148	1403	1524
BIO-9637	201	512	892	950	955	1024	1166	1425	1578
SEm ±	2	8	8	9	11	26	15	16	9
CD (p=0.05)	NS	23	23	25	31	75	42	45	27

NS – Not significant

biomass production and shorter period for development of yield attributes. The results are close agreement with the findings of Parashar (2011). Thus, it is evident that the crop sown in the most favourable environmental factors *viz.*, rainfall, relative humidity and soil moisture, therefore attained, higher rate of photosynthetic efficiency. Eventually there was significant improvement in grain yield under June 30 sown crop which ultimately resulted in significant increase in grain yield. These results are in close agreement with the findings of Awasthi *et al.* (2009).

Variety BIO-9637 recorded maximum grain yield (51.78 q ha^{-1}) which were significantly higher over PEHM-2, HQPM-1, Pratap QPM-1 and Pratap Makka-5. It seems that a major portion of the photosynthates of different cultivars was diverted toward economic yield i.e. grain. The results are in close accordance with finding of Leelarani *et al.*, (2013). The positive and significant correlation between grain yield and 1000- grain weight (r = 0.568*), number of grain cob^{-1} (r = 0.538*), GDD at maturity (r = 0.703**) and HUE grain (r = 0.982**) validates this hypothesis. The findings of present investigation are in close agreement with the finding of Khan *et al.* (2011).

Data (Table 4.1) show that under June 30 sown crop, variety HQPM-1 gave the highest grain yield of 56.77 q ha^{-1} which was statistically at par with rest of the varieties except variety Pratap Makka-5. However, under June 15 and July 15 the highest grain yield was recorded by variety BIO-9637 (48.69 and 52.46 q ha^{-1}). Under July 15, variety Pratap QPM-1, BIO-9637 and HQPM-1 were statistically at par with respect to grain yield but these varieties were significantly superior to PEHM-2 and Pratap Makka-5. Variety HQPM-1 gave the highest grain yield of 56.77 q ha^{-1} under June 30 sowing which was significantly superior to June 15 (33.58 q ha^{-1}) and July 15 (49.69 q ha^{-1}) sown crops. Variety PEHM-2 also gave maximum grain yield under June 30 sowing which was significantly superior to June 15 and July 15 sown crops. Variety Pratap Makka-5 and BIO-9637 performed equally in all sowing dates.

Phenology indices

Data (Table 2) show that date of sowing brought about significant variation in number of days taken to attain emergence, fifth leaf, knee high and maturity stage. The crop sown on June 15 took significantly higher number of days (5.1) of emergence and knee high (32.7) as compared to June 30 (4) and June 30 (29.1) and July 15 (25.1) sown crops except fifth leaf and maturity stage. The phonological studies revealed that delayed sowing on July 15 required significantly less number of days for initiation and completion of the

Table 4: Effect of date of sowing and varieties on heat use efficiency (HUE) and grain yield of maize varieties

Treatment	Heat use efficiency (kg ha^{-1} ^{0}C^{-1} day^{-1})								Grain yield
	Dry matter basis						Yield basis		
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Harvest	Biological	grain	(q ha^{-1})
Date of sowing									
June 15	0.34	0.34	2.81	4.53	6.63	6.34	8.09	2.77	41.19
June 30	0.38	0.41	3.00	5.27	7.12	6.78	8.83	3.33	50.87
July 15	0.37	0.38	2.91	5.03	7.01	6.64	8.17	2.87	43.55
SEm ±	0.01	0.01	0.07	0.16	0.21	0.19	0.11	0.10	1.31
CD (P=0.05)	NS	0.03	NS	0.55	NS	NS	0.37	0.36	4.53
Varieties									
HQPM-1	0.35	0.36	2.78	4.97	6.90	6.34	8.11	3.02	46.68
PEHM-2	0.36	0.37	2.91	4.90	6.97	6.73	8.36	2.95	43.56
Pratap Makka-5	0.38	0.39	3.14	5.15	7.09	6.97	8.34	2.62	37.28
Pratap QPM-1	0.36	0.37	2.76	4.75	6.76	6.43	8.31	3.07	46.70
BIO-9637	0.37	0.38	2.95	4.96	6.89	6.46	8.70	3.28	51.78
SEm ±	0.01	0.01	0.08	0.09	0.12	0.12	0.14	0.10	1.58
CD (p=0.05)	NS	0.02	0.22	0.25	NS	0.33	NS	0.30	4.52

NS – Not significant

Table 4.1 Interaction effect of date of sowing and varieties on grain yield (q ha^{-1})

Treatment	Date of sowing		
Varieties	June 15	June 30	July 15
HQPM-1	33.58	56.77	49.69
PEHM-2	42.28	51.30	37.11
Pratap Makka-5	36.33	38.07	37.44
Pratap QPM-1	45.04	54.00	41.05
BIO-9637	48.69	54.20	52.46

	SEm ±	CD (p = 0.05)
Same varieties for different date of sowing	2.72	7.83
Same date of sowing and different varieties	2.79	8.63

reproductive phenophases in comparison to the sowing on June 15 and June 30. The June 15 sown crop took maximum duration for initiation of critical growth stage, which manifested in increased duration for vegetative, reproductive as well as total crop duration closely followed by June 30 sown crop. Conversely under late sowing, reproductive growth as well as total crop duration was drastically reduced. It is an established fact that the crop phenology is largely dependent on genetic and environmental factor *viz.,* temperature, solar radiation, rainfall etc. (Soleymani *et al.,* 2011). Varieties brought significant variation in number of days taken to attain first tassel initiation, 50 % tasselling, first silk initiation, 50 % silking, milking, dough and maturity stage. Variety BIO-9637 took maximum number of days (52.4) of first tassel initiation, (55.3) first silk initiation which was significantly superior over Pratap QPM-1, PEHM-2 and Pratap Makka-5, respectively but at par with HQPM-1. Variety BIO-9637 took maximum number of days (93.3) to reach maturity which was significantly higher by 1.6, 3.0, 6.2 and 9.7 days in comparison to HQPM-1, Pratap QPM-1, PEHM-2 and Pratap Makka-5.

Agro meteriological indices

Growing degree day

Data (Table 3) show that dates of sowing brought about significant variation in accumulated GDD at all phenological stages except 50 % silking, dough and maturity stages. The crop sown on June 15 required maximum GDD at knee high (598 ^{0}C day), 1st tassel initiation (909 ^{0}C day), 50 % tasseling (957 ^{0}C day), 1st silk initiation (973 ^{0}C day), 50 % silking (991 ^{0}C day), milking (1205 ^{0}C day) and dough (1419 ^{0}C day). The crop sown on July 15 required maximum GDD to attain fifth leaves stage (208 ^{0}C day) was significantly superior over June 30 but at par with June 15 sown crop. The results are in close conformity with the findings of Hemalatha *et al.* (2013). Variety BIO-9637 required maximum accumulated GDD to attain different phenological stages of maize except knee high stage. Variety BIO-9637 required maximum accumulated GDD (1578 ^{0}C day) to attain physiological maturity which was significantly higher over rest of varieties.

Heat use efficiency

Data (Table 4) show that date of sowing brought about significant variation in heat use efficiency on dry matter basis at 30 and 60 DAS. The maximum heat use efficiency was produced in June 30 sown crop at 30 (0.41 kg ha^{-1} ^{0}c^{-1} day^{-1}) and 60 (5.27 kg ha^{-1} ^{0}c^{-1} day^{-1}) DAS which was significantly superior over June 15 by 18.1 and 16.3 per cent. The maximum heat use efficiency was produced in June 30 sown crop at grain (3.33 kg ha^{-1} ^{0}c^{-1} day^{-1}) and biological yield (8.83 kg ha^{-1} ^{0}c^{-1} day^{-1}) basis was significantly superior over June 15 and July 15 sown crops by 16.0 and 14.4 per cent and 9.1 and 8.2 per cent, respectively. The results are in close conformity with the findings of Girijesh *et al.,* (2011).

Variety Pratap Makka-5 required maximum heat use efficiency on dry matter basis at 15, (0.38 kg ha^{-1} °c^{-1} day^{-1}), 30 (0.39 kg ha^{-1} °c^{-1} day^{-1}), 45 (3.14 kg ha^{-1} °c^{-1} day^{-1}), 60 (5.16 kg ha^{-1} °c^{-1} day^{-1}), 75 (7.10 kg ha^{-1} °c^{-1} day^{-1}) DAS and harvest (6.97 kg ha^{-1} °c^{-1} day^{-1}). At 45 DAS, Pratap Makka-5 required maximum heat use efficiency (3.14 kg ha^{-1} ^{0}c^{-1} day^{-1}) which was significantly superior over HQPM-1 and Pratap QPM-1 by 12.9 and 13.8 per cent but at par with BIO-9637 and HQPM-1. Variety did not influence heat use efficiency at 15 and 75 DAS. Variety BIO-9637 required maximum heat use efficiency (3.28 kg ha^{-1} ^{0}c^{-1} day^{-1}) which was significantly superior over PEHM-2 and Pratap Makka-5 by 11.8 and 25.2 per cent but at par with Pratap QPM-1 and HQPM-1 in respect to grain yield basis heat use efficiency. The positive and significant correlation between GDD at physiological maturity and day to physiological maturity (r = 0.894**) validates this hypothesis. The similar contentions were also given by Parashar (2011).

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