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EVALUATING MAIZE INBREDS FOR MORPHO-PHYSIOLOGICAL CHARACTERS UNDER HIGH TEMPERATURE AND LOW MOISTURE STRESS

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ABSTRACT

The 12 hybrids (HM-4, HM-5, HM-7, HM-9, HQPM-1, HQPM-5, JH-2459, PMH-1, PMH-3, PMH-9, Prakash and Buland) were sown on two dates of sowing i.e. February and March for two consecutive years. Stress was induced at environmental level and irrigation was restricted at both flowering and grain filling stage. The experiment was laid in randomized block design and aimed at identifying the genotype for maximum yield under stress condition. The performance of maize was evaluated on the basis of growth characters (leaf number, leaf area), physiological characters (dry matter partitioning, leaf firing, anthesis silking interval (ASI), tassel blasting, leaf senescence, chlorophyll content) biochemical characters (total soluble protein and yield). The results revealed that HQPM-1 performed best under control conditions whereas the performance of PMH-3 was best under stress condition. The tolerant lines performed better photosynthesis and had better osmotic adjustment and protection as compared to the susceptible lines.

Keywords: High temperature, moisture stress, characters yield, maize hybrids

INTRODUCTION

Maize is the most widely adopted crop across the world and is grown worldwide due to its importance as food for human, feed for poultry and animals as well as a number of other industrial products. The change in environment and rise in temperature has always posed a situation in front of researchers to produce high yielding genotypes of maize that adapts to changing climate as well cope up to compensate yield losses due to high temperature and low moisture stress. For proper physiological growth and development of any crop there is a basic need of water and correct day and night temperature. There is 15-20% yield loss in tropic due to moisture and high temperature stress as compared to well-watered condition. High temperature and low moisture stress damage tissue due to rise in canopy temperature that leads to increased transpiration rate.Araus *et al.,* (2002) suggested that there is need to identify and develop inbreds and hybrids that is tolerant to abiotic stress to compensate yield losses that will cater to the growing population and their increasing needs. It has also been earlier reported that if irrigation is restricted at post and pre silking it leads to low grain setting, decreased test weight and finally reduced yields. The critical growth stage that has been identified for drought and high temperature stress is flowering, grain filling. Crop exposed to stress at flowering gives very low yield (Lobell, 2011). Field experiment was conducted to evaluate 12 hybrid lines for high temperature and low moisture stress to identify the most tolerant lines against high temperature and low moisture stress.

MATERIALS AND METHODS

The field trials were carried out at research farm of the Directorate of Maize Research, Indian Agricultural Research Institute, New Delhi, India. The rainfall received during the growing period from June to March) was 297mm in 2010 and 420.1mm in 2011. Maize seeds were sown on February 26th and March 15th in both the years of study i.e. 2010 and 2011.The experiment was laid out in randomized block design with three replications. Irrigation was restricted at flowering and grain filling stage. Plant height was recorded from the ground level to the third open leaf at flowering stage.Number of leaves were counted at flowering stage. For Dry matter Partitioning, single plant/plot was selected and uprooted from sampled row at flowering stage.These plants that was separated in leaf, shoot, root, lamina, tassel and cob were air-dried followed by oven dried at 65^{0}C for 24 hours and weighed. Leaf area was measured at flowering stage with the help of leaf area meter.

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Tassel blasting score was observed visually in the whole plot and was rated accordingly between 1-5 (lowest1). Leaf Firing score was observed visually in three plants selected randomly and was rated accordingly 1-5 (lowest 1). For calculating ASI i.e. anthesis silking interval days to 50% of anthesis was calculated from days to sowing and similarly days to 50% silking was calculated. From days to 50% of silking days to 50% anthesis was substracted to find out the anthesissilking interval. The chlorophyll content was measured using a chlorophyll meter (Minolta SPAD). It was done in third fully opened leaf at flowering stage. Grain yield was recorded and computed as grain yield g/plant.The data were expressed as the mean± standard error and were analyzed statistically using Statistical Analysis System (SAS 9.2). Significance level of $p< 0.05$ was used.

RESULTS AND DISCUSSION

Maize is a C4 plant and can utilize solar radiations much efficiently and can also tolerate comparatively higher temperature upto a limit (Ashraf and Hafeez, 2004). High atmospheric temperature along with low moisture stress often leads to a limiting factor for maize production.Relatively higher temperature and insufficient moisture stress weakens the plant not only to give lower yields but also become susceptible to insect and pest infestations. Fluctuation of temperature and moisture during summer at critical growth stages can damage the intermolecular interactions required for balanced growth, leading to impair proper development and seed set (Bita et.al. 2013). In the absence of optimum humidity, high temperature at the time of flowering may reduce more than 90% yield in maize. However, 30-40% of yield loss are occurring during rainy season crop in tropical maize. Flowering is one of the critical stage for pollination whereas if there is low moisture stress and nutrient reduction at flowering it results into cob production without seed setting. High temperature and low moisture stress is a serious problem during the spring season. High temperature and low moisture stress is also one of the major limitations to maize productivity causing average annual yield loss of about 35-40 % in tropical maize.

The growth of any crop is affected by soil, its structure, fertility, temperature and humidity and seasonal variability in the period of crop growth**.** Further, the growth and development of crop plants basically depends upon proper management of intrinsic (genotype) and extrinsic (environment) factors (Genotype X Environment i.e. G X E). ANOVA (Analysis of Variance) showed a significant effect on traits by both environment and date of sowing. Genotype X Date of sowing X Environment shows a very marked effect on the plants growth and finally its yield. The chlorophyll content, dry matter weight, leaf firing, leaf senescence, tassel blasting and yield were majorly affected by this interaction. Looking at the meteorological data it was very much evident that February, 2011 seeding was exposed to the most favorable season during the study whereas March, 2010 seeding was exposed to less rainfall and low humidity that was not favorable for the growth of the crop.

Plant biomass is a pooled effect of height, leaf, shoot, root, tassel and cob etc. Biomass production is also a genetically as well as environmentally influenced trait. The plant biomass trait is highly dependent on crop management practices, weather/ climatic conditions. Genotype having higher plant biomass couple with higher harvest index is considered as most desirable genotype. Leaf senescence can also be correlated with reduction in biomass, photosynthesis and further reduction in grain yield. It is observed that plants under moisture stress showed reduction in leaf area further resulting in leaf senescence and abscission thereby decreasing the total leaf area per plant. Generally the lower leaf senescence don't play important role but those leaves that are close to reproductive parts may affect the source sink relationship which leads to biomass as well as yield reduction. The hybrid HQPM-1, PMH-3 followed by HQPM-5 performed best under stress condition whereas PMH-3 followed by HQPM-1 performed best under stressed condition.During periods of high temperatures, in absence of optimum relative humidity, and inadequate soil moisture, exposed silks may desiccate and become no receptive to pollen germination. Moisture and heat stress interferes with synchronization of pollen shed and silk emergence.

The extent to which a plant is impaired morphologically and physiologically during stress totally depends upon the duration till it is exposed to stress (Herrero and Johnson, 1980; Hussain *et al*., 2006). There is an increase in leaf growth in maize crop when grown at temperature between 0-35^{0}C whereas the growth reduces drastically if it is exposed to temperature above 35^{0}C. It has also been reported that there is decrease in photosynthetic activity, protein denaturation and protein inhibition with rise in temperature beyond 40^{0}C (Dubey, 2005; Kim *et al.*, 2007; Wahid *et al.,* 2007). Liu and Huang (2000) reported that high temperature stress generally leads to lower chlorophyll content in maize plants. Leaf firing, tassel blasting are inversely proportional to grain yields (Kaur *et al.* 2011). February planting for year 2011 gave better growth response for plant height, leaf area and leaf number as compared to March seeding, 2011 as well as both DOS in 2010. Plant height, Leaf area and leaf number was not much affected by stress as stress was induced at flowering and grain filling and till that time a plant has already achieved its required height and leaf number. Whereas the SPAD reading for chlorophyll content at flowering stage showed remarkable variation for February, 2011 giving best performance during the study followed by February, 2010, March 2011 and March 2010. Similar results were seen for total soluble protein.

Table1: Interaction for genotypes and date of sowing for plant height, leaf area, leaf number chlorophyll content and total soluble protein

Year	Plant height	Leaf area	Leaf Number	SPAD Reading	Total Soluble Protein
G x D1	117.95±5.803	317.63±24.44	14.34±1.204	55.38±3.226	4.1±0.163
G x D2	117.48±4.902	266.98±16.482	11.72±0.859	46.45±4.159	4.15±0.13
G x D3	118.02±4.958	323.73±16.43	14.71±0.687	58.42±5.183	4.22±0.119
G x D4	117.91±5.098	316.25±24.874	13.98±0.892	51.68±5.08	4.12±0.184

Blum (1988) reported that plant grown at high temperature and low moisture stress produces lower biomass as compared to when grown under optimum temperature and moisture. The plant when subjected to stress at critical growth stages i.e. flowering and grain filling affects its growth rate, biomass partitioning and also leads to barrenness, aborted fertilized system, lower ear growth, lower kernel number thus leading to lower production (Cicchino *et al.*, 2010). The dry matter partitioning was seen at its best at Feb, 2011 seeding and the lowest performance was seen at March, 2010.

Table 2: Interaction for genotypes (dry matter partitioning) and date of sowing

Year	DWShoot	DWCob	DWSheath	DWRoot	DWLamina	DWTassel
G x D1	60.07±1.059	43.36±1.709	33.54±6.651	27.31±3.664	41.42±6.041	2.65±0.394
G x D2	53.33±1.032	41.51±0.877	33.02±6.533	26.01±4.032	38.86±6.014	2.42±0.475
G x D3	62.31±0.852	43.38±2.212	33.84±6.443	28±3.712	42.42±5.66	2.69±0.489
G x D4	55.65±0.752	42.15±0.788	33.41±6.636	27.21±4.323	40.74±6.428	2.45±0.484

It has been reported that leaf firing and tassel blasting is quite high in both inbred and hybrids under high temperature and low moisture stress conditions. The chlorophyll content also depletes and finally the grain yield also reduces (Betran *et al.*, 2003), high temperature and low moisture stress also results in prolonged anthesis-silking interval thus leading to improper seed set and lower yields (Muchow, 1990). Due to heat waves agricultural production has reduced all across the world leading to reduction in grain yield and causing a risk to food security (Christensen and Christensen, 2007). It was seen (Table 3) that leaf firing, tassel blasting and anthesissilking interval was maximum for March seeding in the year 2010 and was least in February seeding 2011. The grain yield was maximum for February, 2011 seeding due to more congenial environment comparatively low temperature and high moisture in 2011. The anthesis-silking interval was seen minimum in HQPM-1 for both the date of seeding in both the years of study. An average of 2.27 in February, 2011, 2.43 in February, 2010, 3.68 in March, 2011 and 3.33 in March, 2010 whereas JH-3459 recorded an average of 3.68 in March seeding for the year 2011 and 4.33 for March, 2010. Similarly, it was seen that PMH-3 gave maximum yield under normal condition 44.82g/plant whereas HQPM-1 gave 44.7 for February seeding, 2011. JH-3459 17.48g/plant. HM-9 recorded an average yield of 34.29 in March, 2011 seeding whereas 40.01g/plant in February, 2011 seeding. The genotypes performed comparatively poor in gave as low as 24.07g/plant in February, 2011 seeding whereas March 2010 yielded 2010 for both February and March planting in comparison to 2011 seeding for February and March respectively.

Table3: Interaction for genotypes and date of sowing for leaf firing, tassel blasting anthesis silking interval and grain yield

Year	Leaf Firing	Tassel Blasting	ASI	Grain Yield
G x D1	0.38±0.215	0.16±0.16	2.96±0.232	33.75±0.963
G x D2	0.68±1.313	0.19±0.133	3.36±0.232	29.58±1.067
G x D3	0.39±0.187	0.17±0.153	2.79±0.232	35.65±1.166
G x D4	0.35±0.213	0.23±0.155	3.29±0.232	30.8±0.878

Where G = Genotype, D1-Feb planting, 2010, D2-Mar planting, 2010, D3-Feb planting 2011, D4- Mar planting, 2011 and DW- Dry Weight

There was not much variation seen for similar dates of seeding in both the years i.e. G X E X DOS gave similar trends for genotypes in both the years. The seeding for February, 2011 gave best performance thus, proved positive interaction between genotype, temperature, relative humidity and rainfall thus giving better yield as compared to rest of the dates of seeding. The hybrids PMH-3, HQPM-1 and HM-9 were the best performing hybrids both under control and stress condition and thus can be used in spring season to minimize yield penalty under both high temperature and low moisture stress. February seeding will be a better alternative than March seeding to avoid comparatively higher temperature at flowering in spring season.

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