Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 2678-2681

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Screening and Identification of Moisture stress Tolerant Maize (*Zea mays* L.) Hybrids for Rainfed Agriculture in Jharkhand

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Abstract

Maize (*Zea mays* L.) being a C_4 plant can capture energy efficiently and capable of producing maximum food grains per unit area as compared to other cereals. Globally, it is a leading cereal in terms of area cultivated nearly 150mh and contributed about 782 mt with an average productivity of 4080kg/ha. However, being an efficient moisture user it requires 500-800 mm of water during life cycle of 80-110days (Critchley &Klaus, 1991). In India maize is mainly grown as kharif crop which accounts for about 85% of the total area but contribute comparatively much lower than rabi maize. Rabi maize contributes >25% of annual production with <10% of total maize growing area. The crop grown in kharif season faces uneven erratic distribution of rainfall and in rabi unavailability of water at proper stage of crop growth. Both the season faces a common problem of moisture stress. At the genetic level, moisture stress has been considered to be quantitative traits which influence on maximal plant yield and productivity. The knowledge of nature and magnitude of genetic component of variation for grain yield and its related morpho- physiological traits is essential. Keeping in view the changing scenario of water availability and erratic rainfall, present experiment was undertaken to evaluate the maize hybrids for their suitability under rainfed kharif cultivation in Jharkhand. Sixteen hybrids and two composite varieties were sown in RBD with 3 replications on 3rd July, 2017. Recommended package of practices were followed during crop growth. Observations were recorded on days to 50% tasseling, days to 50% silking, plant height (cm), ear eight (cm), days to maturity, shelling% and grain yield/plot (kg). Statistical analysis for genetic component of variation and performance of individual hybrids were done following standard methods. During the month of July, 2017 just after sowing the crop received a total amount of 847.6mm rainfall which is 137.4% excess than the normal average rainfall(357mm) and followed by 331.6 mm rainfall in the month of August,2017. This provides an opportunity for screening of hybrids for excess moisture stress under field condition. Continuous heavy rain effects the initial establishment of crop and ultimately poor crop growth. Among the traits under study, plant height and shelling per cent was highly effected and resulted poor grain yield. Four hybrids BAUMH2017-15 (BAUIM2X HKI1532), BAUMH2017-14 (BAUIM5XHKI1532), SIRI4527 and Kavery Profit recorded significantly higher yield and can be recommended for kharif cultivation under erratic rainfall.

Keywords: maize hybrids, moisture stress, erratic rainfall, genetic variation

1. Introduction

Grain yield is a complex trait and is dependent on many factors including vigorous growth, adequate water and nutrient supplies, enhanced solar radiation interception and conversion to chemical energy, and improved genetics (Russell, 1991). Despite its complexities, nearly all of the commercial breeding programmes today include yield as a selection parameter. However, because of the complex nature of grain yield, a better under- standing of the components that contribute to higher yields should improve the selection process. Abiotic stresses such as salinity, drought, nutrient deficiency or toxicity, and flooding limit crop productivity world-wide. However, this situation becomes more problematic in developing countries, where they cause food insecurity for large populations and poverty.

In this scenario, it is widely urged that strategies should be adopted to get maximum crop stand and economic returns from stressful environments. Major strategies include breeding of new crop varieties, screening and selection of the existing germplasm, production of genetically modifi ed (GM) crops, exogenous use of osmoprotectants etc. In the last century, conventional selection and breeding program proved to be highly effective in improving crops against abiotic stresses. However, extent and rate of progress in improving stress tolerance in crops through conventional breeding program is limited. This is due to complex mechanism of abiotic stress tolerance, which is controlled by the expression of several minor genes. Furthermore, techniques employed for selecting tolerant plants are time consumable and consequently expensive. During the last decade, using advanced molecular biology techniques different researchers showed some promising results in understanding molecular mechanisms of abiotic stress tolerance as well as in inducing stress tolerance in some potential crops.

Maize (*Zea mays* L.) being a C_4 and day neutral plant can capture energy efficiently and capable of producing maximum food grains per unit area as compared to other cereals. Globally, it is a leading cereal in terms of area cultivated nearly 150 mh and contributed about 782 mt with an average productivity of 4080 kg/ha. However, being an efficient moisture user it requires 500-800 mm of water during life cycle of 80-110days (Critchley & Klaus, 1991). In India, maize is mainly grown as kharif crop which accounts for about 85% of the total area but contribute comparatively much lower than rabi maize. Rabi maize contributes >25% of annual production with <10% of total maize growing area. The crop grown in kharif season faces uneven erratic distribution of rainfall and in rabi unavailability of water at proper stage of crop growth. Both the season faces a common problem of moisture stress. At the genetic level, moisture stress has been considered to be quantitative traits which influence on maximal plant yield and productivity.

When maize encounters water deficits, there is a decline in photosynthesis per plant. This can be due to a reduction in light interception as leaf expansion is reduced or as leaves senesce, and to reductions in C fixation per unit leaf area as stomates close or as photo-oxidation damages the photosynthetic mechanism. The accumulation of abscisic acid (ABA) may enhance survival but reduces productivity (Leung and Giraudat, 1998; Mugo *et al*., 2000). Ability to protect cellular membranes and enzymes from stress and to recover from water deficits will also enhance a crop's capacity to survive and produce grain. Grain yield under stressed conditions is usually the primary trait for selection. A suitable secondary trait is (1) genetically associated with grain yield under stress; (2) highly heritable; (3) stable and feasible to measure; (4) not associated with yield loss under ideal growing conditions (Edmeades *et al*., 2001). Very few proposed secondary traits meet these criteria.

Maize are better adapted to environments including high temperatures, intense sunlight, lack of rain, lack of nitrogen, and lack of CO_2 availability. Being the third most important cereal worldwide after wheat and rice, serves as staple food for both human consumption, animal forage and feed (Rani *et al*. 2015; Pandit *et al.* 2016). This crop has the diversified use as grain, animal feed and other industrial uses (Sah *et al.* 2014). The crop is well suited to be grown over diverse range of climatic condition ranging from tropical, subtropical and temperate agro-climatic conditions (Izhar & Chakraborty, 2013). Over 40% of the world's temperate maize production are cultivated under rain-fed cropping systems. Uncertainty of rainfall creating low moisture stress is a ubiquitous in random stress cropping systems and often limits maize yields (Sah *et al*. 2017). Excess moisture during rainfed season is one of the major production constraints for maize. Identification and development of genotypes capable of withstanding the moisture stress conditions could be an ideal and affordable approach suitable for maize growing farmers in such condition. Excess soil moisture stress severely affects various growth parameters, impaired Anthesis Silking and eventually results in poor kernel development and yield. Crop productivity is highly dependent on climate and weather under rain-fed agriculture (Ekpoh, 2010; Herrero *et al*. 2010). Keeping these points in mind and considering the changing scenario of water availability and erratic rainfall in particular present experiment was undertaken to evaluate the maize hybrids for their screening under rainfed kharif cultivation in Jharkhand.

Material & Methods

An experiment was conducted using 16 maize hybrids (twelve procured from different private organizations along with4 hybrids developed at BAU Ranchi) & two composites during kharif 2017 at experimental farm of Birsa Agricultural University, Ranchi, Jharkhand. Sowing was done in RBD with 3 replications on 3rd July, 2017. All recommended package of practices were followed for maize cultivation. Observation were recorded for days to tasseling, days to silking, days to 75% dry husk (maturity), plant height(cm), ear height(cm) and yield (q/ha). Data were subjected for statistical analyses for normal RBD and component of genetic parameters were also calculated following standard formulae.

Results & Discussion

Actual daily Rainfall received during crop growth period is given in table 1. In July, out of 31 days 21 was rainy days and total rainfall was 847.6mm and in August, 16 rainy days with 331.6 mm rainfall was observed. Due to excess rainfall in early crop growth plant growth (height) was reduced with a proportionate reduction in ear height mostly by 50%. Anthesis Silking Interval varied from 3-6 days. In optimal condition ASI may vary from 2-4 days, during initiation of flowering rainfall was observed for which traits does not show the prominent effect of stress. But, after initiation of flowering no rainfall was observed during dough or grain filling stage which resulted severe reduction in grain yield. The relationship between maize yield and climate variables has been demonstrated by Bergamaschi *et al.*, 2004 and Berlato *et al.* 2005.

Table 1: Daily rainfall at Kanke during the crop growth (July, 2017 to Oct, 2017)

Date	July	August	September	October
1	64.4	4.0	0.0	29.2
2	25.2	0.0	0.0	10.5
3	90.4	25.4	0.0	3.0
4	4.1	0.0	0.0	0.0
5	0.0	26.3	0.0	0.0
6	31.3	2.1	0.0	5.2
7	0.0	3.2	0.0	5.1
8	0.0	0.0	0.0	2.0
9	15.4	10.3	0.0	0.0
10	0.0	0.0	0.0	0.0
11	6.3	60.3	0.0	0.0
12	11.3	18.4	0.0	0.0
13	10.2	2.0	0.0	0.0

14	6.3	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	2.0	0.0
17	11.2	2.1	0.0	0.0
18	2.1	6.4	12.2	0.0
19	4.3	0.0	0.0	10.2
20	5.3	6.0	0.0	6.0
21	0.0	0.0	2.0	11.4
22	33.2	0.0	0.0	0.0
23	30.6	0.0	0.0	0.0
24	69.5	61.3	0.0	0.0
25	196.6	0.0	0.0	0.0
26	216.7	0.0	0.0	0.0
27	11.2	0.0	16.4	0.0
28	0.0	44.4	15.0	0.0
29	0.0	48.2	0.0	0.0
30	0.0	0.0	12.4	0.0
31	2.0	11.2		0.0
Total	847.6	331.6	60.0	82.6
Normal (Average of 20 Years)	357.0	318.3	258.9	79.1
Deviation (%)	137.4	4.2	-76.8	-4.4

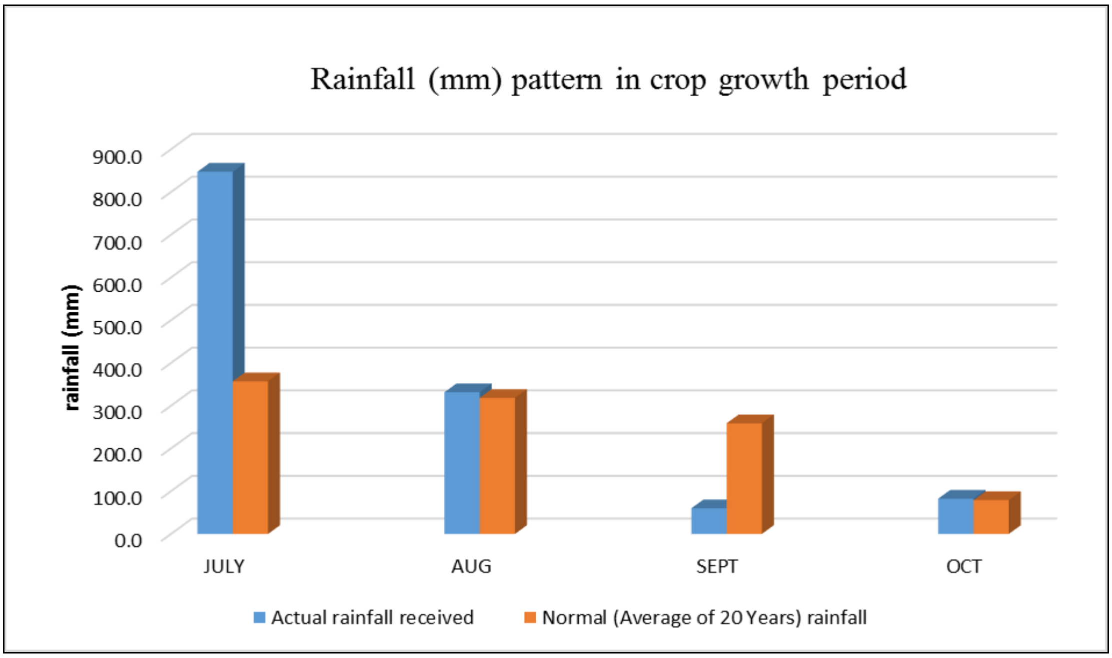

Fig 1: Rainfall pattern during crop growth period

Table 2: Mean Performance of maize hybrids for grain yield and yield contributing traits under moisture stress in rainfed kharif trial

	Entry Name	Shelling%age	Days to 50% pollen shed	Days to 50% silk	Days to 75% dry husk	Plant Height (cm)	Ear Height (cm)	yield(q/ha)
1	MH 2017-1	85.41	57.33	63.00	102.00	121.00	39.87	24.27
2	MH 2017-2	79.45	60.00	65.00	106.00	120.93	42.07	24.14
3	MH 2017-3	85.36	61.33	66.00	106.67	107.20	33.53	22.97
4	MH 2017-4	86.70	60.00	63.00	102.33	140.87	49.20	30.74
5	MH 2017-5	80.65	56.67	60.33	99.33	109.00	36.87	29.02
6	MH 2017-6	83.52	58.67	62.33	100.67	110.07	36.73	28.27
7	MH 2017-7	82.66	56.00	60.00	98.00	88.40	33.40	19.30
8	MH 2017-8	83.77	61.00	65.33	105.00	122.87	40.53	30.02
9	MH 2017-9	85.63	56.67	60.67	99.00	140.47	46.40	35.94
10	MH 2017-10	82.98	58.67	63.33	102.00	118.87	37.07	29.03
11	MH 2017-11	82.92	58.67	63.67	102.67	134.93	44.40	39.02
12	BAU MH 2017-12	80.29	56.00	61.00	99.00	94.67	33.47	26.22
13	BAU MH 2017-13	84.17	58.00	63.00	102.00	103.60	35.20	27.51
14	BAU MH 2017-14	86.56	56.67	61.00	98.67	118.67	42.47	40.67
15	BAU MH 2017-15	83.26	58.00	63.00	102.33	102.33	36.60	41.63
16	Local Check	79.04	60.67	65.00	104.67	116.40	37.13	20.05
17	MH 2017-17	81.32	58.00	61.67	100.00	96.80	36.27	18.06
18	MH 2017-18	77.1	59.7	65.3	105.0	110.4	39.7	25.8
	CD @ 5%	2.3	2.3	2.9	4.3	20.3	6.8	7.1

Four hybrids BAUMH2017-15 (BAUIM2 X HKI1532), BAUMH2017-14 (BAUIM5 X HKI1532), SIRI4527 and Kavery Profit recorded significantly higher yield and can be recommended for kharif cultivation under erratic rainfall.
Estimates of genotypic and phenotypic variances, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense and genetic advance as percent of mean for yield and yield attributing traits are given in Table 3. Genotypic variance ranged from 2.2 for days to 50% pollen shed to 171 for plant height. Likewise Penotypic variance ranged from 4.2 for days to 50% pollen shed to 320.6 for plant height. High Penotypic and genotypic variance was observed for plant height, yield and ear height respectively indicating that the genotypes could be reflected by the phenotype and the effectiveness of selection based on the phenotypic performance for these characters. High genotypic and penotypic coefficients of variation was observed for yield, plant height followed by ear height. Heritability in the broad sense was high for shelling percent. High genetic advance as percentage of means (GAM) coupled with high heritability was recorded for grain yield.

Table 3: Genetic component of maize hybrids under moisture stress

	Range	Mean	$\sigma^2 g$	$\sigma^2 p$	GCV	PCV	h^2	GAM%
Shelling%age	77.1 - 86.7	82.8	6.8	8.6	3.1	3.5	78.3	5.72
Days to 50% Pollen shed	56.0 - 61.3	58.4	2.2	4.2	2.6	3.5	53.0	3.85
Days to 50% silk	60.0 - 66.0	62.9	2.5	5.6	2.5	3.8	44.5	3.45
Days to 75% dry husk	98.0 - 106.6	102	5.0	11.5	2.2	3.3	42.9	2.94
Plant Height	88.4 - 140.8	114.3	171.0	320.6	11.4	15.7	53.3	17.21
Ear Height	33.4 - 49.2	38.9	14.9	31.9	9.9	14.5	46.6	13.94
Yield	18.1 - 41.6	28.5	43.3	61.7	23.1	27.6	70.2	39.83

Conclusion
These findings emphasized that future research should focus on molecular, physiological and metabolic aspects of stress tolerance to facilitate the development of crops with an inherent capacity to withstand abiotic stresses. This would help stabilize the crop production, and significantly contribute to food and nutritional security in developing countries and semi-arid tropical regions.

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