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Performance of hybrid maize genotypes under different moisture and nutrient regimes for improving productivity and nutrient use efficiency

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ABSTRACT

A field experiment was conducted at New Delhi during *kharif* season of 2015 and 2016 to study the performance of maize genotypes under different moisture and nutrient regimes. The results revealed that the yields were significantly improved under normal condition as compared to stress at grain filling stage in 2015 (low rainfall year), while in 2016 result was non-significant. Application of fertilizer through Site Specific Nutrient Manamgenet (170:40:48 kg N:P_2O_5:K_2O) resulted in significant increase in maize yields in both the study years over absolute control. Among genotypes, PMH-4 produced significantly higher grain, stover and biological yields during both the years. Nitrogen and Potassium content in grain, partial factor productivity and agronomic efficiency were significantly affected by applying stress at grain filling stage and SSNM based nutrient application. Amongst genotypes, significant variation in grain N and P was observed in 2015 but partial factor productivity and agronomic efficiency was obtained higher with PMH-4, while lowest was with Bio-9637 and Bio-9681. Therefore, it is concluded that the moisture and nutrient regimes imposes significant effect on yield and nutrient use efficiency of maize hybrids.

Key words: Moisture stress, partial factor productivity, agronomic efficiency, Site Specific Nutrient Management.

Maize (*Zea mays* L.) having highest yield potential amongst cereals and thus known as "Queen of cereal". Globally, it occupies an area of 168.2 million ha with productivity of 5081 kg/ ha and production of 854.67 million tonnes (FAO STAT, 2017). In India, maize is grown over an area of 8.5 million ha (80% in *kharif*) with production of 21 million tonnes and productivity of only 2470 kg/ha. Water is prime and most limiting resource in agricultural productions. While maize is the third most important cereals requires higher amount of water after paddy and sugarcane. Throughout the tropics, periodic drought caused by uncertain and uneven distribution of rainfall and soil with low water holding capacities causes significant reduction in maize yield. Moisture stress at any crop growth stage reduces growth and yield considerably. However, maize is highly sensitive to drought, specifically two weeks prior and after silking periods. Besides moisture, nutrient also played a vital role in realization of higher production in single cross hybrid maize genotype of which production is limited by low fertilizer efficiency but inadequacy in existing fertilizer recommendations and the ignorance of nutrients balance pausing serious threat in maize production (Jat *et al.* 2014). There exists a significant opportunity to increase fertilizer efficiency and productivity of maize by adopting

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balanced fertilizer recommendations for different genotypes of maize. Keeping all these facts in view, an investigation to evaluate the "Performance of hybrid maize genotypes under different moisture and nutrient regimes for yield, nutrient content and nutrient use efficiency" was undertaken on sandy loam soil during *kharif* 2015 and 2016.

Materials and Methods

A field experiment was conducted on sandy loam soil during two consecutive *kharif* seasons of 2015 and 2016 at the research farm of the ICAR-Indian Institute of Maize Research, IARI Pusa Campus, New Delhi. The site is located at a latitude of 28°40'N and longitude of 77°12'E, altitude of 228 m above the mean sea level. This area has a typical semi-arid and sub-tropical climate characterized by hot dry summers and cool winters. The mean annual rainfall of Delhi is 650 mm and more than 80% generally occurs during the south-west monsoon season (July to October) with mean annual evaporation of 710.7 mm. The rainfall received during the crop growing period from July to October was 710.7 mm and 1140.3 mm in 2015 and 2016 respectively. The experimental soil was sandy loam in texture having pH 8.2, low in organic C (0.3%) and available nitrogen, medium in available P and high in available K. The experiment was laid out in a split- split plot design with three treatment combinations (Main plot: moisture stress, sub-plot: 2 fertility levels and 9 genotypes in sub-sub plot) and each treatment was replicated thrice. The moisture regimes were normal and moisture stress at grain filling stage, two fertility levels were absolute control and SSNM (170:40:48 kg/ha N: P_2O_5: K_2O). The nine genotypes used in the present study were PMH-1, PMH-4, DHM-117, CMH-08 -292, HQPM-1, HQPM-7, HM-8, Bio-9637 and Bio-9681. Crop was planted at 67 cm apart with a seed rate of 20 kg/ha. Pre-sowing irrigation was applied for land preparation and germination of seed. Thinning was done 10-15 days after sowing to maintain plant to plant distance of 20 cm. The grain samples of each plot in triplicate were dried and grounded fine before analysis for total N, P and K using standard procedures Prasad *et. al.* (2006). The partial factor productivity and agronomic efficiency of applied nutrients were calculated as follows:

Partial factor productivity of applied nutrient (PFP) = Y_t/N_a, Where, Y_t = Yield under treatment (kg/ha) Na = Amount of nutrient added (kg/ha)

Table 1. Effect of moisture and nutrient regimes on grain, stover and biological yield of maize hybrids.

Treatments	Grain yield (kg/ha)		Stover yield (kg/ha)		Biological yield (kg/ha)	
	2015	2016	2015	2016	2015	2016
Stress						
Normal	3.35[a]	3.72	8.81[a]	8.60	13.23[a]	13.51
Grain filling	2.13[b]	3.49	6.40[b]	8.33	9.59[b]	13.09
Nutrient management practices						
Control	2.06[b]	2.69[b]	6.7[b]	6.48[b]	9.12[b]	10.19[b]
SSNM (170:40:48)	3.42[a]	4.52[a]	9.14[a]	10.44[a]	13.70[a]	16.41[a]
Hybrids						
H_1 : PMH 1	3.06[b]	3.92[b]	8.18[c]	8.99[b]	12.27[b]	14.13[b]
H_2 : PMH 4	3.57[a]	4.41[a]	9.41[a]	9.78[a]	14.16[a]	15.36[a]
H_3 : DHM 117	2.98[b]	3.68[bc]	9.00[ab]	8.98[b]	13.50[ab]	14.11[b]
H_4 : CMH-08-292	2.98[b]	3.92[b]	8.27[bc]	8.92[b]	12.40[b]	14.02[b]
H_5 : HQPM 1	2.56[c]	3.43[cd]	7.29[d]	8.57[b]	10.94[c]	13.46[b]
H_6 : HQPM 7	2.45[c]	3.22[d]	6.76[de]	7.20[d]	10.14[cd]	11.32[d]
H_7 : HM 11	2.40[c]	3.31[d]	6.64[de]	8.38[bc]	9.96[cd]	13.17[bc]
H_8 : BIO-9637	2.31[c]	3.29[d]	6.46[e]	7.72[cd]	9.69[cd]	12.13[cd]
H_9 : BIO-9681	2.37[c]	3.27[d]	6.44[e]	7.641[d]	9.66[d]	12.01[d]

Agronomic efficiency (AE) = $Y_t - Y_0 / A_t$

Where, Y_t = Yield under test treatment (kg/ha), Y_o = Yield under control (kg/ha)

A_t = Units of nutrient applied in the test treatment (kg/ha)

The data were analyzed using SAS 9.3 software and means were compared with least significance difference (P > 0.05).

Results and Discussions

Maize yields

The yields (grain, stover and biological) were significantly improved under normal condition as compared to stress at grain filling stage in 2015, however, due to very high rainfall received during 2016 there was no significant effect on grain, stover and biological yields (Table 1). Amongst nutrient management practices SSNM based nutrient application over absolute control resutled significant increase in grain, stover and biological yield in both the years of study. Similar type of results was also obtained by (Kumar *et. al.* 2014), where grain yield was recorded significantly higher under SSNM.

With regards to genotypes, PMH-4 produced significantly higher grain, stover and biological yield during both the years. However, significantly lower yield (grain, stover and biological) was obtained by Bio-9637, Bio-9681, HM-11 and HQPM-7. Enhancement in growth attributes lead to photosynthetic partitioning and better source-sink relationship, which enhances yield attributes. Giunta *et. al.* (2009) where significantly different yields of different hybrid were reported and Kumar *et. al.* (2014) also confirmed similar findings in maize.

Nitrogen content and uptake

The nitrogen content and uptake was significantly affected by applying stress as compared to normal condition during both the years of study (Table 2). Similarly, application of nutrients SSNM over absolute control also significantly affected nitrogen content and nitrogen uptake during both the years. Amongst genotypes, significantly higher nitrogen uptake by grain was obtained in PMH-4 which was at

Table 2. Effect of moisture and nutrient regimes on content and uptake of NPK in grain of maize hybrids.

Treatments	Grain content (kg/ha)						Grain uptake (kg/ha)					
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Stress												
Normal	1.29	1.20^{b}	0.272	0.496	0.528^{b}	0.444^{b}	43.7^{a}	45.0	9.54^{a}	18.7	17.7^{a}	16.7
Grain filling	1.38	1.28^{a}	0.238	0.434	0.631^{a}	0.516^{a}	29.7^{b}	45.2	5.24^{b}	15.5	13.5^{b}	17.9
Nutrient management practices												
Control	1.29^{b}	1.20^{b}	0.218^{b}	0.434^{b}	0.559^{b}	0.469	26.4^{b}	32.1^{b}	4.55^{b}	11.7^{b}	11.2^{b}	12.5^{b}
SSNM	1.38^{a}	1.28^{a}	0.292^{a}	0.496^{a}	0.601^{a}	0.492	47.0^{a}	58.1^{a}	10.24^{a}	22.5^{a}	20.0^{a}	22.2^{a}
Hybrids												
H_1 : PMH 1	1.34^{abc}	1.28	0.299^{a}	0.494	0.567	0.443	41.2^{b}	51.1^{ab}	9.62^{a}	19.9^{ab}	17.0^{ab}	17.6^{b}
H_2 : PMH 4	1.41^{ab}	1.29	0.260^{bc}	0.476	0.531	0.496	50.4^{a}	57.5^{a}	9.53^{a}	21.1^{a}	18.5^{a}	22.3^{a}
H_3 : DHM 117	1.25^{c}	1.19	0.272^{ab}	0.474	0.594	0.467	37.3^{bc}	43.9^{cd}	8.61^{ab}	17.7^{bc}	17.4^{a}	17.4^{b}
H_4 : CMH-08-292	1.27^{c}	1.18	0.233^{cd}	0.463	0.560	0.447	37.7^{bc}	46.6^{bc}	7.18^{bc}	18.5^{b}	16.6a^{bc}	17.4^{b}
H_5 : HQPM 1	1.47^{a}	1.34	0.267^{abc}	0.457	0.584	0.500	37.6^{bc}	46.6^{bc}	7.23^{bc}	15.9^{cd}	14.6^{cde}	17.3^{b}
H_6 : HQPM 7	1.42^{ab}	1.30	0.253^{bcd}	0.472	0.607	0.500	34.6^{cd}	41.8^{cd}	6.62^{cd}	15.6^{cd}	15.0^{bcd}	16.0^{b}
H_7 : HM 11	1.27^{c}	1.19	0.246^{bcd}	0.451	0.610	0.491	30.5^{d}	39.5^{d}	6.27^{cd}	14.8^{d}	14.6^{cde}	16.2^{b}
H_8 : BIO-9637	1.29^{bc}	1.20	0.243^{bcd}	0.450	0.562	0.495	29.6^{d}	39.4^{d}	6.02^{cd}	15.2^{cd}	12.6^{e}	16.1^{b}
H_9 : BIO-9681	1.32^{bc}	1.20	0.220^{d}	0.448	0.603	0.483	31.6^{d}	39.5^{d}	5.47^{d}	15.0^{d}	14.3^{de}	15.8^{b}

Table 3. Effect of moisture and nutrient regimes on Partial factor productivity and agronomic efficiency of different maize hybrids.

Treatments	Partial factor productivity (kg grain/kg nutrient applied)						Agronomic Efficiency (kg grain/kg nutrient applied over control)					
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Stress												
Normal	27.2^{a}	24.9^{a}	115.6^{a}	106.0^{a}	96.4^{a}	88.3^{a}	10.8	10.53^{a}	46.0	44.3^{a}	38.2	36.9^{a}
Grain filling	25.9^{b}	15.3^{b}	110.3^{b}	65.1^{b}	91.9^{b}	54.3^{b}	11.3	5.72^{b}	47.0	24.6^{b}	39.1	20.6^{b}
Hybrids												
H_1 : PMH 1	29.1^{ab}	22.9^{ab}	123.9^{ab}	97.1^{ab}	103.2^{ab}	80.9^{ab}	12.1^{ab}	9.70^{a}	49.9^{abc}	41.3^{a}	43.0^{ab}	34.4^{a}
H_2 : PMH 4	31.0^{a}	24.9^{a}	131.7^{a}	105.7^{a}	109.7^{a}	80.9^{ab}	12.8^{a}	8.13^{bc}	52.0^{ab}	35.6a^{bcd}	41.4^{abc}	30.1^{abc}
H_3 : DHM 117	27.2^{bc}	21.9^{b}	115.6^{bc}	93.2^{b}	96.3^{bc}	77.7^{b}	11.1^{abc}	8.79^{ab}	46.9^{cd}	37.4^{abc}	39.2^{cd}	31.1^{abc}
H_4 : CMH-08-292	29.4^{ab}	22.1^{b}	124.8^{ab}	93.9^{b}	104.0^{ab}	78.3^{b}	12.6^{a}	9.16^{ab}	53.7^{a}	38.9^{ab}	44.8^{a}	32.4^{ab}
H_5 : HQPM 1	25.8^{cd}	18.6^{c}	109.8^{cd}	79.2^{c}	91.5^{cd}	66.0^{c}	11.3^{abc}	7.22^{c}	48.1^{bc}	30.6^{de}	40.1^{bcd}	25.5^{de}
H_6 : HQPM 7	24.3^{d}	18.2^{c}	103.1^{d}	77.5^{c}	85.9^{d}	64.6^{c}	10.6^{bcd}	7.61^{bc}	45.2^{cd}	32.4^{cde}	37.7^{de}	27.0^{cd}
H_7 : HM 11	24.0^{d}	17.1^{c}	102.1^{d}	72.5^{c}	85.1^{d}	60.4^{c}	9.1^{d}	6.65^{c}	39.0^{e}	26.4^{e}	32.2^{f}	22.0^{e}
H_8 : BIO-9637	24.3^{d}	17.7^{c}	103.0^{d}	75.2^{c}	85.9^{d}	62.7^{c}	9.8^{cd}	8.18^{abc}	41.8^{de}	34.8^{bcd}	34.8^{ef}	29.0^{bcd}
H_9 : BIO-9681	24.2^{d}	17.8^{c}	102.6^{d}	75.6^{c}	85.5^{d}	63.0^{c}	9.8^{cd}	7.64^{bc}	41.8^{de}	32.5^{cde}	34.7^{ef}	27.1^{cd}

par with PMH-1. Significantly lowest nitrogen content was obtained with HM-11 whereas significantly lowest uptake during both the years was obtained by HM-11, Bio-9637 and Bio-9681. Better timing and splitting of fertilizer N applications during the season was probably the major reason in higher nutrient concentration. Kumar *et. al.* (2015) also reported significant differences in N content and uptake of maize hybrids.

Phosphorus content and uptake

Phosphorus content was not affected significantly by applying stress, however in both the years grain phosphorus content and uptake was significantly higher with fertility dose of (170:40:48 kg/ha N:P_2O_5:K_2O) over absolute control (Table 2). Amongst genotypes significantly higher phosphorus uptake by grain was obtained by PMH-4, however, it remained at par with PMH-1 in both the years. Significantly lowest P uptake was obtained by Bio-9682 and HM-11. Kumar *et. al.* (2015) also reported significant differences in content and uptake of P with SSNM and different maize hybrid.

Potassium content and uptake

During both the years potassium content was significantly affected by applying stress at grain filling stage as compared to normal condition, however, due to heavy rainfall in 2016 potassium uptake was not affected significantly. But the SSNM based nutrient application (170:40:48 kg/ha N:P_2O_5:K_2O) over absolute control (Table 2) affected significantly on grain potassium content and uptake during *kharif* 2015. During both the years, significantly higher potassium uptake was obtained with PMH-4, but DHM-117 and PMH-1 also produced at par K uptake during 2015. However, significantly lowest uptake was obtained by Bio-9637. Kumar *et. al.* (2015) also reported similar findings of higher grain yield significant differences for potassium uptake was obtained in hybrid maize.

Nutrient use efficiency

During both the years significantly highest partial factor productivity was obtained for N, P and K under normal condition as compared to stress situation (Table 3). Amongst genotypes, PMH-4 produced significantly higher NPK partial factor productivity which remaiend at par with PMH-1. Significantly lowest NPK partial factor productivity was obtained by HQPM-7, HM-11, Bio-9637 and Bio-9681, respectively.

Application of stress during grain filling stage reduced the agronomic efficiency of N, P and K significantly only during 2016 (Table 5). Amongst genotypes PMH-1, PMH-4, DHM-117 resulted in significantly higher N, P and K agronomic efficiency, while HM-11, Bio-9637 gave significantly lowest N, P and K agronomic efficiency. Kumar *et. al.* (2015) also reported that hybrid maize genotypes variation in nitrogen, phosphorus and potassium efficiency.

Based on this study, it may be concluded that maize yields (grain, stover and biological) and nutrient use efficiency was significantly reduced due to stress given at grain filling stage. Application of SSNM based nutrients (170:40:48 kg/ha $N:P_2O_5:K_2O$) over absolute control produced significant increased grain, strover and biological yield and nutrient content and uptake. Amongst genotypes, PMH-4 produced significantly higher yields, NPK content and nutrient use efficiency.

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