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Research Communication

Influence of site-specific nutrient management on growth and yield of maize (*Zea mays*) under conservation tillage

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ABSTRACT

A field experiment was conducted at New Delhi during rainy (*kharif*) season of 2013, to study the effect of nutrient management on growth and development behaviour of maize (*Zea mays* L.) hybrids. Normalized difference vegetation index (NDVI), SPAD value, dry-matter accumulation, leaf-area index, crop growth rate (CGR) and relative growth rate (RGR) were significantly higher with site-specific nutrient management (SSNM) over the recommended dose of fertilizer (RDF) under conservation agriculture. Of the maize–genotypes 'CMH 08-292' recorded significantly highest dry-matter accumulation at various stages and CGR, while 'PMH 1' recorded higher NDVI, SPAD, leaf-area index and RGR. Cobs/plot, cob length and girth, grain rows/cob, grains/row, cob yield, shelling, harvest index and grain yield were significantly higher with SSNM over RDF. 'PMH 3' recorded significantly higher cobs/plot, cob length and girth, grains/row, cob yield and grain yield, whereas 'S 6217' recorded significantly higher grain rows/cob and harvest index, while significantly higher shelling was recorded with 'CMH 08-292'.

Key words: CGR, Growth parameters, NDVI, RGR, SPAD, Yield attributes and Yield

Maize also known as queen of cereals, which is the now world's highest producing cereal crop that surpassed wheat and rice. It is cultivated in India over 8.67 million ha with 22.26 million tonnes production having an average productivity of 2566 kg/ha, contributing nearly 8% in the national food basket (DACNET, 2014). Now-a-days, maize is gaining importance in conservation agriculture as it is a wide-spaced crop, having slow growth rate in its early stage, which leads to more loss of water, and nutrient through evaporation and heavy infestation of weeds. To overcome this problem, adoption of conservation agriculture-based crop-management practices are increasing in maize production area of peninsular India. But production is limited by low fertilizer efficiency, inadequacy in existing fertilizer recommendations and the ignorance of nutrients balance and hence pausing serious threat in maize production. The Nutrient Expert^{TM} for Hybrid Maize is a new, computer-based decision support tool developed to assist local experts to quickly formulate fertilizer guidelines for tropical hybrid maize based on the principles of site-specific nutrient management (SSNM). There exists significant opportunity to increase fertilizer efficiency and productivity of maize by adopting Nutrient Expert-based field specific fertilizer recommendations (Satyanarayana *et al.,* 2013).

Keeping all in view, an investigation to evaluate the effect of SSNM on maize genotypes under conservation agriculture was undertaken on sandy-loam soil of the Indian Agricultural Research Institute, New Delhi 28^{o}40'N, 77^{o}12'E, 228 m above the mean sea-level during rainy (*kharif*) season 2013. This location has a typical semi-arid and sub-tropical climate characterized by hot dry summers and cool winters. The rainfall during cropping period was 1,207.2 mm, while the evaporation was 638 mm. The mean maximum and minimum temperature were 32.6 and 22.2^{o}C respectively. The experimental soil was sandy loam having pH 8.2, low in organic carbon (0.3%) and available N, medium in available P and high in available K. The experiment was laid out in a randomized block design (RBD) with 20 treatments combinations having 4 nutrient-management practices and 5 genotypes and replicated thrice. The 5 genotypes used in the experiment were; 'PMH-1', 'PMH-3', 'HQPM 1', 'CMH 08-292' and 'S 6217'. In order to evaluate current nutrient-management practices and farmer practices the general recommended

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dose of fertilizer for Delhi region and half of the recommended dose of fertilizer (RDF) were taken, respectively. The nutrient-management practices were: absolute control, 100% RDF (150:60:40 kg/ha $N:P_2O_5:K_2O$), 50% RDF, SSNM ('PMH1', 'PMH 3', 'CMH 08-292' and 'S 6217' (170:40:48 kg/ha $N:P_2O_5:K_2O$), and with 'HQPM 1' (170:33:40 kg/ha $N:P_2O_5:K_2O$). This experiment was taken under permanent conservation agriculture trial on maize–wheat–mungbean started in the rainy season *(kharif)* 2012, in which mungbean straw @ 1.5 t/ha was retained before maize planting. Five random were tagged for measuring plant height and SPAD reading, while leaf-area index, fresh and dry-matter accumulation were measured from 3 randomly sampled plants at 90 days after sowing. The SPAD reading was recorded with the help of SPAD meter as per the procedure. The normalized difference vegetation index (NDVI) was measured using hand-held green seeker sensors. The leaf-area index (LAI) was calculated by using formula:

LAI= [Leaf area/plant (cm^2)/Ground area/plant (cm^2)]

The crop growth rate (CGR) and relative growth rate (RGR) were calculated using standard formula, as given below

$$CGR= w_2–w_1/t_2–t_1$$

$$RGR=Log\ w_2–Log\ w_1/t_2–t_1,$$

where w_2 and w_1 are weight per plant at $time_2$ and $time_1$ respectively.

The yield attributes of cobs/plant was calculated from plant present in net plot divided by number of cobs. Length of 5 randomly selected cobs was taken from base of ear to its tip. Total numbers of grain row from these selected 5 cobs were counted. The cobs selected were shelled. The weight of 1,000 seeds drawn at random from the grains of 5 cobs was recorded to get 1,000-grain weight. The harvest index was computed as the ratio of grain yield to total biological yield.

Significantly higher growth characters was recorded with SSNM over 100% RDF (Table 1). It seems that SSNM-based balanced dose provided nutrient as per the crop requirement, hence better plant growth was observed with SSNM. With regards to different hybrids at harvest, significantly highest plant growth was recorded by 'CMH 08-292' over all other hybrids and significantly lowest plant height was recorded by 'HQPM 1'. The leaf area and dry-matter accumulation have direct correlation with grain yield of crop as the leaf area indicates the photosynthetic efficiency while dry- matter accumulation shows the crop health. Leaf-area, dry-matter accumulation and leaf-area index at 90 days after sowing (DAS) was significantly increased by SSNM, followed by 100% RDF, 50% RDF and significantly lowest was recorded with absolute control (Table 1). Of the different genotypes, recorded 'PMH 1' and 'PMH 3' recorded significantly highest leaf-area index the lowest. The maize hybrid 'CMH 08-292' recorded significantly highest and 'S 6217' recorded significantly lowest dry-matter accumulation. It clearly showed that owing to better leaf-area, higher growth parameters, SSNM proved better than other nutrient applications. Similarly,

Table 1. Effect of nutrient management practices and genotypes on growth characters, normalized difference vegetation index (NDVI), SPAD and growth rate in maize

Treatment	Dry matter (g/plant) at 90 DAS	LAI at 90 DAS	NDVI At 45 DAS	SPAD at 45 DAS	CGR (g/day)			RGR (g/g/day)		
					0–30 DAS	30–60 DAS	60–90 DAS	0–30 DAS	30–60 DAS	60–90 DAS
Nutrient management practices										
Absolute control	246^{c}	1.83^{d}	0.57^{bc}	32.6^{b}	0.96^{c}	1.25^{b}	5.98^{c}	0.048^{c}	0.010^{c}	0.018^{c}
100% RDF	317^{b}	2.39^{b}	0.62^{a}	36.2^{a}	1.25^{a}	1.27^{b}	8.02^{b}	0.052^{a}	0.011^{b}	0.021^{b}
50% RDF	256^{c}	1.96^{c}	0.57^{c}	33.9^{ba}	1.15^{b}	1.27^{b}	6.15^{c}	0.051^{b}	0.011^{b}	0.019^{c}
SSNM	345^{a}	2.64^{a}	0.60^{ba}	35.5^{a}	1.26^{a}	1.36^{a}	8.89^{a}	0.053^{a}	0.012^{a}	0.021^{a}
SEm±	4.29	0.027	0.009	0.83	0.014	0.026	0.133	0.0002	0.0002	0.0002
CD (P=0.05)	12.30	0.078	0.028	2.37	0.039	0.075	0.382	0.0005	0.0005	0.0006
Genotypes										
'PMH 1'	291^{b}	2.27^{b}	0.63^{a}	32.9^{b}	1.17^{b}	1.26^{b}	7.71^{b}	0.051^{ba}	0.011^{bc}	0.021^{b}
'PMH 3'	304^{b}	2.10^{c}	0.59^{bc}	33.6^{ba}	1.12^{c}	1.34^{a}	6.25^{c}	0.051^{b}	0.011^{a}	0.018^{c}
'HQPM 1'	261^{c}	2.36^{a}	0.53^{d}	34.0^{ba}	1.18^{ba}	1.20^{b}	7.31^{b}	0.052^{a}	0.010^{c}	0.020^{b}
'S 6217'	248^{c}	2.15^{c}	0.59^{c}	36.1^{a}	1.08^{c}	1.22^{b}	5.98^{c}	0.050^{c}	0.011^{ba}	0.018^{c}
'CMH 08-292'	351^{a}	2.14^{c}	0.62^{ba}	36.1^{a}	1.23^{a}	1.42^{a}	9.05^{a}	0.052^{a}	0.011^{a}	0.021^{a}
SEm±	4.80	0.031	0.011	0.93	0.015	0.029	0.149	0.0002	0.0002	0.00021
CD (P=0.05)	13.70	0.088	0.031	2.65	0.043	0.084	0.427	0.0006	0.0005	0.0007

DAS, Days after sowing; CGR, crop-growth rate; RGR, relative growth rate, RDF, recommended dose of fertilizer; SSNM, site-specific nutrient management

Ashok (2013) also reported that 'PMH 3' recorded the highest dry-matter accumulation/plant compared to other hybrids at all growth stages of maize.

The NDVI and SPAD or chlorophyll meter values shows direct correlation with plant growth. At 45 DAS significantly highest NDVI and SPAD values were recorded by 100% RDF which was at par with SSNM at 45 DAS (Table 1). Amongst genotypes, 'PMH 1' showed significantly highest value of NDVI at both 30 and 45 DAS and it remained at par with 'PMH 3'. With regards to SPAD value significantly higher values were recorded in 'CMH 08-292'. Both 'PMH-1' and 'CMH 08-292' were tall in nature, hence utilized nitrogen in better way, which resulted in better NDVI and SPAD values. The balanced nutrient prescription in the SSNM leads to more chlorophyll development in crop plant which probably resulted in more NDVI and SPAD values. Similar type of results were also obtained by Ashok (2013) where significantly higher SPAD values were recorded with 'PMH 3' compared to other hybrids at all growth stages of maize.

The CGR and RGR also increased significantly by SSNM at all stages, but during 0–30 days period the CGR remained at par with 100% RDF, while during 60–90 days the RGR remained at par with 100% RDF (Table 2). It clearly indicated that due to better availability of nutrients crop-growth rate was highest in SSNM and lowest in absolute control. Amongst genotypes, significantly higher CGR was recorded by 'CMH 08-292'. While significantly highest RGR was obtained in 'PMH-1', which was on a par with 'CMH 08-292' and lowest by 'HQPM 1' at all growth stages, which show the limitation of such genotypes to perform better for dry-matter enhancement. It also indicates the difference in growth potential of maize genotypes used in the experimentation.

All the yield attributes, viz. cobs/plot, cob length (cm), cob girth (cm), grain rows/cob, grains/row, cob yield, shelling (%), and harvest index (%) and grain yield were recorded significantly higher by SSNM over absolute control and 50% RDF, however it remained at par with 100% RDF (Table 2). With regards to genotypes, 'PMH 3' recorded significantly higher cobs/plot at harvest, cob length, cob girth, grains/row, cob yield and 1,000-grain weight and grain yield, whereas 'S 6217' significantly more grain rows/cob and harvest index. Significantly higher shelling percentage was recorded by 'CMH 08-292'. Significantly lowest yield attributes and grain yield were recorded by 'HQPM 1'. Enhancement in growth attributes lead to photosynthate partitioning and better source–sink relationship, which enhances yield attributes. Giunta *et al.*, (2009) and Kolo *et al.*, (2012) also confirmed similar findings in maize.

Based on the above-mentioned findings, it was concluded that all growth, yield attributes and grain yield in maize can be enhanced with SSNM-based nutrient management over recommended dose of fertilizer along with use of 'PMH 3' hybrid.

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Table 2. Effect of nutrient-management practices and genotypes on yield attributes and yield of maize

Treatment	Cobs/ plot	Cob length (cm)	Cob girth (cm)	Grain rows/cob	Grains/ row	Cob yield (kg/ha)	Shelling (%)	Harvest index (%)	1,000-grain weight (g)	Grain yield (kg/ha)
Nutrient management practices										
Absolute control	130^{b}	17.7^{b}	13.8^{b}	13.34^{b}	30.33^{b}	4.38^{b}	69.97^{c}	31.57^{b}	257a	3.03d
100% RDF	133^{ba}	18.7^{a}	14.1^{a}	13.58^{ba}	30.44^{b}	5.43^{a}	78.16^{b}	32.88^{b}	266a	4.03b
50% RDF	131^{b}	18.0^{b}	14.0^{ba}	13.84^{a}	30.36^{b}	5.20^{a}	67.75^{c}	32.78^{b}	264a	3.65c
SSNM	136^{a}	19.1^{a}	14.2^{a}	13.29^{b}	31.87^{a}	5.50^{a}	85.22^{a}	38.12^{a}	270a	4.62a
SEm±	1.29	0.21	0.11	0.116	0.395	0.167	2.32	1.031	5.59	0.118
CD (P=0.05)	3.7	0.59	0.31	0.333	1.29	0.479	6.665	2.954	NS	0.337
Hybrids										
'PMH 1'	136^{a}	18.7^{ba}	13.7^{dc}	13.6^{b}	30.08^{c}	5.06^{b}	76.04^{a}	31.71^{c}	286a	3.81b
'PMH 3'	136^{a}	18.9^{a}	14.5^{a}	14.1^{a}	33.24^{a}	5.67^{a}	75.22^{a}	35.33^{b}	291a	4.25a
'HQPM 1'	130^{b}	17.8^{c}	13.7^{c}	13.1^{d}	31.54^{b}	4.09^{c}	74.07^{a}	30.51^{c}	246b	2.98c
'S 6217'	132^{ba}	18.4^{b}	14.3^{ba}	13.5^{cb}	29.85^{c}	5.63^{a}	74.98^{a}	38.71^{a}	242b	4.18ba
'CMH 08-292'	129^{b}	18.3^{bac}	14.1^{bc}	13.1^{cd}	29.04^{c}	5.20^{a}	76.06^{a}	32.93^{cb}	254b	3.95ba
SEm±	1.44	0.234	0.12	0.130	0.441	0.187	2.60	1.153	6.25	0.132
CD (P=0.05)	4.1	0.67	0.35	0.372	1.263	0.536	7.451	3.303	17.09	0.377

RDF, recommended dose of fertilizer; SSNM, site-specific nutrient management

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