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Research Communication

Yield components and nutrient accumulation in maize (*Zea mays*) under variable growing environments and chlorophyll meter-guided nitrogen fertilization

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ABSTRACT

A field experiment was conducted during 2014–15 on sandy loam soil at ICAR–Indian Agricultural Research Institute, New Delhi, to study the effect of different growing environments and chlorophyll meter-based nitrogen (N)-management practices on yield components, yield and nutrient uptake in maize (*Zea mays* L.) cultivars. Maize hybrid 'PEEHM 5' exhibited significantly larger yield attributes and higher grain yield than 'Pusa Composite 3' ('PC 3'), and earlier planting dates, 9 July and 24 July, depicted significant edge over later planting on 7 August. Chlorophyll meter-based N application up to silking (CMB), i.e. 30 kg/ha N basal + 30 kg/ha N top-dressed when soil-plant analysis development meter (SPAD) value falls to ≤ 37.5, increased the magnitude of all yield attributes and yield compared to soil-test-crop response based (STCRB)-N application. Grain N, P and K uptakes were 13.3, 30.7 and 11.8%, respectively, higher in 'PEEHM 5' than in 'PC 3'. Similarly, CMB N application resulted in 17.2, 18.7 and 11.2% higher N, P and K uptake in grain and 9.3% greater grain yield compared to STCRB N. Overall, variety 'PEEHM 5' planted on 9 July and fertilized with N based on chlorophyll meter readings was a better option than the others with respect to yield attributes, yield and nutrient uptake in the north Indian plains.

Key words : Chlorophyll meter, Maize cultivar, Nutrient uptake, Planting date, Yield components

Maize is an important staple food crop in India and cultivated over 8.67 million ha, with 22.26 million tonnes production having an average productivity of 2.57 t/ha, contributing nearly 8% in the national food basket (DACNET, 2014). However, major concern of maize producers is its very low yield due to inefficient and imbalanced use of nitrogenous fertilizers resulting in low nutrient uptake, high leaching and volatilization losses, groundwater pollution, declining soil fertility and ultimately, less profit. These constraints can be overcome by precise N-management which can be ensured by using chlorophyll meter, a relatively new technology, because values from the chlorophyll meter are highly correlated with the leaf-N status of maize. Dass *et al*. (2014) found that applying N based on SPAD value ≤ 37.5 resulted in the highest maize grain yield (5.2 t/ha) and saved 30–45 kg N/ha. Chlorophyll-meter readings can be recorded at different physiological stages of maize crop or after certain periodical intervals, depending on the availability of resources, requirement and ease of the cultivators. Soil-test value-based N application is one of the widely followed methods of N fertilization, which advocates entire N application in 2–3 doses and takes into account soil contribution and target yield. Hence it is worthwhile to make a comparative study among these methods of N fertilization, to find out superiority of one over the other for yield-forming parameters, yield and nutrient uptake.

Like many other crops, the growth, development and nutrient uptake in maize are influenced by environmental changes (temperature, rainfall, sunshine, etc.) associated with different planting dates. Norwood (2001) advised that farmer might opt for staggered planting using different planting dates, but this option may not be feasible at farmers level due to lack of resources. Hybrid 'PEEHM 5' and composite 'PC 3' are 2 maize genotypes recently developed by the Indian Agricultural Research Institute of extra-early and medium-duration, respectively, and recommended for cultivation under north Indian conditions. Due to unfavourable climatic conditions and intensive cropping systems, farmers of north India oftenly become compelled to use varying planting dates for above-mentioned geno-

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types. Thus, it is essential to determine optimum planting time for the specified maize varieties to get higher yield with nutrient rich-grains. Hence a field experiment was carried out to study yield components, nutrient and uptake in maize cultivars as influenced by different planting dates and chlorophyll meter-based N rates.

The field experiment was conducted during the rainy (*kharif*) season of 2014 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi (28° 40' N, 77° 12' E and 228.6 m above mean sea-level). Soil of the experimental field was sandy loam with medium organic carbon (0.58%), low available N (alkaline permanganate method) (224 kg/ha) and medium available phosphorus (Olsen method) (18.7 kg/ha) and potassium (flame-photometer method) (262 kg/ha) contents, with *p*H 7.4. Climate during experimental crop-growth period was variable with 34.2< C and 22.8< C mean weekly maximum and minimum temperatures, respectively. Total rainfall during crop period (9 July 2014 to 12 November 2014) was 389 mm, with a weekly average of 21.61 mm (18 weeks). The experiment having 24 treatment combinations was laid-out in a split-plot design with 3 replications and, thus, had a total of 72 plots (sub-plots) of 4.8 m × 3 m size each. The main-plot treatments comprised 2 maize genotypes (Hybrid 'PEEHM 5', Composite 'PC 3') and 3 planting dates (July 9, July 24, August 7) and sub-plot treatments comprised 4 N rates, control (no-N), chlorophyll meter-based N application up to silking (CMB): 30 kg N/ha basal + 30 kg N/ha top-dressed at SPAD value ≤ 37.5, chlorophyll meter based N application stage-wise (CMBSW): 30 kg N/ha basal + 30 kg N/ha top-dressed during knee-high, pre-tasseling and silking stages at SPAD value ≤ 37.5, and soil-test crop response based (STCRB) application. In this experiment, maize crop was sown on different planting dates as per treatments by dibbling the bavistin-and thiram-treated seeds on flat beds prepared manually in rows, 60 cm apart, by using 20 kg seed/ha. Plant-to-plant distance was kept as 20 cm by thinning 10 days after sowing. The crop was raised as per normal package of practices except treatments. As per treatments, for STCRB-treated plots (160 kg N/ha), 56 kg N for CMB (150 kg N/ha) and CMBSW (120 kg N/ha) treated plots, 30 kg N and for control plots (no-N), zero kg N/ha was applied as basal dose at the time of land preparation by using urea. Subsequent N fertilizer was applied according to SPAD meter readings as per treatments. Phosphorus (60 kg P_2O_5) from single super phosphate, potassium (40 kg K_2O) from muriate of potash and 25 kg/ha zinc sulphate were uniformly applied in all plots at the time of final land preparation.

At harvesting, 5 plants were sampled from the second row from the plot-border for each plot to determine yield attributes like cobs/plant, cob weight, grains/cob and 1,000-grain weight. To determine grain yield, maize cobs from the net plots, leaving 2 border rows from both sides of the plots and a half meter on opposite directions of the plots, were harvested and sun-dried for 6 days and weighed. The cobs were dehusked, shelled, cleaned, dried in sun, weighed again and grain yield was adjusted at 14% moisture content. The weight of husk and rachis (cob after removal of grains) were also recorded separately. After cob harvesting, maize stalks were cut at ground level from the net-plot and were sun-dried for 7 days. After proper sun drying, the stalk weight/ plot was taken and reported as stover yield. The N, P and K contents in plant parts (grain and straw) were estimated from the samples collected at harvesting by following chemical analysis methods described by Prasad *et al.* (2006). Nutrient uptake (N, P and K) in grain and stover was estimated by multiplying N, P and K contents (%) in grain and stover with their respective dry-matter yields. The data were statistically analyzed as per analysis of variance techniques (ANOVA) and critical differences were estimated at 0.05 probability.

Hybrid variety 'PEEHM 5', on an average, bore 1.3 cobs/plant compared to 1.2 cobs/plant in 'PC 3'. Number of grains/cob in 'PEEHM 5' was 220, being 7.31% higher than 'PC 3'. The 1,000-grain weight and cob weight were also significantly higher in 'PEEHM 5' than 'PC 3' (Table 1). Enujeke (2013) also reported significant variation in yield attributes among different maize hybrids. These differences between varieties for yield attributes could be due to variation in the genetic potential make-up, with hybrid 'PEEHM 5' being more efficient in translocation of photosynthates from leaves to grains (source to sink). The crop sown on 9 July recorded significantly higher number of cobs/plant, number of grains/cob, 1,000-grain weight and cob weight than the crop sown on 24 July and 7 August; the increase being 8.3 and 18.2% for cobs/plant, 9.8 and 25.7% for number of grains/cob, 3.2 and 9.7% for 1,000-grain weight, 10 and 21% for average cob weight respectively. The reduction in yield attributes in delayed planting is due to lower biomass production and below optimal climatic conditions. Azadbakht *et al.* (2012) also observed that delay in planting caused reduction in plant-growth period, and yield attributes and yield. Among the N application rates, CMB N treatment resulted in significantly higher yield attributes than STCRB N application due to small but regular N supply (Table 1). These results are in consistency with findings of several researchers, who opined that chlorophyll meter is an efficient N management tool to detect location-specific and timely N deficiency to supply readily-available N to different crops (Fox *et al.,* 1994; Dass *et al.,* 2015).

Hybrid variety 'PEEHM 5' recorded 5% higher grain yield than 'PC 3', while the latter was significantly higher

Table 1. Effect of varieties, planting dates and chlorophyll meter based N application on yield components, yield and nutrient uptake in grain and stover of maize at harvest

Treatment	Cobs/ plant	Grains/ cob	1,000-grain weight (g)	Cob weight (g)	Yield (t/ha)		N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
					Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Varieties												
'PEEHM 5'	1.3	220	229	85.5	4.62	8.37	67.6	41.3	14.9	15.1	21.1	102.6
'PC 3'	1.2	205	204	82.7	4.39	9.34	58.6	53.5	10.5	16.1	18.6	112.3
SEm±	0.02	2.3	3.4	0.50	0.071	0.146	1.25	1.09	0.33	0.58	0.41	1.92
CD (P=0.05)	0.06	7.0	10.2	1.50	0.213	0.437	3.75	3.27	0.99	1.73	1.24	5.77
Planting dates												
9 July	1.3	235	226	92.2	4.87	9.45	74.9	56.5	16.0	17.9	23.2	117.1
24 July	1.2	214	219	83.8	4.58	8.96	63.8	47.4	12.9	16.1	20.1	108.8
7 August	1.1	187	206	76.2	4.06	8.15	50.6	38.2	9.3	12.9	16.1	96.6
SEm±	0.02	2.9	4.2	0.60	0.087	0.179	1.53	1.33	0.41	0.71	0.51	2.36
CD (P=0.05)	0.07	8.6	12.4	1.90	0.261	0.536	4.59	4.00	1.22	2.11	1.52	7.07
Nitrogen rates												
Control	1.0	128	161	57.7	3.03	6.19	36.2	25.3	6.2	9.6	10.7	69.4
CMB	1.3	258	246	99.8	5.31	10.27	81.8	61.7	17.1	19.3	24.9	127.9
CMBSW	1.2	232	230	88.8	4.82	9.42	66.6	50.9	13.6	16.6	21.6	115.2
STCRB	1.2	231	230	90.0	4.86	9.54	67.7	51.6	13.9	17.1	22.1	117.5
SEm±	0.02	3.8	3.7	1.30	0.074	0.143	1.96	1.38	0.39	0.83	0.72	2.06
CD (P=0.05)	0.06	10.9	10.6	3.60	0.213	0.412	5.64	3.98	1.12	2.39	2.08	5.92

CMB, Chlorophyll meter-based N application up to silking, i.e. 30 kg/ha N basal + 30 kg/ha N top-dressed each time leaf SPAD value falls to ≤ 37.5; CMBSW, Chlorophyll meter-based N application stage-wise, i.e. 30 kg/ha N basal + 30 kg N top-dressed each at knee-high, pre-tasseling and silking stages when SPAD value falls to ≤ 37.5; STCRB, Soil-test-crop response-based N application

straw yielder. This could be attributed to different inherent efficiencies of 2 genotypes in photosynthates partitioning. It was observed that delayed planting decreased economic yield as well as stover yield. The crop planted on 9 July recorded 16.6% higher grain yield and 13.7% higher straw yield than 7 August planted crop owing to congenial growing environments. Delayed sowing caused reduction in leaf area index and dry-matter accumulation due to shorter vegetative growth stage, and poor dry-matter partitioning from source to sink, finally leading to low yields (Jadhav *et al*., 2015). In accordance with yield attributes, CMB N treatment resulted in significantly higher grain and stover yields than the others owing to continuous supply of N as per crop requirement (Table 1).

Grain N, P and K uptakes were significantly higher in 'PEEHM 5' than 'PC 3', while N and K uptakes in stover were significantly higher in 'PC 3'. This might be attributed to higher grain and stover yield in 'PEEHM 5' and 'PC 3' respectively, because nutrient uptake is a function of nutrient content in grain and stover and their respective yield (Layek *et al.,* 2015). Among different planting dates, 9 July planted crop showed significantly higher N content in grain and straw, P and K content in grain than the others owing to higher root length at knee-high stage and longer duration that enabled the plants to capture higher amount of nutrients. Owing to higher yield, N, P and K uptake in grain was also higher in earlier planted (9 July) crop than the rest. The CMB N treatment resulted in higher nutrient (N, P and K) content and uptake in both grain as well as stover than the others, because chlorophyll meter-based application supplied nitrogen in readily-available form according to plant need and produced higher biomass.

Overall, it could be concluded that maize hybrid 'PEEHM 5' showed higher grain yield with better-grain quality than 'PC 3'. Delayed planting on 7 August caused significant reduction in yield and nutrient uptake both in grain and straw compared to 9 July planting. Scheduling N application as per SPAD value ≤ 37.5 up to silking resulted in better yield and nutrient uptake than the other methods of N application.

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