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RESEARCH PAPER

Productivity of medium-duration maize cultivars under varying planting densities and nutrient levels in rainfed conditions of Northeast India

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Abstract: Maize is the second important staple crop after rice in the hill rainfed ecosystem of north eastern India. Due to high variable climatic conditions, erratic rainfall and wide range of temperature in the region, shorter duration of maize varieties is gaining popularity over long duration and local landraces. A field experiment was conducted during the *kharif* season of 2020-21 to identify the most medium duration varieties of maize under different planting densities and nutrient levels. Three varieties of medium maturity maize (DKC 9190, DKC 8191 an Bio 9544) were tested in two different planting densities (Normal- 66,666 and high- 83,666 plants ha^{-1}) and two nutrient levels (RDF *i.e.* 120:60:60 and 150% RDF *i.e.* 180:90:90 N:P:K kg ha^{-1}) in split-split plot design replicated thrice. The experimental result observed, normal planting density possess taller plant height (245.2 cm), lesser days to tasselling (56.3) and silking (60.3) and yield attributes. The variety DKC 8191 recorded the shortest duration to tasselling (54.7) and silking (58.7), higher length (17.0 cm), girth (16.0) of the cobs, more number of rows (14.0) and kernels per row (37.9) compared to the other varieties under normal planting density. Also under normal planting density the variety DKC 8191 recorded the maximum yield (6537 kg ha^{-1}), net return (103767 Rs. ha^{-1}) and B:C (2.97) followed by DKC 9190 and Bio 9544 respectively. Thus, it can be concluded that the variety DKC 8191 with normal planting density of 66,666 plants ha^{-1} and nutrient level of 120:60:60 NPK kg/ha, showed more suitability for attaining higher yield and economic benefits under rainfed condition of North East India when compared to DKC 9190 (4428 kg ha^{-1} and 57175 Rs. ha^{-1} respectively) and Bio 9544 (3203 kg ha^{-1} and 30354 Rs. ha^{-1} respectively).

Keyword: Maize • Planting densities • Nutrient levels • Growth • Yield • Economics

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Introduction

In India, maize is cultivated in a variety of climates, from extremely semiarid to sub-humid and humid areas. In India's highland regions, maize is regarded as a promising alternative for agricultural diversification. It is currently India's third-most significant crop for food grains. However, compared to other prospective corn-growing nations like the United States, Argentina, and China, India's productivity is significantly lower. The crop enjoys great popularity in the north-eastern hill (NEH) regions as well as in low and mid-hill regions. Maize is farmed mostly on terraced ground and jhum soil in the North-eastern region of India with lesser yield than the national average. One of the main causes of the region's low productivity is the adoption of traditional low-yielding genotypes that are susceptible to soil acidity-induced fertility stresses, such as phosphorus (P), calcium (Ca), magnesium (Mg), and other micronutrient deficiencies (Patiram, 2007). Another significant factor is the uneven distribution of rainfall, which causes intermittent moisture stress in the rainfed upland condition (Choudhary *et al.*, 2013).

The genetic composition, environmental conditions, and edaphic factors determine maize's potential yield. However, as the yield is the product of the interplay between genotype, management, and environmental factors, the genetic potential can be fully utilized by creating an environment that is favorable for growth and development. Crop output is largely influenced by technological interventions, such as pest and disease control, planting density, water and fertilizer management, genotyping, etc. (Sivamurugan *et al.*, 2018). Different contexts elicit different reactions from these approaches. Among other factors, managing nutrients, planting density, and genotypes are critical to raising maize yields. Sustaining the ideal plant population is beneficial for yield because it is one of the main factors that directly influences yield. Due to its intensive nature, it needs higher nutritional levels at different stages of growth. This means that to increase productivity, a balanced application of fertilizers containing, appropriate planting population and suitable shorter duration variety to tackle the climatic variable is required Therefore, the goal of the current experiment was to determine how varied planting densities and NPK levels, along with their interactions, affected the genotypes of medium-maturity maize varieties.

Materials and methods

A field experiment was conducted during *kharif* season, 2020 at Andro Research Farm, Central Agricultural University, Imphal, Manipur to study the performance of medium maturity varieties of maize in variable planting population and nutrient levels under rainfed condition on growth, yield, and economics of the varieties. The soil at the site is sandy clay loam soil with 5.6 pH, 1.71% organic carbon, 272.5 kg ha^{-1} available nitrogen, 21.62 kg ha^{-1} available phosphorus and 163 kg ha^{-1} exchangeable potassium. During the entire crop growth period, total rainfall received is 789 mm with average maximum and minimum temperature 34^{o}C and 17^{o}C respectively. The experiment was laid out in split-split plot design, with main plot sixe being 4x4m maintaining spacing of 60 x 25 cm^2 and the plot consisting of 2 treatment combinations, i.e., 2 plant densities (Normal – 66,666 plants/ha, High-83,666 plants/ha), sub plot consisting of 2 nutrient levels (RDF-120:60:60, 150% RDF 180:90:90 kg NPK/ha) and sub-sub plot comprising of three varieties (DKC 9190, DKC 8191 and Bio 9544) with three replications. The crop was planted on 27th July 2020 and harvested according to the maturity duration of the varieties. As per the treatments N, P and K were applied to the crops in the form of urea, single super phosphate, and muriate of potash, respectively. Out of these, 50% nitrogen and 100% phosphorus and potassium were applied as basal dose and remaining 50% of the nitrogen was split first at knee height and at tasseling stage. The observations on plant height at harvesting (cm), number of days to 50% tasseling, number of days to 50% silking, length of the cobs (cm), length of the cob girth (cm), number of kernels row cob^{-1}, number of kernels row^{-1}, 100 seed weight (seed index), cob yield and green fodder yield were recorded. Also, the economics of crop were calculated as per the market price of medium maturity varieties of maize. The statistical analysis of the recorded data was done using the standard procedure as suggested by Gomez and Gomez (1983).

Results and discussion

Growth and yield attributes as affected by plant densities, nutrient levels, and medium maturity maize varieties

The experimental results in Table 1 revealed that the normal densities of 66,666 plants ha^{-1} possess taller plant height (245.2 cm), lesser number of days to 50% tasseling (56.3 days) and silking (60.3 days), length of the cobs (16.6 cm) and number of kernels row cob^{-1} (13.7 cm) over higher planting density of 83,333 plants/ha. This might be due to lesser competition for space, sunlight and available nutrients in lower plant population. The results are in conformity with the findings of Pal and Bhatnagar (2012) and Bangarwa *et al.* (1988). However, variation in nutrient levels could not bring the significant difference in growth and yield attributes of medium maturity maize. The medium maturity varieties of maize were significantly influenced on growth and yield attributes. DKC 9190 gave higher plant height (252.6 cm) followed by DKC 8191 and Bio 9544, respectively. However, minimum number of days to tasseling (54.7 days) and silking (58.7 days), length of cob (17.0 cm), girth of the cob (16.0 cm), kernel rows cob^{-1} (14.0) and kernel rows^{-1} (37.9) were attributed to DKC 8191 variety followed by DKC 9190 and Bio 9544, respectively. The variation in growth and yield attributes of different varieties may be due to specific genotypic character of different varieties (Biswas *et al.*, 2019). Interaction of planting densities, nutrient levels and varieties were not observed on growth and yield attributes of maize.

Table 1. Influence of planting densities and nutrient levels on growth and yield attributes of medium maturity varieties of maize

Treatments	Plant height (cm)	Days 50% tasseling	Days 50% silking	Cob length (cm)	Cob girth (cm)	Kernel rows cob^{-1}	Kernels cob^{-1}
Density (plant ha^{-1})							
Normal (66,666)	245.2	56.3	60.3	16.6	15.4	13.7	35.8
High (83,666)	227.5	56.8	60.8	14.8	15.3	13.4	35.5
SE(m)±	2.51	0.079	0.079	0.395	0.227	0.041	0.963
CD (P=0.05)	15.45	0.3	0.3	0.8	NS	0.25	NS
Nutrient Levels (kg ha^{-1})							
RDF (120:60:60)	238.7	56 .6	60.6	15 .9	15 .4	13 .6	36.0
150% RDF (180:90:90)	234.1	56.7	60.8	15.5	15.2	13.5	35.4
SE(m)±	3.89	0.176	0.176	0.262	0.096	0.198	0.575
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
Varieties							
DKC 9190	252.6	57.5	61.5	15.3	15.2	13.5	35.4
DKC 8191	223.6	54.7	58.7	17.0	16.0	14.0	37.9
Bio 9544	232.9	57.5	61.5	14.9	14.7	13.1	33.8
SE(m)±	6.12	0.102	0.102	0.516	0.230	0.220	0.813
CD (P=0.05)	18.35	0.31	0.31	1.54	0.69	0.66	2.4

Yield and seed index as affected by plant density, nutrient levels, and medium maturity varieties of maize genotypes

Normal planting density (66,666 plants ha^{-1}) and nutrient level with recommended dose of 120:60:60 recorded maximum grain yield (4723 kg/ha and 4473 kg/ha) and stover yield (11119 kg/ha and 11275 kg ha^{-1}). This clearly indicated that plants at lower density fully exploited the natural resources efficiently, besides responding to externally applied inputs and expressed the same liberally compared to plants at highest plant density where the competition was stiff. The findings of Ashok (2009) and Singh *et al.* (2022) confirmed these results. The plant density at 66,666 ha^{-1} recorded higher values and even differed significantly from 83,666 ha^{-1} for yield attributes namely, cob weight without husk, number of kernel rows per cob and 100 kernel weights, indicating a stress free environment.

There was no marked influence of grain yield and stover yield due to higher levels of nutrients as compared to lower levels of nutrients applied (Table 2) which could be due to the limitations in the genetic potential of the crop or the non – availability of the other nutrients leading to no increase in the yield of the crop as indicated in the findings of Pandey *et al.* (2021) and Mitcherlich (1947). With respect to varieties, DKC 8191 registered higher grain yield of 5460 kg ha^{-1} as compared to DKC 9190 (4076 kg ha^{-1}) and Bio 9544 (3138 kg ha^{-1}). This was ascribed to genetic makeup of plants coupled with improved nutrient uptake under high nutrient status. Genotypic variations in yield were also reported by Patil *et al.* (2000), Ahmed *et al.* (2010), Singh *et al.* (2022). Among the genotypes, DKC 8191 was superior in terms of seed index (30.6 g) followed by DKC 9190 (27.5 g). However, the 100 seed weight (seed index) was not influenced due to varied planting densities and nutrient levels.

The interaction effect of planting densities and genotypes has shown marked influence on the genotype DKC 8191 (Table 3) with significantly higher grain yield (6537 kg/ha) under normal planting density. The higher yield under normal planting density might be due to better interception of light, solar radiation, nutrient use efficiency and good genetic potential from the rest of the genotypes.

Net returns and B:C ratio as affected by plant density, nutrient levels, and medium maturity varieties of maize genotypes

The assessment of economics of medium maturity maize varieties showed that net returns and B:C ratio were significantly affected by the planting densities, nutrient levels and varieties (Table 2). Among the planting populations, normal planting density (66,666 plants ha^{-1})

Table 2. Influence of planting densities and nutrient levels on yield and economics of medium maturity varieties of maize

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Seed index (g)	Net returns (Rs. ha^{-1})	B:C ratio
Density (plant ha^{-1})					
Normal (66,666)	4723	11119	28.5	63766	2.22
High (83,666)	3728	10854	27.9	39821	1.71
SE(m)±	78	151	0.31	1765	0.04
CD (P=0.05)	473	NS	NS	10891	0.21
Nutrient Levels (kg ha^{-1})					
RDF (120:60:60)	4473	11275	28.3	59966	2.16
150% RDF (180:90:90)	3977	10697	28.1	43621	1.77
SE(m)±	149	239	0.15	3327	0.06
CD (P=0.05)	NS	NS	NS	12990	0.24
Varieties					
DKC 9190	4078	10400	26.4	47670	1.89
DKC 8191	5460	12984	30.6	80479	2.50
Bio 9544	3138	9574	27.5	27231	1.51
SE(m)±	154	229	0.19	3285	0.06
CD (P=0.05)	463	685	0.6	9850	0.18

Table 3. Interaction of planting densities and genotypes on grain yield (kg ha^{-1})

	DKC 9190	DKC 8191	Bio 9544
Normal density	4428	6537	3203
High density	3727	4382	3074
SE(m)±		218	
CD (P=0.05)		655	

registered the highest net return (63766/- Rs. ha^{-1}) and B:C ratio (2.22). This is due to higher yield in normal planting density that led to more B:C ratio and crop productivity. Lower nutrient level (120:60:60 NPK kg ha^{-1}) produced higher net returns (59966/- Rs ha^{-1}) and B:C ratio (2.16) than higher nutrient levels. Lesser monetary return in higher nutrient levels might be due to higher costs of cultivation in applying higher dose of fertilizer. Similar result of higher economic return under lower nutrient was obtained by Singh *et al.* (2022). The varieties have shown marked influence on the economics of the crop. Among the varieties DKC 8191 has recorded highest net returns (80479/- Rs. ha^{-1}) and B:C ratio (2.50) due to its greater potential to produce seed and fodder resulting in greater return.

Table 4. Interaction of planting densities and genotypes on net return (Rs. ha^{-1})

	DKC 9190	DKC 8191	Bio 9544
Normal density	57175	103767	30354
High density	38165	57191	24108
SE(m)±		4646	
CD (P=0.05)		13930	

The combined effect of the planting densities and genotypes has also shown a marked influence on the net returns and B:C ratio with significantly highest in the variety DKC 8191 (103767/- Rs. ha^{-1} net return, 2.97 B:C) as shown in table 4 and 5 with no significant effect of the other combinations with planting density and rest of the varieties.

Table 5. Interaction of planting densities and genotypes on B:C

	DKC 9190	DKC 8191	Bio 9544
Normal density	2.11	2.97	1.58
High density	1.68	2.02	1.43
SE(m)±		0.09	
CD (P=0.05)		0.26	

Conclusion

Based on the experimental findings, it can be concluded that the medium maturity variety DKC 8191 at normal planting density of 66,666 plants ha^{-1} and a nutrient level of 120:60:60 NPK kg ha^{-1} is recommendable for attaining higher grain yields and economic benefits under rainfed condition of north east India during the *kharif* season.

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