The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 20(2): 141-145, 2025 www.thebioscan.com

Effect of nutrient management practices on crop growth and yield of maize (*Zea mays* L.)

Utkarsh Singh[1], Rajesh kumar[1], Sanjeev Singh[3], Abhinav Kumar[1], Anand Singh[2], Abhinandan Singh[1], Shipra Yadav[1], Anil Kumar Singh[1], Neeraj Kumar[1], Ajay Singh[4], Shyam Beer Singh[1] and Pramod Kumar Singh[5]

[1]Department of Agronomy, Acharya Narendra Deva University of Agriculture &Technology, Kumarganj, Ayodhya, India

[2] Department of Soil Science, Acharya Narendra Deva University of Agriculture &Technology, Kumarganj, Ayodhya, India

[3]Assistant Agronomist, Deptt. Of Vegetable Science, Acharya Narendra Deva University of Agriculture &Technology, Kumarganj, Ayodhya, India

[4]Deptt. Of Agronomy, School of Agriculture, L.M.N.T University, Bhopal

[5]SMS, KVK Amethi, Acharya Narendra Deva University of Agriculture &Technology, Kumarganj, Ayodhya, India

1st corresponding author- agabhi92@gmail.com

2nd corresponding author- singhanand10795@gmail.com

DOI: https://doi.org/10.63001/tbs.2025.v20.i02.pp141-145

KEYWORDS
Dustavrana, Shashtirupakrama, Platelet Rich Plasma (PRP).

Received on: 08-04-2025
Accepted on: 05-05-2025
Published on: 02-06-2025

ABSTRACT

The field experiment was conducted at the agronomy research farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh to access the effect of optimization of nutrient management practices on growth and yield of maize during *kharif* season of 2023 and 2024. The experiment was laid out in factorial randomized block design (FRBD) with 3 replications and consists three RDF Levels 50% RDF (NPK), 75% RDF (NPK) and 100% RDF (NPK)) and five Bio-agent enriched FYM and micronutrient (Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1}, Enriched FYM @ 5 t ha^{-1}, Enriched FYM @ 10 t ha^{-1}, Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 5 t ha^{-1}, Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}). Results indicate that among the RDF levels crop fertilized with 100% RDF (NPK) recorded significantly highest plant height (96.76 & 99.36 cm, 176.24 & 180.98 cm and 205.88 & 211.38 cm), highest leaf area index (2.88 & 2.91, 4.18 & 4.23 and 3.34 & 3.38) at knee-high, tasseling and harvest stage of crop growth during 2023 and 2024, respectively. Similarly, maximum grain yield (43.20 & 44.94 q ha^{-1}) was recorded under 100% RDF. Among the bio-agent enriched FYM and micronutrient application of Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}) recorded significantly the highest plant height (95.93 & 98.50cm, 174.73 & 179.40 cm and 204.13 & 209.60 cm), highest leaf area index (2.84 & 2.87, 4.11 & 4.16 and 3.29 & 3.33) at knee-high, tasseling and harvest stage of crop growth during both the years of investigation. Similarly, maximum grain yield (47.12 & 49.02 q ha^{-1}) was reported with same treatment.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important grain crop, after rice and wheat. It is an important cereal crop in tropical regions, covering 9.89 million hectares in India and producing 31.64 million tonnes with a productivity of 3.2 t/ha **(FAO, 2022).** About 9% of India's total food security comes from maize, making it the third most important cereal crop in the nation **(Jat *et al.*, 2013).** For India's impoverished, maize is especially crucial as a way to combat hunger and increase food security because of its great diversity.

In India, maize is an essential component of the rice-wheat cropping system because it increases total agricultural output, diversifies crop cycles, and improves soil health (the ongoing assimilation of residues in the soil). Recently, more than 47% of maize produced in India is used for poultry feed while 14% is utilized for starch production. Approximately 13% is designated for both food consumption and livestock feed, 7% for food processing and the remaining 6% is exported or allocated for other purposes (IIMR 2021). Nutrient management strategies play a vital role in sustainable production of crop. Farmers are using huge amount of chemical fertilizers. This

excessive application of chemical fertilizer has been associated with decline in soil physical and chemical properties and crop yield (Kumar *et al*. 2016). Efficacy of organic sources to fulfill the nutrient demand of crop is not as assured as mineral fertilizers, but the joint use of inorganic fertilizers along with various organic sources is capable of higher crop productivity along with improving the soil quality on long-term basis. Hence, instead of applying recommended dose of fertilizers through chemical fertilizers, a strategy of integrated use of recommended dose of fertilizers through inorganic sources in combination with different organic sources, which is available locally should be developed to meet the nutrient requirement of crops without deteriorating the soil and other natural resources. It is necessary to identify the best available organic resources which can be used in combination with appropriate proportion of inorganic fertilizers to achieve maximum yield potential of crops. Keeping these points in view, the present investigation under irrigated condition has been proposed and in order to maximise crop yield potential, the best available organic resources must be identified and combined with the right amount of inorganic fertilisers.

MATERIALS AND METHODS

The field experiment was conducted at the agronomy research farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh. The soil of experimental field was silty loam, comprising 27.5% sand, 54% silt, and 18.5% clay, with an electrical conductivity of 0.28 dS/m, slightly alkaline in reaction with a pH of 8.35, low in organic carbon (0.36%), low in available nitrogen (149.26 kg/ha) and medium in available phosphorus (16.02 kg/ha) and medium in available potassium (237.08 kg/ha). The experiment was laid out in factorial randomized block design (FRBD) with 3 replications and consists three RDF Levels(50% RDF (NPK), 75% RDF (NPK) and 100% RDF (NPK)) and five Bio-agent enriched FYM and micronutrient (Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1}, Enriched FYM @ 5 t ha^{-1}, Enriched FYM @ 10 t ha^{-1}, Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 5 t ha^{-1}, Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}).The enriched FYM was applied 15 days before sowing. The recommended fertilizer dose of 150:60:40 kg/ha of N, P_2O_5 , and K_2O was applied using urea, di-ammonium phosphate (DAP) and muriate of potash (MOP). The variety was used 'RASI-4212'. The spacing adopted was 60 cm × 20 cm and the seed rate used for maize was 20 kg/ha.The all-other standard agronomic practices were followed as per the recommendation. Key crop parameters were recorded using established methodologies **(Rana *et al*., 2014).** The collected data were analysed statistically using analysis of variance (ANOVA) with OPSTAT software. The standard error of the mean and least significant difference (LSD) at a 5% significance level were calculated for each treatment, allowing for the comparison of treatment means.

RESULTS AND DISCUSSION

Plant height:

Data presented in Table-1 indicate that increase in application of RDF from 50% to 100%, increased the plant height significantly. Maximum plant height was recorded under 100% RDF (96.76 & 99.36 cm, 176.24 & 180.98 cm and 205.88 & 211.38 cm) at knee-high, tasseling and harvest stage during 2023 & 2024, respectively. Crop fertilized with 75% RDF recorded significantly higher plant height (90.78 & 93.24 cm, 165.34 & 169.76 cm and 193.16 & 198.32 cm) over 50% RDF (85.66 & 87.94 cm, 155.96 & 160.12 cm and 182.22 & 187.12 cm) at all stages of crop growth during 2023 and 2024, respectively.

Among bio-agent enriched FYM & micronutrient, crop fertilized with Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 10 t ha^{-1} recorded significantly maximum plant height (95.93 & 98.50 cm, 174.73 and 179.40 cm and 204.13 & 209.60 cm) at knee-high, tasseling and harvest stage during 2023 & 2024, respectively, which was at par with Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 5 t ha^{-1} (93.03 & 95.53 cm, 169.43 & 173.97 cm and 197.93 & 203.23 cm) and enriched FYM @ 10 t ha^{-1} (93.80 & 96.33 cm, 170.83 & 175.40 cm and 199.57 and 204.90 cm) while significantly higher over rest of the treatments. This might be due to the readily available and mineralized nutrients present in inorganic fertilizers along with constant release of nutrients by organic fertilizers. Increase in plant height is a function of cell division, cell elongation and cell differentiation which depend upon nutrient availability. These results confirm the findings of Pinjari (2007) and Tetarwal *et al*. (2011).

Leaf area index:

Data presented in Table-2 indicate that application of RDF from 50% to 100%, increased the leaf area index significantly. Maximum leaf area index was recorded under 100% RDF (2.88 & 2.91, 4.18 & 4.23 and 3.34 & 3.38) at knee-high, tasseling and harvest stage, which was significantly higher over rest of the treatments during 2023 & 2024, respectively. Crop fertilized with 75% RDF recorded significantly higher leaf area index (2.69 & 2.72, 3.90 & 3.95 and 3.12 & 3.16) over 50% RDF (2.51 & 2.54, 3.65 & 3.69 and 2.92 & 2.95) at all stages of crop growth during 2023 and 2024, respectively.

Among bio-agent enriched FYM & micronutrient, crop fertilized with Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 10 t ha^{-1} recorded maximum leaf area index (2.84 & 2.87, 4.11 & 4.16, 3.29 & 3.33) at knee-high, tasseling and harvest stage which was at par with Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 5 t ha^{-1} and enriched FYM @ 10 t ha^{-1} while significantly higher over rest of the treatments. It might be due to the adequate and continuous availability of nutrients with recommended dose of NPK or combined application of FYM with N improved the LAI of maize. These results are in close conformity with Kumar (2008) and Baradhan & Kumar (2018).

Yield:

A perusal of the data summarized in Table-3 indicate that increase in application of RDF from 50% to 100% increased the grain yield significantly. Maximum grain yield recorded under 100% RDF (43.20 and 44.94 q ha^{-1}) which was at par with 75% RDF (42.72 and 44.43 q ha^{-1}) while significantly higher than 50% RDF (35.15 and 36.55 q ha^{-1}) during 2023 and 2024, respectively. The mean percent increase in grain yield due to 100% RDF was recorded 1.15% and 22.92% over 75% RDF and 50% RDF, respectively.

Among bio-agent enriched FYM & micronutrient, crop fertilized with Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 10 t ha^{-1} recorded significantly maximum grain yield (47.12 and 49.02 q ha^{-1}) during 2023 and 2024, respectively, which was significantly higher than rest of the treatments during both year. Application of Zn@ 5 kg ha^{-1} + B@ 1 kg ha^{-1} + enriched FYM @ 5 t ha^{-1} and enriched FYM @ 10 t ha^{-1} was found at par with each other but produced significantly higher grain yield over rest of the treatments. It might be attributed to a better accumulation of plant biomass (source), which was later mobilized to the reproductive parts (sink) owing to higher availability of nutrients, which shifted the balance in favour of crop. The grain yield is the fraction of the total biomass (total dry matter accumulation) that gets available in the form of economic yield (grain yield) which is the ultimate result of the bio-physiological processes. The higher yield attributing characters *viz*. No. of cobs $plant^{-1}$, number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, cob length , Test weight of 100 seeds and weight of kernel cob^{-1} contributed to the higher grain yield. These results corroborate the findings of Fallah *et al*. (2013), Khandelwal *et al*. (2017).

CONCLUSION

The findings suggested that application of 75% RDF coupled with Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1} could significantly enhance crop growth and grain yield of maize crop.

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Table-1: Effect of RDF Levels and Bio-agent enriched FYM & micronutrient on plant height (cm) of maize (*Zea mays* L.).

Treatments	Plant height (cm)					
	At knee-high Stage		At Tasseling Stage		At Harvest Stage	
RDF Levels						
	2023	**2024**	**2023**	**2024**	**2023**	**2024**
50% Recommended of NPK	85.66	87.94	155.96	160.12	182.22	187.12
75% Recommended of NPK	90.78	93.24	165.34	169.76	193.16	198.32
100% Recommended of NPK	96.76	99.36	176.24	180.98	205.88	211.38
SEM ±	1.583	1.665	2.819	2.921	4.267	4.294
CD (P=0.05)	4.585	4.824	8.167	8.462	12.360	12.439
Bio-agent enriched FYM and micronutrient						
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1}	84.10	86.37	153.13	157.23	178.90	183.70
Enriched FYM @ 5 t ha^{-1}	88.47	90.83	161.10	165.43	188.23	193.27
Enriched FYM @ 10 t ha^{-1}	93.80	96.33	170.83	175.40	199.57	204.90
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 5 t ha^{-1}	93.03	95.53	169.43	173.97	197.93	203.23
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}	95.93	98.50	174.73	179.40	204.13	209.60
SEM ±	2.043	2.150	3.640	3.771	5.508	5.543
CD (P=0.05)	5.919	6.228	10.544	10.924	15.957	16.058

Table-2: Effect of RDF Levels and Bio-agent enriched FYM & micronutrient on leaf area index of maize (*Zea mays* L.).

Leaf area index						
	At knee-high stage		At Tasseling stage		At Harvest stage	
RDF Levels						
Treatments	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**
50% Recommended of NPK	2.51	2.54	3.65	3.69	2.92	2.95
75% Recommended of NPK	2.69	2.72	3.90	3.95	3.12	3.16
100% Recommended of NPK	2.88	2.91	4.18	4.23	3.34	3.38
SEM ±	0.06	0.06	0.06	0.08	0.05	0.05
CD (P=0.05)	0.17	0.17	0.18	0.24	0.15	0.15
Bio-agent enriched FYM and micronutrient						
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1}	2.49	2.52	3.62	3.66	2.89	2.93
Enriched FYM @ 5 t ha^{-1}	2.63	2.66	3.81	3.85	3.04	3.08
Enriched FYM @ 10 t ha^{-1}	2.75	2.78	3.99	4.03	3.19	3.23
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 5 t ha^{-1}	2.78	2.81	4.03	4.07	3.22	3.26
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}	2.84	2.87	4.11	4.16	3.29	3.33
SEM ±	0.07	0.07	0.08	0.11	0.06	0.07
CD (P=0.05)	0.22	0.22	0.25	0.33	0.20	0.20

Table-3: Effect of RDF Levels and Bio-agent enriched FYM & micronutrient on Grain yield of Maize.

	Grain Yield (q ha^{-1})	
Treatments	**2023**	**2024**
RDF Levels		
50% Recommended of NPK	35.15	36.55
75% Recommended of NPK	42.72	44.43
100% Recommended of NPK	43.20	44.94
SEM ±	0.68	0.82
CD (P=0.05)	1.98	2.38
Bio-agent enriched FYM and micronutrient		
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1}	33.30	34.60
Enriched FYM @ 5 t ha^{-1}	37.50	38.98
Enriched FYM @ 10 t ha^{-1}	41.70	43.40
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 5 t ha^{-1}	42.17	43.87
Zn @ 5 kg ha^{-1} + B @ 1kg ha^{-1} + Enriched FYM @ 10 t ha^{-1}	47.12	49.02
SEM ±	0.88	1.06
CD (P=0.05)	2.56	3.07