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Growth and yield response of maize to integrated nutrient management and plant growth regulator application

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Abstract

The application of plant growth regulators and balanced nutrition management have a significant impact on maize productivity. In order to investigate the impact of integrated nutrient management and plant growth regulator on nutrient dynamics and yield performance of irrigated maize, a field experiment was carried out in the *rabi* season of 2025 at Karunya Institute of Technology and Sciences, Coimbatore. The experiment was laid out in factorial randomized block design with four integrated nutrient management practices and four levels of NAA spray. The results showed that significantly higher growth parameters like Plant height (218.6 cm) and Dry matter production (14846.6 kg ha⁻¹), physiological parameters like Leaf area index (2.6), Crop growth rate (12.5 g m⁻² day⁻¹), Relative growth rate (13.4 g g⁻¹ day⁻¹), SPAD value (51.13), as well as improved yield parameters like cob length (25.667 cm), cob girth (16 cm), No. of grain rows-1 cob (22 grain rows-1 cob), No. of grains-1 row (34.6) and grain weight (143.3 gm) and higher grain yield (6897 kg ha⁻¹), stover yield (12942 kg ha⁻¹) and nutrient uptake (129.4 kg ha⁻¹ N, 21.3 kg ha⁻¹ P and 126.4 kg ha⁻¹ K), were observed in 75% RDF + 25% enriched vermicompost along with NAA @ 40 ppm (N₃P₃) followed by 75% RDF + 25% enriched vermicompost along with NAA @ 30 ppm over control (N₄P₄). Thus, combining organic and inorganic nutrient sources with foliar NAA application can be regarded as a successful tactic for enhancing maize yield and maintaining soil health.

Keywords: Integrated nutrient management, maize, NAA, plant growth regulator, vermicompost

1. Introduction

Maize (*Zea mays* L.) is a major cereal crop that served as a staple food for more than 900million people in developing countries (Gezahegn, A. M., 2021) ^[4]. It is also the third most produced cereal crop around the world, after rice and wheat. Maize is often called as “queen of cereals” due to its high yield potential and wide adaptability to diverse agro- ecological conditions (Gezahegn, A. M., 2021) ^[4]. It is an annual C4 plant belonging to the family Poaceae and originated in Central America (Singh *et al.*, 2018) ^[19]. Nutritionally, maize grain is a rich source of energy for both human and animal consumption because it contains 7-23% moisture, 6-12% protein, 82.2-82.9% carbs, and 8.3-11.9% fiber. Being a heavy feeder, maize efficiently converts solar energy into plant biomass or dry matter (Patra, P. S., and S. Biswas., 2009) ^[14]. Maize is used not only as food and feed for livestock but also as a raw material in many industries, for products such as corn oil, flour, alcohol and syrup (Nayak *et al.*, 2020) ^[13]. To achieve higher yield, farmers often apply high dose of chemical fertilizers; however their continuous use of chemical fertilizers can harm soil health and create negative effect on environment. Since no single nutrient source can supply all essential nutrients in the required proportion, the combined use of organic and inorganic sources through Integrated Nutrient Management (INM) has gained importance. Integrated Nutrient Management, its primary goal is to ensure that nutrients are made available in a ratio and manner which properly sustains soil health and crop production over the long term. This can be achieved in a sustainable way without harming soil health, environmental safety, and other natural resources (Chandrashekara *et al.*, 2000) ^[1]. Moreover, Integrated Nutrient Management (INM) practices help reduce the cost of cultivation and improve the economic returns for farmers (Mahapatra *et al.*, 2018) ^[8].

Plant growth regulators play an important role in improving the growth and development of maize plants. They help in controlling vital plant functions such as cell division, elongation, and nutrient transport. Improved plant height, root growth, and leaf development can be achieved by the use of growth regulators. Additionally, they help in enhancing photosynthesis and the crop's effective usage of nutrients. Naphthalene acetic acid (NAA), which belongs to the auxin group of plant growth regulators, promotes plant growth by encouraging better vegetative development and supporting the reproductive phase of the crop (Elmongy *et al.*, 2018) [3]. Growth regulators have been shown to increase crop production and quality in various field crops when applied as foliar sprays at the right growth stage and concentrations (Nagasubramaniam *et al.*, 2007) [12]. The combined use of Integrated Nutrient Management (INM) and plant growth regulators can produce a synergistic effect, where balanced nutrient supply supports plant growth and PGRs enhance physiological activities, leading to better yield stability.

2. Materials and Methods

2.1 Location of the experiment

A field experiment was carried out during the *rabi* season of 2025 at Karunya Institute of Technology and Sciences in Coimbatore, Tamil Nadu 10.9362°N latitude and 76.744°E longitude. The average rainfall received during the crop growing period was (24.7 mm). The weekly maximum and minimum temperature during the experimental period are (29.7°C) and (20.3°C) respectively. Soil analysis indicated that the soil of the experimental plot was sandy clay loam in texture, available nitrogen (52 kg ha⁻¹), available potassium (25 kg ha⁻¹), phosphorus content (36 kg ha⁻¹), organic carbon content (37.5%) and basic in nature (8.36). Maize hybrid "COHM8" was sown with a spacing of 60 x 25 cm with seed rate of 20 kg/ha.

2.2 Experimental materials

Maize hybrid "COHM8" was sown on September 11th with a spacing of 60 x 25 cm with seed rate of 20 kg/ha. The Calculated amount of NPK 250:75:75 was applied as basal dose to each plot and enriched vermicompost, Municipal solid waste compost and Biogas slurry are applied before sowing and NAA was applied through foliar spray on 30 and 45th da as per treatment calculation. From seeding to harvest, the maize crop underwent all required intercultural procedures to guarantee healthy crop growth. When the crop reached maturity, it was physically harvested plot-wise. After being sun-dried, the gathered product was manually threshed. Each plot's grain and stover yields were appropriately identified and recorded individually. Growth and yield metrics were recorded by averaging the values of five randomly chosen plants from each plot.

2.3 Treatment details

The experiment was laid out in factorial randomized block design with integrated nutrient management of 75% RDF + 25% N equivalent as Biogas Slurry (N1), 75% RDF + 25% N equivalent as Municipal solid waste compost (N2), 75% RDF + 25% N equivalent as Enriched Vermicompost (N3), 100% RDF (N4) combined with application of Plant growth regulator NAA @ 20 ppm (P1), NAA @ 20 ppm (P2), NAA @ 20 ppm (P3) at 30 and 45 DAS and no application (P4).

2.4 Statistical analysis

Statistical analysis of the experimental data was carried out using analysis of variance (ANOVA) described by Gomez and

Gomez (2010) [5]. The significance of treatment differences was evaluated by calculating the critical difference (CD) at the 5% level of probability. In addition, the standard error of difference (SE d) values was computed and presented in the respective tables for each parameter.

3. Results and Discussion

3.1 Effect of Integrated nutrient management and plant growth regulator on growth attributes

The effect of combined application of Integrated nutrient management and Plant growth regulator on growth attributes is presented in table.1. Among all the different treatments, the treatment (N3P3) 75% RDF + 25% enriched vermicompost along with NAA @40 ppm produced in a higher plant height of 218.6 cm and dry matter production of 14846.6 kg ha⁻¹ at harvest, while the treatment (N4P4) 100% RDF + no spray (control) produced the lowest plant height of 127.6 cm and dry matter production of 9869 kg ha⁻¹ at harvest. Improved nutrient availability and prolonged nutrient release from vermicompost under integrated nutrient management may have contributed to the increase in plant height and dry matter output by promoting photosynthesis and biomass buildup. Furthermore, the administration of NAA may have boosted plant development by promoting cell division and elongation (Mahato *et al.*, 2020) [9] and (Maurya *et al.*, 2021) [11].

3.2 Effect of Integrated nutrient management and plant growth regulator on Physiological attributes

The effect of combined application of Integrated nutrient management and Plant growth regulator is presented in table.1. The results revealed that treatment (N3P3) 75% RDF + 25% enriched vermicompost along with NAA @40 ppm resulted in a highest leaf area index (2.6), Crop growth rate (12.5 g m⁻² day⁻¹), Relative growth rate (13.4 g g⁻¹ day⁻¹) and SPAD value (51.13) at harvest. In contrast the lowest leaf area index (0.89), crop growth rate (2.5 g m⁻² day⁻¹), Relative growth rate (3.5 g g⁻¹ day⁻¹) and SPAD value (42) were observed in (N4P4) 100% RDF + no spray (control). The combined effect of adequate nitrogen supply and NAA might have promoted vegetative growth and increased chlorophyll production, hence enhancing leaf development and photosynthetic efficacy. Higher LAI, dry matter production, SPAD and better crop growth dynamics were the outcomes of this (Maurya *et al.*, 2021) [11] and (Singh *et al.*, 2018) [19]. Similar results found by (Ponmozhi *et al.*, 2019) [14].

3.3 Effect of Integrated nutrient management and plant growth regulator on yield and yield attributes

The results showed that the effect of combined application of Integrated nutrient management and Plant growth regulator with treatment (N3P3) 75% RDF + 25% enriched vermicompost along with NAA @40 ppm resulted in higher cob length (25.667 cm), cob girth (16 cm), No. of grain rows-1 cob (22 grain rows-1 cob), No. of grains-1 row (34.6) and grain weight (143.3gm), where as the lowest cob length (14.3 cm), cob girth (7.3 cm), No. of grain rows-1 cob (12.3 grain rows-1 cob), No. of grains-1 row (22) and grain weight (120.3gm) was observed in (N4P4) 100% RDF + no spray (control). This increase in yield attributes might be due to balanced nutrient supply from integrated nutrient management, which enhanced maize growth and photosynthesis (Singh *et al.*, 2017) [17]. Additionally, the use of NAA improved yield qualities by increasing cell division and photosynthate, similar results observed by (Lone *et al.*, 2013) [7] and (Chapagain., 2010) [12].

4. Yield

The results revealed that the effect of combined application of Integrated nutrient management and Plant growth regulator with treatment (N3P3) 75% RDF + 25% enriched vermicompost along with NAA @40 ppm resulted in higher Grain yield of 6897 kg ha⁻¹ and stover yield of 12942 kg ha⁻¹, where as the lowest grain yield of 2962 kg ha⁻¹ and stover yield of 7556 kg ha⁻¹ was observed in (N4P4) 100% RDF + no spray (control). This increase in grain output may be the result of early and sufficient nitrogen availability, which improved the root zone's nutritional conditions and encouraged the crop's improved growth and development (Maurya *et al.*, 2021) ^[11], (Rao *et al.*, 2021) ^[16] and (Makwana *et al.*, 2023) ^[10] observed similar results.

4.1 Effect of Integrated nutrient management and plant growth regulator on plant nutrient uptake

The results showed that among all the treatments, the treatment (N3P3) 75% RDF + 25% enriched vermicompost along with NAA @40 ppm resulted in a higher nutrient uptake of 129.4 kg ha⁻¹ nitrogen, 21.3 kg ha⁻¹ phosphorus and 126.4 kg ha⁻¹ potassium at harvest, where as the lowest nutrient uptake was

recorded in treatment (N4P4) 100% RDF + no spray (control). Higher nutrient uptake might be due to improved nutrient availability, also enhanced root growth and nutrient absorption by INM and PGR. Similar results were obtained by (Patra *et al.*, 2009) ^[14] and (Kumbhare *et al.*, 2023) ^[6].

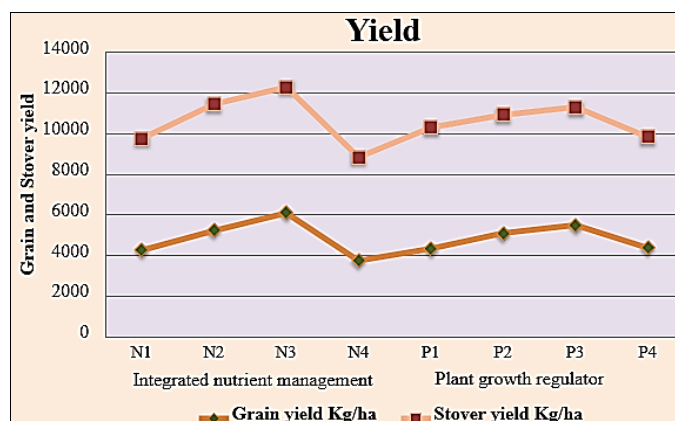


Fig 1: Effect of Integrated nutrient management and plant growth regulator on yield

Table 1: Effect of Integrated nutrient management and plant growth regulator on growth and physiological attributes

Treatment	Plant height	DMP	LAI	CGR	RGR	SPAD
Integrated nutrient management (N)						
N1	152	11326	5.068	6.789	6.512	44.3
N2	186.7	13330	6.268	10.11	9.677	47.3
N3	205.3	14311	6.813	11.954	11.352	49.3
N4	136.7	10537	4.219	4.993	5.335	42.4
SE (d)	0.030	70.713	0.049	0.088	0.136	0.308
CD (p = 0.05)	0.062	145.1	0.101	0.18	0.279	0.632
Plant growth regulator (P)						
P1	161	11805	5.430	7.042	6.973	45.3
P2	176.5	12795	5.738	9.778	9.233	46.8
P3	186.4	13325	6.199	10.217	10.31	47.6
P4	156.8	11468	5.001	6.81	6.36	43.5
SE (d)	0.030	70.713	0.049	0.088	0.136	0.308
CD (p = 0.05)	0.062	145	0.101	0.180	0.279	0.632
Interaction (N×P)						
SE (d)	0.060	141.426	0.098	0.176	0.272	0.436
CD (p = 0.05)	0.123	290.2	0.201	0.36	0.558	1.264

Table 2: Effect of Integrated nutrient management and plant growth regulator on yield attributes

Treatment	Cob length (cm)	Cob girth (cm)	No. of grain rows-1 cob	No. of grains-1 row	grain weight
Integrated nutrient management (N)					
N1	18.417	10.583	16.5	25.5	124.583
N2	21.917	13.5	18.917	28.583	135.167
N3	24.25	16.167	21.083	31.417	139.417
N4	16.5	9.5	14.833	24.25	122.3
SE (d)	0.704	0.405	0.592	0.323	0.369
CD (p = 0.05)	1.446	0.83	1.216	0.664	0.758
Plant growth regulator (P)					
P1	19.5	11.5	17.5	26.5	128.083
P2	21.5	13.333	18.083	28	132.417
P3	21.25	14.083	19.667	29.5	133.667
P4	18.833	10.833	16.083	25.75	127.3
SE (d)	0.704	0.405	0.592	0.323	0.369
CD (p = 0.05)	1.446	0.83	1.216	0.664	0.758
Interaction (N×P)					
SE (d)	1.409	0.809	1.185	0.647	0.738
CD (p = 0.05)	2.891	NS	NS	1.328	1.515

Table 3: Effect of integrated nutrient management and plant growth regulator on plant nutrient uptake

Treatment	N	P	K
Integrated nutrient management (N)			
N1	67.4	10.8	82.2
N2	102.4	15	111.23
N3	120.4	19	120.1
N4	53.8	9	76.34
SE (d)	0.131	0.104	0.218
CD (p = 0.05)	0.269	0.214	0.447
Plant growth regulator (P)			
P1	78.2	12.2	91.59
P2	93.075	14.5	101.2
P3	100.7	16.3	107
P4	72.058	11.1	90
SE (d)	0.131	0.104	0.218
CD (p = 0.05)	0.269	0.214	0.447
Interaction (N×P)			
SE (d)	0.262	0.208	0.436
CD (p = 0.05)	0.537	0.427	0.895

5. Conclusion

The current study found that the application of plant growth regulators and integrated nutrition management had a substantial impact on maize growth, yield characteristics, yield, and nutrient uptake. When compared to other treatments, the treatment N₃P₃ (75% RDF + 25% enriched vermicompost together with NAA @ 40 ppm) showed better growth parameters and yield features. Crop growth, soil fertility, and nutrient availability were all enhanced by a balanced supply of nutrients from both organic and inorganic sources. Applying NAA improved photosynthate translocation and increased physiological activity. Vermicompost and fertilizers worked together to increase soil microbial activity and nutrient utilization. Thus, the combined application of 75% RDF + 25% enriched vermicompost together with NAA @ 40 ppm might be regarded as an efficient method for enhancing yield and preserving soil health in maize farming.

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