



Research Article

Integrated Nutrient Management influencing the yield and growth of Maize (*Zea mays* L.) in Central India

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Abstract

Increasing worldwide demand for food items with limited per capita land for cropping will be a major challenge. Corn (*Zea mays* L.) is one of the world's most important cereal crops, second only to wheat and rice. To increase crop output and maintain soil health, Integrated Nutrient Management combines chemical fertilizers with organic manures through a biological process. An integrated plant nutrient supply system could aid in achieving balanced fertilization goals, which would improve the soil's physicochemical qualities on a long-term basis. The treatment T₂ (100 percent N₂ through Urea + Boron @ 3 kg. ha⁻¹) has emerged superior over other treatments and shows better growth, yield, followed by T₁₄ (50 percent N₂ through Urea + 25 percent N₂ through FYM + 25 percent N₂ through Azotobactor @ 3 kg. ha⁻¹), while the treatment T₄ (50 percent N₂ through Urea + 25 percent N₂ through FYM + 25 percent N₂ through Azotobactor @ 3 kg. ha⁻¹).

Keywords inorganic fertilizer, maize, organic manures, soil health

Introduction

Increasing worldwide demand for food items with limited per capita land for cropping will be a major challenge. Corn (*Zea mays* L.) is one of the world's most important cereal crops, second only to wheat and rice. A substantial shift in global grain demand is underway, with maize demand likely to surpass wheat and rice demand in developing countries by 2020. Except for Antarctica, it is grown on every continent of the world, over a broad area in the Tropical, Subtropical, and Temperate zones, for human nourishment and fodder production. The genetic potential of the hybrid, soil features, agro-technical techniques, and climate factors all influence maize grain yield [1]. Maize (*Zea mays* L.) is a widely utilized crop for food, feed, and industrial use. Maize is the world's third most important cereal, behind wheat and rice, and the world's largest grain crop in terms of total production per metric ton (MT). In 125 developing countries, maize is grown on over 184 million hectares, and it is one of the top three crops planted in 75 of them [2]. Azotobactor and Azosprillum are free-living bacteria that fix nitrogen from the atmosphere in cereal crops without the need for symbiosis. In beans, corn, and potato, they improve grain production by 10-18% [3]. In wheat, maize, and cotton, Azotobactor inoculations considerably improve plant weight and grain content [4-5].

Each year, they fix 20-40 kg nitrogen ha⁻¹. Azotobactor species can also create antifungal chemicals that are effective against a variety of plant diseases [4]. As a result, if true agricultural progress is not achievable, farmers will compensate for increased production by using more types of inputs,

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Table 1. The impact of Boron application with Integrated Nitrogen Management on plant height of Maize at 80 DAS

Treatment	Treatment Combination	Plant Height (cm) 80 DAS 2018	Plant Height (cm) 80 DAS 2019	Plant Height (cm) 80 DAS Pooled
T ₁	100 % N ₂ through Urea + Boron @ 2 kg. ha ⁻¹	184.0	176.4	180.2
T ₂	100% N ₂ through Urea + Boron @ 3 kg. ha ⁻¹	198.4	193.0	195.7
T ₃	100% N ₂ through Urea + Boron @ 4 kg. ha ⁻¹	182.1	176.3	179.2
T ₄	50% N ₂ through Urea + 50% N ₂ through FYM + Boron @ 2 kg. ha ⁻¹	178.9	171.5	175.2
T ₅	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 3 kg. ha ⁻¹	193.7	186.7	190.2
T ₆	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 4 kg. ha ⁻¹	181.2	175.0	178.1
T ₇	50 % N ₂ through Urea + 50% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	184.7	178.4	181.5
T ₈	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	192.1	186.3	189.1
T ₉	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	187.0	182.7	184.8
T ₁₀	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	188.1	184.1	186.1
T ₁₁	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	189.9	184.9	187.4
T ₁₂	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	185.7	176.4	181.1
T ₁₃	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 2 kg. ha ⁻¹	187.9	183.2	185.6
T ₁₄	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 3 kg. ha ⁻¹	195.1	187.5	191.3
T ₁₅	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 4 kg. ha ⁻¹	187.8	181.4	184.6
	C.D.	0.980	2.160	1.058
	C.V.	0.337	0.742	0.363

particularly more mineral fertilizers, which are neither environmentally acceptable nor agriculturally viable, for example. One of the most commonly used nutrients in agricultural production is nitrogen fertilizer for its Key role in the formation of protein and nucleic acid in the plant then if they are applied by chemicals, they are not eco-friendly, the alternative methods will be Biological fertilizers, such as – Azotobactor, Azosprillum, BGA, Azolla, phosphorus solubilizing microorganisms, Mycorrhizae and Shinorhizobium [6]. Vermicompost is an organic substance that has been broken down in a mesophilic (up to 250°C) process by the interaction of microorganisms and earthworms, resulting in fully stable organic soil additions with a low C: N ratio. They have a lot of microbial and enzymatic activity, fine particle structure, a lot of moisture-holding capacity, and nutrients like N, P, K, Ca, and Mg in forms that plants may easily absorb [7-8]. The use of RDF in combination with FYM improves maize crop germination and boosts plant height [9-10]. Increased quantities of FYM treatment increased by germination percent [11]. Boron, after Zinc, is the most limiting micronutrient shortage in soils, impacting the production of several crops, including cereals, where the Maize plant is especially sensitive to micronutrient insufficiency, exhibiting symptoms of deficiency [12-13]. Boron is an essential micronutrient for crop growth because it is necessary for meristem cell formation and division near the tips of plant shoots and roots, plasma membrane integrity, carbohydrate breakdown and absorption, pollen tube evolution through flower pollination, pollen tube development, and, as a result, healthy seed formation [14]. After zinc deficiency, soil boron deficit is the second most common cause of soil fertility problems. According to a study, boron is widely distributed throughout nature, both in the Lithosphere and the Hydrosphere [15-17]. Boron is related in three essential directions of physiological reaction in plant cells, aside from its fundamental function in cell walls, membrane, and metabolic actions [18]. Environmental conditions have been shown to alter plant

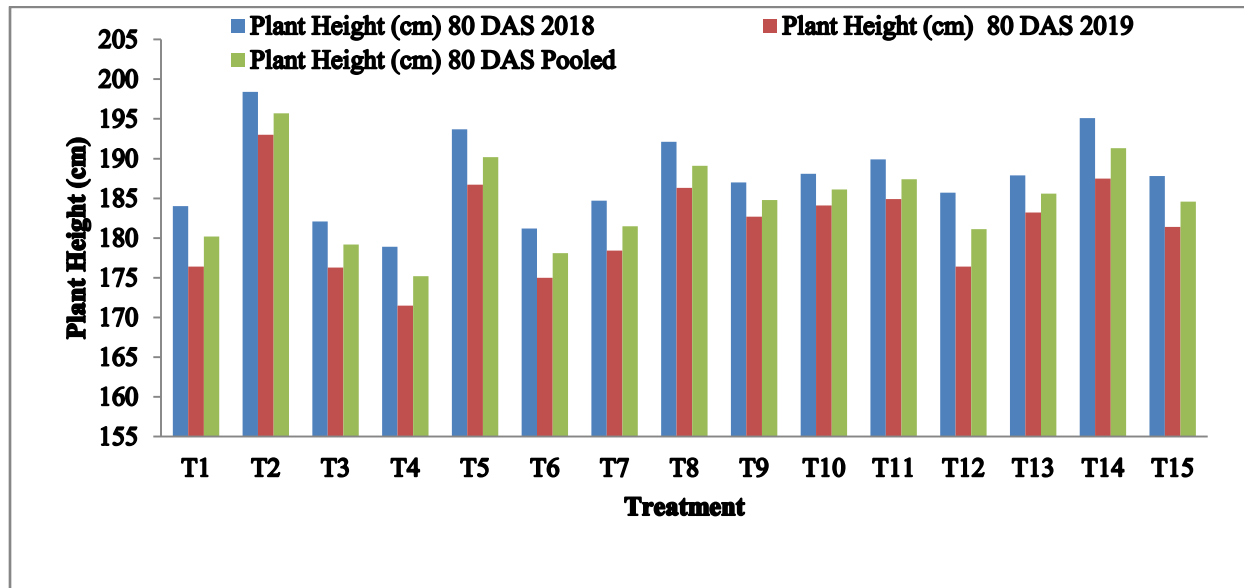


Figure 1. Plant height effects of Integrated Nitrogen Management with Boron application

responsiveness to Boron [19]. Many plants require boron, and its bioavailability in soil and water is critical for agronomic production [20]. Under drought conditions, however, boron levels in soil may rise to levels that are hazardous to plants and reduce yield production. Soil has become a problem as a result of widespread chemical use and intensive cropping systems, resulting in crop toxicity and nutrient imbalances in soil, both of which have negative effects on soil health and crop yields [20]. The soil became detritus-filled as a result of this. As a result, there is a need to improve the nutrient delivery system through Integrated Nutrient Management, which incorporates the use of chemical fertilizers in conjunction with organic manures via biological processes. An integrated plant nutrient supply system could aid in achieving balanced fertilization goals, which would improve the soil's physicochemical qualities on a long-term basis. Besides, this several Research Scientists, in their researches have reported that Indian Soils are deficient in Macronutrients and Micronutrients. In macronutrients due to deficiency of Nitrogen different symptoms were seen such as the yellow or pale green color of leaves, drying up or firing of bottom leaves, and short stature. In light of this, the current study "Effect of INM (Integrated Nitrogen Management) with Boron Application on Maize Growth and Yield," was conducted (*Zea mays* L.).

Methodology

Experimental site

The experiment took place at the Crop Research Farm throughout the 2018 and 2019 zaid seasons. Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), in Prayagraj of Uttar Pradesh, India. The Crop Research Farm is situated at 25° 57'N Latitude and 87° 19' E Longitude, at an altitude of 98 m above Sea Level. This location is located on the right bank of the Yamuna River and the other side of Prayagraj City. The Experimental field's soil, which is part of the Central Gangetic alluvium, is neutral and deep. The experiment was set up using a Randomized Block Design method. The treatments comprised of different levels of Urea, FYM, Vermicompost, Azotobactor, and Boron. There were 15 Treatments and each replicated Thrice. Each replication was divided into forty-five plots with treatments assigned at random. Fertilizers and manures were administered by hand hoeing 4-5 cm deep furrows along the seed rows. The nutrient sources were Urea, SSP, MOP, FYM, VC, Boron, and Azotobactor. The RDN 150 kg N ha⁻¹, 80 kg P₂O₅ ha⁻¹, 60 kg K₂O ha⁻¹ and 2, 3 & 4 kg of Boron ha⁻¹ were applied according to the Treatment details through Urea, SSP, MOP, FYM, VC, Azotobactor and



Table 2. Effect of Integrated Nitrogen Management with Boron application on stover yield (q/ha) of Maize

Treatment	Treatment Combination	Stover yield q/ha 2018	Stover yield q/ha 2019	Stover yield q/ha Pooled
T ₁	100 % N ₂ through Urea + Boron @ 2 kg. ha ⁻¹	100.0	65.0	82.7
T ₂	100% N ₂ through Urea + Boron @ 3 kg. ha ⁻¹	116.7	146.3	132.0
T ₃	100% N ₂ through Urea + Boron @ 4 kg. ha ⁻¹	140.0	56.7	98.7
T ₄	50% N ₂ through Urea + 50% N ₂ through FYM + Boron @ 2 kg. ha ⁻¹	136.7	61.7	99.3
T ₅	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 3 kg. ha ⁻¹	138.3	116.7	127.7
T ₆	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 4 kg. ha ⁻¹	113.3	60.0	87.0
T ₇	50 % N ₂ through Urea + 50% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	120.0	72.2	96.3
T ₈	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	118.3	101.7	110.3
T ₉	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	108.3	55.0	82.0
T ₁₀	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	141.7	60.0	101.0
T ₁₁	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	131.7	83.3	107.7
T ₁₂	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	150.0	60.0	105.0
T ₁₃	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 2 kg. ha ⁻¹	133.3	65.0	99.3
T ₁₄	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 3 kg. ha ⁻¹	141.7	121.7	132.0
T ₁₅	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 4 kg. ha ⁻¹	140.0	71.7	106.0
	C.D.	N/A	17.124	22.862
	C.V.	21.105	12.766	13.018

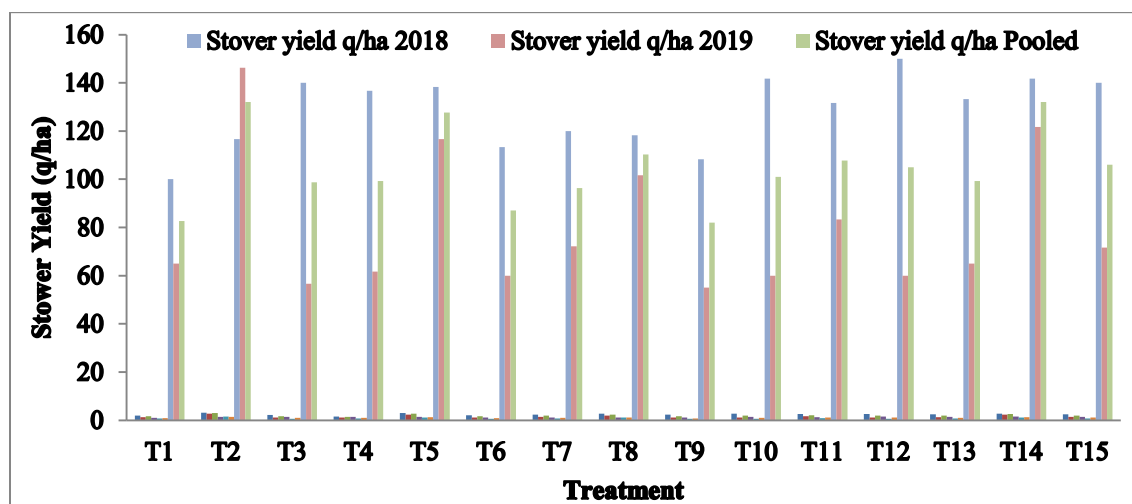


Figure 2. Effect of Integrated Nitrogen Management with Boron application on stover yield



boron. At the time of sowing, the total amount of Phosphorus, Potash, and Boron was administered as a basal application. But In Organic Nitrogenous fertilizer, Urea is applied in 3 split doses – 1/2 dose at the time of sowing, 1/4 dose at 30 DAS, and 1/4 dose at 60 DAS.

Statistical analysis

The data obtained from the experiment was processed and entered into the datasheet in MS Excel and subjected to statistical analysis using OPSTAT based software in experimental design CRBD (Completely Randomized Block Design) for the experiments. The ANOVA was constructed for further inference. To compare the treatment means, the relevant standard error of the mean (SEM) was determined in each case, as well as the crucial difference (CD) at a 5% level of probability.

Results and Discussion

During the Zaid seasons of 2018 and 2019, the use of nitrogen and boron resulted in considerable increases in plant height at 80 DAS. The maximum plant height (198.4 and 193 cm) at 80 DAS was found in T₂ using 100% N through urea+3 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively followed by treatment T₁₄ (195.1and 187.5cm) with the application of using 50% N through urea + 25% N through FYM+25% N through Azotobactor.

Table 3. Effect of Effects of Integrated Nitrogen Management with Boron application on grain (q/ha) yield of Maize

Treatment	Treatment Combination	Grain Yield (q/ha) 2018	Grain Yield (q/ha) 2019	Grain Yield (q/ha) Pooled
T ₁	100 % N ₂ through Urea + Boron @ 2 kg. ha ⁻¹	150.7	161.3	156.0
T ₂	100% N ₂ through Urea + Boron @ 3 kg. ha ⁻¹	280.0	292.0	286.0
T ₃	100% N ₂ through Urea + Boron @ 4 kg. ha ⁻¹	151.3	154.7	153.0
T ₄	50% N ₂ through Urea + 50% N ₂ through FYM + Boron @ 2 kg. ha ⁻¹	142.0	147.3	144.7
T ₅	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 3 kg. ha ⁻¹	257.0	261.3	259.3
T ₆	50 % N ₂ through Urea + 50% N ₂ through FYM + Boron @ 4 kg. ha ⁻¹	146.7	151.3	149.0
T ₇	50 % N ₂ through Urea + 50% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	151.3	159.3	155.3
T ₈	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	218.7	220.3	219.7
T ₉	50 % N ₂ through Urea + 50 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	155.0	157.3	156.3
T ₁₀	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25% N ₂ through VC + Boron @ 2 kg. ha ⁻¹	181.3	191.3	186.3
T ₁₁	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 3 kg. ha ⁻¹	180.7	186.0	183.3
T ₁₂	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through VC + Boron @ 4 kg. ha ⁻¹	184.7	190.3	187.7
T ₁₃	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 2 kg. ha ⁻¹	184.0	184.7	184.3
T ₁₄	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor@ 3 kg. ha ⁻¹	267.3	270.0	268.7
T ₁₅	50 % N ₂ through Urea + 25 % N ₂ through FYM + 25 % N ₂ through Azotobactor @ 4 kg. ha ⁻¹	175.3	177.3	176.3
	C.D.	29.107	33.931	21.905
	C.V.	9.19	10.423	6.819

However minimum plant height (178.9 and 171.5 cm) was observed in T₄ with the application of 50% N through urea + 50% N through FYM+2 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively (Table 1 and Figure 1). During the Zaid season of 2018 and 2019, the application of nitrogen and boron improved plant stover output considerably. The maximum plant stover yield was (1.4 and 1.5 kg) at harvest was found in T₂ using 100% N through urea+3 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively followed by treatment T₁₄ (1.5 and 1.2 kg.) with the application of using 50% Nitrogen through urea + 25% N through FYM+25% N through Azotobactor. However minimum plant stover yield (1.4 and 0.7kg) was observed in T₄ the application of 50% Nitrogen through urea + 50% N through FYM+2 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively (Table 2 and Figure 2).

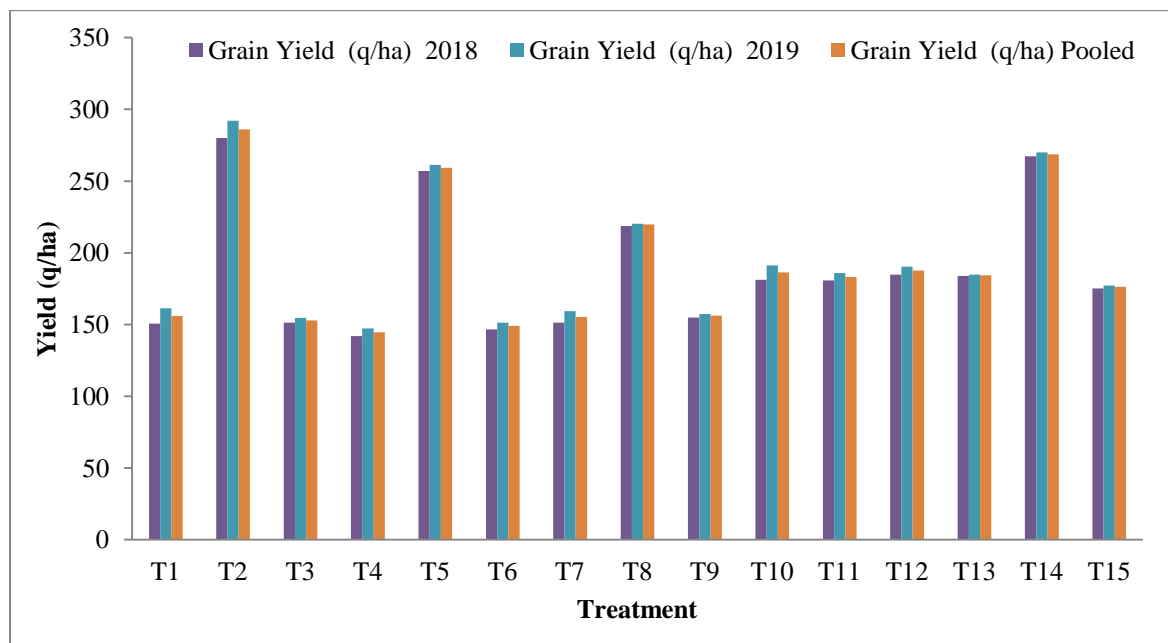


Figure 3. Effect of Effects of Integrated Nitrogen Management with Boron application on grain (q/ha) yield

The application of Nitrogen and boron significantly increased the No. of grains per row and test weight was during 2018 and 2019 in Zaid season. The maximum No. of grains per row (29.6 and 29.2) and Test Weight (236.0 and 231.0 g.) were found at harvest in T₂ using 100% N through urea+3 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively followed by treatment T₁₄ (29.5 and 23.0) and Test Weight (234 and 223.3 g.) with the application of using 50% Nitrogen through urea + 25% N through FYM+25% N through Azotobactor. However minimum No. of grains per row (23.7 and 21.8) and Test Weight (198.7 and 191.7 g.) were observed in T₄ with the application of 50% Nitrogen through urea + 50% N through FYM+2 kg Boron ha⁻¹ during the cropping year 2018 and 2019 respectively (Table 3 and Figure 3).

Conclusion

Based on a field experiment on the influence of various doses of organic manures and inorganic fertilizer on maize growth and yield, a conclusion was reached that the treatment T₂ (100% N₂ through Urea + Boron @ 3 kg. ha⁻¹) has emerged superior to other treatments and shows better growth, yield followed by T₁₄ (50 % N₂ through Urea + 25 % N₂ through FYM + 25 % N₂ through Azotobactor @ 3 kg. ha⁻¹) while the minimum was recorded for treatment T₄ (50% N₂ through Urea + 50% N₂ through FYM + Boron @ 2 kg. ha⁻¹).



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