



Residual Effect of Nitrogen and Micronutrient Management on Growth and Yield of Transplanted Mustard (*Brassica juncea* L.)

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ABSTRACT

The field experiment was conducted during winter seasons (*rabi*) of October, 2019 to March, 2020 at Bhujabala, Rayagada in Odisha and October, 2020 to March, 2021 in the farmer's field, Lephripara, Sundargarh in Odisha, India. The objective of the study was to find out residual effect of nitrogen and micronutrient managements applied in preceding rice crop on the growth and yield of transplanted mustard (*Brassica juncea* L.). Experiment was laid out in Factorial Randomized Block Design, treatments consist of three levels of nutrient management viz.; 80 kg N ha⁻¹, 60 kg N ha⁻¹+5 t FYM ha⁻¹ and 40 kg N ha⁻¹+10 t FYM ha⁻¹ and six micronutrient managements, viz., Control, 0.5% zinc sulphate as foliar, 0.5% ferrous sulphate as foliar, 0.3% zinc sulphate as seed priming, 0.3% ferrous sulphate as seed priming, and 0.5% zinc sulphate as foliar+0.5% ferrous sulphate as foliar. Results revealed that among different levels of nitrogen management, application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ perceived maximum growth parameters and yield attributes. Among micronutrient managements, most of the cases residual effect of foliar spraying of 0.5% zinc sulphate recorded better results in respect of growth parameters and yield attributes. Among micronutrient managements, foliar application of 0.5% ferrous sulphate (M₃) perceived highest seed and stover yield during both the years of experiment. The combined application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂) along 0.5% zinc sulphate as foliar spray (M₂) exhibited higher growth parameters.

KEYWORDS: FYM, micronutrient, nitrogen, transplanted mustard, yield

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Indian mustard (*Brassica juncea* L.) has been categorized under the family Brassicaceae and is a worldwide essential source of cooking oil (Rahman et al., 2018). Mustard oil is used in many industrial products, oil cake is used as cattle feed and also as manure while the green leaves are used as vegetable (Anup et al., 2018). Mostly mustard raised under rainfed conditions in India with low or minimal input leads to a lower productivity (Lal et al., 2016). The world production of mustard seeds is estimated to be around 775,000 mt covering an area of about 7.8 mha with a total productivity of 1.1 t ha⁻¹ (Anonymous, 2021). In India, the annual production of rapeseed-mustard was about 10.11 mt covering an area of about 6.69 mha with a total productivity of 1511 t ha⁻¹ (Anonymous, 2021). However, the yield of mustard is low due to poor agronomic practices, among them nutrient management, time of sowing, and plant density. The plant density and date of sowing have pronounced effects on the yield. However, farmers have to sow mustard crop late due to delay sowing and harvesting of *kharif* paddy resulting poor growth and productivity (Sharma et al., 2018). Under timely sown conditions, seed yield per plant showed significant and positive correlations with plant height, primary branches, and test weight (Sharma et al., 2022). Hence, timely method of planting through transplanting technique could be a satisfactorily alternative to minimize yield reduction in mustard (De et al., 2021). This transplanting method can also maintain the optimum crop stand as the interval of crop in the field is reduced by at least 14–15 days without hampering productivity (Biswas et al., 2023). India meets 60 percent of the domestic edible oil requirements through imports (Jat et al., 2021). According to Lal et al. (2016), mustard production system is mainly suffering due to excessive and imbalanced nutrient management. Application of Farmyard manure (FYM) improves soil structure, microbial activity, which, in order, enhances the fertility of soil (Yazdanpanah et al., 2016; Zhao et al., 2016). It also results in improvement of necessary nutrients, eventually the crop yields increase (Bhatia and Shukla, 1982, Singh and Kumar, 2009). Also the application of nitrogen fertilizers promotes flowering, setting of siliquae and increase the size of siliquae and yield (Singh and Meena, 2004).

Mustard is highly sensitive to zinc (Zn) and iron (Fe) deficiency, thereby resulting in small leaves, chlorosis and dwarfing, leading to a decline in its productivity (Vanisha et al., 2013, Sanwal et al., 2016). The phyto-availability of Zn and Fe is related to soil pH and physico-chemical properties (Dhaliwal et al., 2019; Alloway et al., 2010). It can activate many enzymes that are associated with the regulation of growth, gene expression, and protein formation (Gowayed

and Kadasa, 2016). Foliar feeding of micronutrients is usually cheap, more effective with greater nutrient use efficiency and considerably reduce environmental pollution (Bhatt et al., 2020; Aziz et al., 2021). Foliar fertilization has been evidenced to promote root growth, leading to an increased uptake of nutrients by crops (Bhatt et al., 2020). A small amount of nutrients, particularly Zn and Fe supplied through foliar spray, have resulted in significant increases in the yield of crops (Aziz et al., 2021; Wissuwa et al., 2008). Although, there is lots of research work carried out to see the effect of nitrogen and micronutrient directly on the crops but very few studies were undertaken to see their residual effect on the succeeding crop. Thus, the present study was carried out to observe the residual effect of different level of nitrogen and micronutrient managements in the preceding rice crop on the growth, yield attributes and yield of transplanted mustard.

2. MATERIALS AND METHODS

2.1. Description of study area

The experiment was carried out at MITS Institute of Professional Studies (MIPS), Bhujabala, Rayagada, Odisha, India where mustard crop was grown in sequence after rice crop during winter season. The initial fertility status of the soil for at Bhujabala, Rayagada in Odisha was 480.0 kg ha⁻¹ alkaline permanganate oxidizable nitrogen (N) (Subbiah and Asija, 1956), 40 kg ha⁻¹ available phosphorus (P) (Bray and Kurtz, 1945), 250 kg ha⁻¹ N ammonium acetate exchangeable potassium (K) (Jackson, 1973) and 0.91% organic carbon (Walkley and Black, 1934). The pH of the soil was 5.8 (1:2.5 soil: water ratio) (Prasad et al., 2006). The DTPA extractable Zn and Fe (Lindsay and Norvell, 1978) in soil was 0.23 and 3.42 mg kg⁻¹ of soil. The initial fertility status of the soil in the farmer's field, Lephripara, Sundargarh in Odisha was 470.0 kg ha⁻¹ alkaline permanganate oxidizable nitrogen (N) (Subbiah and Asija, 1956), 35 kg ha⁻¹ available phosphorus (P) (Bray and Kurtz, 1945), 265 kg ha⁻¹ N ammonium acetate exchangeable potassium (K) (Jackson, 1973) and 0.88% organic carbon (Walkley and Black, 1934). The pH of the soil was 5.5 (1:2.5 soil: water ratio). The DTPA extractable Zn and Fe (Lindsay and Norvell, 1978) in soil was 0.29 and 3.79 mg kg⁻¹ of soil during second year of study. Total rainfall received during the rice growth period (wet season) in the year 2019 and 2020 was 1149.2 mm and 988 mm, respectively.

2.2. Experimental treatments and design

The field experiment was carried out in FRBD design with three level of nitrogen management viz., N₁: 80 kg N ha⁻¹, N₂: 60 kg N ha⁻¹+5 t FYM ha⁻¹ and N₃: 40 kg N ha⁻¹+10 t FYM ha⁻¹ and six micronutrient managements, viz., M₁:



Control, M₂: 0.5% zinc sulphate as foliar, M₃: 0.5% ferrous sulphate as foliar, M₄: 0.3% zinc sulphate as seed priming, M₅: 0.3% ferrous sulphate as seed priming, and M₆: 0.5% zinc sulphate as foliar+0.5% ferrous sulphate as foliar. The plot size was 5×4 m². Rice seeds were primed with zinc sulphate heptahydrate and ferrous sulphate @ 0.3% solution by using tap water before sowing. Seed weight to solution volume ratio was 1:1.5 (w/v). Seeds were soaked in respective solution for 18 h at 25±2°C. Thereafter seeds were removed, given three surface washing. Afterwards, primed seeds were allowed to re-dry with forced air under shade near to original weight. Foliar application of zinc as zinc sulphate @ 0.5% and iron as ferrous sulphate @ 0.5% solution at 30 and 60 DAS. The solution was prepared by dissolving ZnSO₄ powder and 0.25% lime with tap water. The prepared solution was poured into the sprayer and was applied by evenly spraying the solution until the whole plants were wet at morning. The amount of water was 500–750 l for 1 ha area.

2.3. Crop husbandry

The mustard variety “Kesari Gold” was used as a test crop, sown in portraits on 28th October 2019 and transplanted in the field on 11th November 2019. During 2nd year of experimentation, crop was sown in portraits on 22th October and transplanted in the field on 5th November. 15 days old seedling was uprooted and transplanted with spacing of 45×15 cm² at desired soil depth manually. The transplanted mustard was harvested on 3rd March, 2020 during first year and 27th February, 2021 during second year. The treatments were applied in the preceding direct seeded rice crop and their residual effects were being observed in succeeding transplanted mustard crop. Other agronomic management practices like weeding, irrigation, agrochemical application was similar irrespective of treatment variability. Two irrigations were given during both the years in transplanted mustard crop.

2.4. Growth and yield parameters

Average plant height was measured randomly from 5 selected plants at 60 and 90 DAT and at harvest from each plot. To determine dry matter accumulation, mustard plants were cut at ground level in the earmarked area in each plot for the purpose of destructive sampling at 60 and 90 DAT. Plants of each plot were separated into green leaves and stems and dried in a hot air oven, kept at 65°C for 48 h till constant weights were obtained. The dry weight of leaves and stems were recorded and used for determination of dry matter accumulation. The number of branches plant⁻¹ and siliqua plant⁻¹, and test weight were counted from each plot at the time of harvesting. The weight of the harvested plants after sun drying and before threshing was recorded. After threshing, the seeds were cleaned and sundried and

their weight was recorded. The seed yield and stover yield in kg plot⁻¹ were converted to kg ha⁻¹.

2.5. Statistical analysis

All the data obtained from mustard crop for consecutive two years were statistically analyzed using the F-test as per the procedure given by Gomez and Gomez (1984). LSD values at $p=0.05$ were used to determine the significance of differences between treatment means. The analysis of data on growth, seed yield and stalk yield for mustard was also performed using SPSS software.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

In order to quantify the response observed due to nitrogen levels and micronutrient managements to the preceding *kharif* rice, the plant height of succeeding transplanted mustard crop was recorded at 60, 90 DAT and at harvest (Table 1). Under 60 DAT, 60 kg N ha⁻¹ (75% of RDN)+5 t FYM ha⁻¹ recorded tallest plants which was significantly higher than 80 kg N ha⁻¹ (RDN) during both the years of the experimentation. On other hand, this treatment significantly more plant heights over 40 N kg ha⁻¹ (50% of RDN)+10 t FYM ha⁻¹ during the first year but remained statistically at par during second year. At 90DAT, tallest plant was recorded with the 60 kg N ha⁻¹ (75% of RDN)+5 t FYM ha⁻¹ that proved statistically at par with 80 kg N ha⁻¹ (RDN) but significantly higher than 40 N kg ha⁻¹ (50% of RDN)+10 t FYM ha⁻¹ during 2019–20 and 2020–21. At harvest, almost similar trend was followed as 90 DAT. It is quite established that the integration of chemical and organic sources provided enough nutrients (Nagarjuna et al., 2021). This finally impacted the soil environment positively for plant growth and this favourable soil condition to the succeeding mustard crop by providing macro and micronutrients especially nitrogen which helped to promote cell division and cell elongation of the plant. FYM had synergistic effect and helping in mineralization of applied nitrogen and phosphorus, which might help in enhancing of growth parameters (Jat et al., 2009). These results were also in agreement with Duary and Pramanik (2019). Raghuwanshi et al. (2017) also suggested that application micronutrients enhanced growth attributes like plant height. The integration of organic and inorganic sources might have resulted in slow-release of major and minor nutrients during entire season and their carried over the effects to succeeding crop. These findings corroborated the results of Patidar and Mali (2002).

The effect of nitrogen levels of preceding rice crop showed a significant influence on dry matter accumulation of succeeding transplanted mustard crop. Table 1 revealed that application of 60 kg N ha⁻¹+5t FYM ha⁻¹ (N₂) recorded



Table 1: Residual effect of nitrogen levels and micronutrient managements in the preceding rice crop on the growth parameters of transplanted mustard

Treat- ments	Plant height (cm)				Dry matter accumulation (g plant ⁻¹)					No. of branches plant ⁻¹		
	60 DAT		90 DAT		Harvest		60 DAT		90 DAT		Harvest	
	2019– 20	2020– 21	2019– 20	2020– 21	2019– 20	2020– 21	2019– 20	2020– 21	2019– 20	2020– 21	2019–20	2020–21
Nitrogen levels (kg ha ⁻¹)												
N ₁	89.2	85.7	106.2	98.7	110.3	104.3	12.49	11.88	24.42	22.67	7.8	7.2
N ₂	92.3	89.3	108.9	101.4	112.4	106.2	12.93	12.39	24.83	23.20	8.4	7.3
N ₃	88.9	86.2	104.7	97.4	106.7	101.4	12.09	11.51	23.75	22.07	7.9	6.9
SEm±	1.0	1.1	1.2	1.1	1.5	1.3	0.23	0.24	0.30	0.30	0.2	0.1
LSD (<i>p</i> =0.05)	3.0	3.1	3.3	3.1	4.4	3.6	0.65	0.70	0.86	0.85	0.4	0.3
Micronutrient managements												
M ₁	89.8	87.2	105.5	97.3	108.9	100.7	12.19	11.77	23.50	22.16	7.9	7.1
M ₂	93.5	89.6	109.2	101.9	112.0	105.8	13.09	12.54	25.11	23.43	8.2	7.5
M ₃	88.8	85.6	106.6	99.4	110.1	105.0	12.43	11.76	24.51	22.52	7.8	7.1
M ₄	89.9	87.1	106.5	98.2	108.9	102.3	12.36	11.87	24.49	22.54	8.2	6.8
M ₅	87.4	84.6	104.9	98.3	108.2	103.2	12.24	11.84	24.12	22.60	7.7	7.0
M ₆	91.6	88.2	107.0	99.8	110.6	106.6	12.71	12.02	24.28	22.62	8.4	7.2
SEm±	1.5	1.5	1.6	1.5	2.1	1.8	0.32	0.35	0.43	0.42	0.2	0.1
LSD (<i>p</i> =0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

N₁: 80 kg N ha⁻¹ (100% RDN); N₂: 75% of N₁ (60 kg N ha⁻¹)+5 t FYM ha⁻¹; N₃: 50% of N₁ (40 N kg ha⁻¹)+10 t FYM ha⁻¹; M₁: Control; M₂: 0.5% zinc sulphate as foliar; M₃: 0.5% ferrous sulphate as foliar; M₄: 0.3% zinc sulphate as seed priming; M₅: 0.3% ferrous sulphate as seed priming; M₆: 0.5% zinc sulphate as foliar+0.5% ferrous sulphate as foliar

significantly higher dry matter accumulation (g plant⁻¹) over application of 40 N kg ha⁻¹+10 t FYM ha⁻¹ (N₃), but it was at par with application of 80 kg N ha⁻¹ (N₁) at 60 and 90 DAT during both the years of study.

This might be due to combined application of inorganic form N along with FYM, which was highly persistent bulky organic manure with a wider C:N ratio which resulted in slower mineralization. Therefore, essential nutrients from organic sources had not been fully utilized by the rice crop in the first crop season and possibly exploited by the succeeding transplanted mustard crop. Mangaraj et al. (2022) also observed the close to this finding in rice-green gram cropping system. Obviously, the micronutrient managements had no significant effect on plant height and dry matter accumulation during both the years of studies.

The effect of nitrogen levels in the preceding rice crop showed a significant influence on number of branches plant⁻¹ (Table 1). Among different level of nitrogen, application of 60 kg N ha⁻¹+5t FYM ha⁻¹ (N₂) recorded significantly highest number of branches plant⁻¹ (8.4) during 2019–20.

However, during second year of experiment it was at par with application of 80 kg N ha⁻¹ (N₁). High availability of macro and micronutrient under inorganic nitrogen+FYM treatments might have resulted increased conversion of carbohydrates into protein which enhanced the size of the cell resulting in increasing of plant height, number of branches and ultimately higher dry matter accumulation. The slower release of nutrients for a longer period due to mineralisation of undecomposed FYM favoured congenial microclimate by increasing soil organic matter content; consequently, reducing bulk density compaction of soils (Mangaraj et al., 2022). Synergistic effects on nitrogen uptake in Indian mustard was observed with the integrated application of vermicompost @ 6.0 t ha⁻¹+80 kg N+40 kg P₂O₅ ha⁻¹ (Kansotia et al., 2015). Meena et al. (2021) reported that application of 10 t FYM ha⁻¹ gave significant effect on yield and growth parameters of Indian mustard. Among micronutrient managements, foliar application of 0.5% zinc sulphate and 0.5% ferrous sulphate (M₆) recorded highest number of branches plant⁻¹ (8.4) during 2019–20,

Table 2: Effect of nitrogen levels and micronutrient managements in the preceding rice crop on the number of siliquae, test weight, seed and stalk yield of succeeding transplanted mustard

Treatments	No. of siliquae plant ⁻¹		No. of seeds siliqua ⁻¹		Test weight (g)		Seed yield (kg ha ⁻¹)		Stover yield (kg ha ⁻¹)		Harvest index	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
Nitrogen levels (kg ha ⁻¹)												
N ₁	125	120	9.7	9.1	3.9	3.9	633	609	1434	1404	30.75	30.33
N ₂	129	123	9.9	9.3	4.1	3.9	640	617	1464	1450	30.52	30.02
N ₃	121	115	9.4	8.8	3.9	3.7	616	606	1378	1377	31.02	30.63
SEm±	2.1	2.2	0.2	0.2	0.1	0.1	6.3	3.2	23	20	0.40	0.36
LSD (p=0.05)	6.2	6.4	NS	NS	NS	NS	18.0	9.1	66	58	NS	NS
Micronutrient managements												
M ₁	122	117	9.2	8.8	3.9	3.8	608	603	1395	1401	30.36	30.16
M ₂	131	125	10.0	9.4	4.0	4.0	634	618	1420	1423	30.95	30.29
M ₃	124	118	9.8	9.0	3.9	3.8	644	620	1427	1458	31.31	29.94
M ₄	124	118	9.8	9.1	4.1	3.7	633	616	1380	1353	31.52	31.39
M ₅	122	118	9.6	9.0	3.8	3.8	635	605	1521	1466	29.61	29.42
M ₆	127	120	9.7	9.0	4.1	3.9	626	602	1409	1359	30.84	30.77
SEm±	3.0	3.1	0.3	0.3	0.1	0.1	8.9	6.5	32	28	0.57	0.50
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

N₁: 80 kg N ha⁻¹ (100% RDN); N₂: 75% of N₁ (60 kg N ha⁻¹)+5 t FYM ha⁻¹; N₃: 50% of N₁ (40 N kg ha⁻¹)+10 t FYM ha⁻¹; M₁: Control; M₂: 0.5% zinc sulphate as foliar; M₃: 0.5% ferrous sulphate as foliar; M₄: 0.3% zinc sulphate as seed priming; M₅: 0.3% ferrous sulphate as seed priming; M₆: 0.5% zinc sulphate as foliar+0.5% ferrous sulphate as foliar

but during second year of study, foliar spraying of 0.5% zinc sulphate (M₂) recorded highest number of branches plant⁻¹ (7.5).

3.2. Yield attributes and yield

Most of the yield attributing parameters viz., number of siliqua plant⁻¹, number of seeds siliqua⁻¹ and test weight (Table 2) of transplanted mustard were significantly influenced due to residual effect of nitrogen levels in the preceding rice crop. Application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂) recorded significantly highest number of siliqua plant⁻¹ (*i.e.*, 129 and 123 during 2019–20 and 2020–21, respectively) over application of 40 N kg ha⁻¹+10 t FYM ha⁻¹ (N₃), but it was at par with application of 80 kg N ha⁻¹ (N₁) during both the years of study. Similarly application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂) recorded higher number of seeds siliqua⁻¹ and test weight during both the years of study and was followed by application of 80 kg N ha⁻¹ (N₁). Such effect might be owing to better availability of macro and micronutrient in soil from native pool as well as their residual effect through mineralization. Similar outcomes

had been described former studies concerning diverse crops by Koireng et al. (2018) in potato-green gram, Dash et al. (2017) in rice-green gram. Residual effect of STFR based integrated plant nutrient management along with FYM and biofertilizers imposed by preceding rice crop on black gram seed yield was reported by Senthilvalavan and Ravichandran (2016), rice crop on black gram (Saha and Moharana, 2008) and rice crop on green gram (Mangaraj et al., 2022). There was no significant effect of micronutrient managements on yield attributes of transplanted mustard crop. However, foliar spraying of 0.5% zinc sulphate (M₂) noticed highest number of siliqua plant⁻¹, number of seeds siliqua⁻¹ and test weight (except 2019–20) during both the years of experiment.

The application of different level of nitrogen levels in the preceding rice crop showed a significant influence on seed and stover yield of succeeding transplanted mustard during 2019–20 and 2020–21. Results indicated that application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂) recorded significantly higher seed yield (640 kg ha⁻¹ and 617 kg ha⁻¹ during 2019–20 and



2020–21, respectively) and stover yield (1464 kg ha⁻¹ and 1450 kg ha⁻¹, during 2019–20 and 2020–21 respectively) over application of 40 N kg ha⁻¹+10 t FYM ha⁻¹ (N₃), but it was at par with application of 80 kg N ha⁻¹ during both the years of experiment. Application of 40 N kg ha⁻¹+10 t FYM ha⁻¹ (N₃) recorded significantly higher harvest index during both the years of study over application of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂), but it was at par with application of 80 kg N ha⁻¹ (N₁) during both the years of experiment. The increased transplanted mustard seed and stover yield might be due to balanced addition of 60 kg N ha⁻¹+5 t FYM ha⁻¹ (N₂) to preceding rice crop resulting in improvement macro and micronutrient status of soil. Higher stover yield might be due to increase in vegetative growth in terms of plant height, number of branches, and dry matter accumulation. Bodruzzaman et al. (2010), stated that FYM application on a preceding rice crop had a residual effect on the yield of a succeeding wheat crop. Thus, improvements in soil N and P nutrient status due to FYM application could sustain high rice crop yields ensuring long term sustainability of the system. Koireng et al. (2018) also pointed out that growth, grain and haulm yield of green gram were significantly increased by the residual effect of organic manure and micronutrients applied to the previous crop. The farm yard manure not only supplied numbers of macro and micronutrients but also helped significantly to improve the physical, chemical and biological properties of the soil. The farm yard manure required more time for its mineralisation resulting in less available of macro and micronutrients to immediate crop i.e., *khari* rice and rest to subsequent crops (Inoko, 1984) which sustained the productivity. These findings are closely related to the results of Mohanty et al. (2015) and Alagappan et al. (2016). The micronutrient managements had no significant effect on seed and stover yield during both the years of study. Among micronutrient managements, foliar application of 0.5% ferrous sulphate (M₃) perceived higher seed and stover yield during both the years of experiment.

4. CONCLUSION

Residual effect of integrated nitrogen in the preceding rice crop showed significant influence on growth parameters like plant height, dry matter accumulation and number of branches plant⁻¹ yield attributes like number of siliqua plant⁻¹, number of seeds siliqua⁻¹, test weight and seed and stover yield. There was no residual effect of foliar as well as seed priming of zinc and iron influence on growth attributes, yield attributes and yield.

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