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To find out the effect of integrated nutrient management on the growth, yield and quality of *rabi* maize

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Abstract
Present experiment entitled "Effect of Integrated Nutrient Management on growth & yield of rabi maize (*Zea mays* L.)" was conducted during the Rabi season of 202223 at Agriculture Research Farm, Rama university, Mandhana, Kanpur. The experiment was laid out in Randomized Block Design (RBD) with three replications and 10 treatments *viz.* T_1 = Control T_2 = 100% NPK (180:60:40), T_3 = Seed treatment with *Azotobacter* @200 g/10 Kg seeds T_4 = Seed treatment with *Azospirillum* @200 g/10 Kg seeds T_5 = Seed treatment with *Azospirillum* + *Azotobacter*, T_6 = 50% NPK + Seed treatment with *Azotobacter*, T_7 = 50% NPK + Seed treatment with *Azospirillum*, T_8 = 50% NPK+ Seed treatment with *Azospirillum* + *Azotobacter* and T_9 = 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter* and T_{10} = 100%NPK+seed treatment with *Azospirillum* + *Azotobacter*. The result of the study revealed that the maximum plant height (225.08) cm, dry matter (467.00 gm), Leaf area Index (0.17), Cob Length (17.33), Number of cobs per plant (17.33), number of cob per plant (2.09), number of grain per cobs (15.56) yield per hectare (141.59 q) and C:B ratio (2.11) was reported in treatment T_{10} = 100% NPK+seed treatment with *Azospirillum* + *Azotobacter* followed by treatment T_9 = 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter* Basis on these results treatment T10 can be suggested to the local farmer of Kanpur regions to obtain 15 higher yield and net return in rabi maize.

Keywords: Growth, Leaf area Index, plant height, treatments, season. yield

Introduction

Maize (*Zea mays* L.) is the most important and common cereal crop in India and due to its high yield potential it is eulogized "queen of cereals". In the area, Maize is the third most important staple food crop in the world after wheat, and rice regarding to productivity. It is first ranks followed by rice, wheat and other millets. Worldwide maize is cultivated on approximately 177 mha area with production of 967 mt and productivity of 5.46 t/ha (USDA, 2013-14). In India, maize is cultivated on 10.43 mha area, with production and productivity of 32.35 mt and 2987 kg/ha, respectively (Sinha, 2020). Maize is grown mainly as a rainfed crop during rabi season with only 22.8% area under irrigated conditions. Karnataka, Maharashtra, Andhra Pradesh, and Madhya Pradesh and Uttar Pradesh are leading states in area, Andhra Pradesh, Karnataka, Maharashtra and Bihar in production and Tamil Nadu, Punjab, Andhra Pradesh and West Bengal have higher crop productivity i.e., 5139, 3651 and 2794 kg/ha respectively. Similarly in world, USA, China, Brazil, India and Argentina are leading countries in maize production.

The demand of *rabi* maize is increasing day by day in countries such as USA, Japan, Singapore, Australia, Canada, New Zealand and Arab countries and it is expected to double worldwide by 2050 (Gill *et al.* 2018) [6] India also has a great potential and may lead in the world mainly because of suitable weather conditions throughout the year. Among the Indian states, Meghalaya, Bihar, Western UP, Haryana, Punjab, Maharashtra, Karnataka and Andhra Pradesh are the leading states in rabi maize production. The net income from rabi maize is four to five times higher from a single crop than grain maize crop. Therefore, the acreage as well as the production of *rabi* maize is increasing in India.

Materials and Methods

The experiment was conducted at Rama University's research farm in Mandhana, Kanpur Nagar, U.P., India., during the *Rabi* season of 2022-23. The Farm is located between 26.35° N and 80.09° E latitudes. A height of 130.00m (426.51 ft) above sea level marks the site. The soil of the experimental field is sandy clay loam in texture with good drainage and water transmission characteristics.

1. **Plant height** the plant height of five randomly tagged plants was measured in centimeters from ground level to the base of well-developed last leaf with the help of meter scale. The observations on plant height were recorded on 30, 60, 90, 120 and at harvest DAS and at harvest stages of crop in each plot. at harvest the plant height was measured from the ground level to the base of the tassel. Finally, mean was computed for each observation.
2. **Leaf area index** the leaf area index (LAI) was determined plot wise at 30, 60 and 90 DAS growth stages by using following formula as suggested by Watson (1952):

where,

$$LAI = \frac{A}{P}$$

A = Leaf area/m2
P = Ground area/m2 from where leaf area was recorded

Grain yield (q/ha) the Grain yield of each plot was recorded after shelling the cobs. The weight of Grain obtained from five plants used for post-harvest studies in each plot was added to the weight of Grain of respective plots. After this, Grain yield/plot was converted into Grain yield per hectare by multiplying with conversion factor.
Protein content in grain (%) the per cent protein content in grain was calculated by multiplying the percentage of nitrogen content with the conversion factor 6.25 (Piper, 1966

Results and Discussion
Plant height (cm) At 30, 60, 90, at harvest the data pertaining to plant height of maize at 30, 60, 90 DAS and at harvest as influenced by different INM treatments are given in Table 1 and graphically depicted through the Figure 4.2 It is evident from the data that plant height gradually increased with the advancement in the growth intervals of the crop till the final stage under all treatments. The rate of increase in plant height was most rapid during 30 to 60 DAS. The full height was attained by the plants at 90 DAS and thereafter the plant height was almost ceased or decreased at harvest.
Plant height significantly affected by various treatments at all the growth intervals of maize. Plant height was maximum (20.27 cm) under 100% NPK+ seed treatment with *Azospirillum* + *Azotobacter* at 30 DAS which was significantly superior 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter*. While minimum plant height (15.98c m) was recorded under Control.
Plant height recorded at 60 DAS showed that the plants were taller (220.18 cm) with the application of, 100%NPK+seed treatment with *Azospirillum* + *Azotobacter* followed by 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter* and both these treatments were significantly superior over rest of the treatments. The plant height was minimum (122.67 cm) under the application of control.
At 90 DAS the maximum plant height (143.28 cm) was noted under the application 100% NPK+ seed treatment with *Azospirillum* + *Azotobacter* which was at par 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter* However, the variation in the plant height between the above treatments was not marked. The minimum (143.98 cm) plant height was recorded under Control.
Plant height was recorded at harvest showed slightly decline. The plant height was maximum (225.08 cm) under the application of 100% NPK+ seed treatment with *Azospirillum* + *Azotobacter* Which was significantly at par with 75% NPK+ seed treatment with *Azospirillum* + *Azotobacter* However, the minimum plant height (142.1 cm was recorded) under the application of Control.

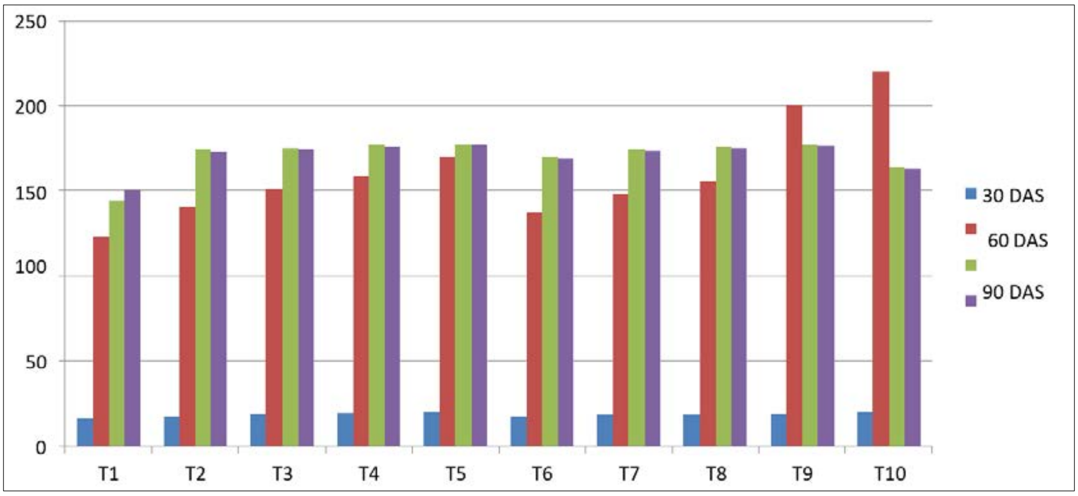

Fig 1: Effect of integrated nutrient management on plant height

Table 1: Effect of integrated nutrient management on plant height

S. N.	Treatments	Plant Height			
T_1	Control	15.98	122.67	143.98	142..1
T_2	100% NPK (180:60:40)	17.83	140.57	174.00	173.06
T_3	Seed treatment with *Azotobacter* @200g/10Kg seeds	19.02	150.97	174.73	174.00
T_4	Seed treatment with *Azospirillum* @200g/10Kg seeds	19.79	158.40	177.07	176.23
T_5	Seed treatment with *Azospirillum* + *Azotobacter*	19.94	170.47	177.30	177.09
T_6	50% NPK + Seed treatment with *Azotobacter*	17.81	137.03	170.27	168.90
T_7	50% NPK + Seed treatment with *Azospirillum*	18.42	148.33	174.20	173.60
T_8	50% NPK+ Seed treatment with *Azospirillum* + *Azotobacter*	18.50	155.67	175.87	175.10

T9	75% NPK+ seed treatment with *Azospirillum* + *Azotobacter*	19.12	200.21	177.20	176.53
T10	100%NPK+seed treatment with *Azospirillum* + *Azotobacter*	20.27	220.18	225.18	225.08
	CV%	2.98	3.09	1.65	2.11
	CD %	1.22	5.77	4.77	5.21

Leaf Area Index

Leaf area index was the ultimate expression of the photosynthetic activity of the plant, which might have a great bearing on the growth and yield parameters during the development phases of the crop. The data in relation to LAI at 30, 60 and 90 DAS as influenced by different treatments are given in Table 2 and graphically depicted through the Figure 4.4

The LAI was significantly influenced by different treatments at all the stages of crop growth. Though LAI increased with increasing the doses of biofertilzers with rapid rate of increment between 30 to 60 DAS and it declined slightly at 90 DAS.

LAI at 30 DAS noted under the application of 100%NPK+seed treatment with *Azospirillum* + *Azotobacter* was significantly more (4.90) in comparison to all the treatments. However the differences between the later treatments were not marked in respect of LAI. Minimum LAI (3.06) was recorded under water spray with RDF.

At 60 DAS the LAI noticed with the application of 100%NPK+seed treatment with *Azospirillum* + *Azotobacter* and The LAI under the application of water spray with RDF was noticed minimum. At 90 DAS 100%NPK+seed treatment with *Azospirillum* + *Azotobacter* was significantly. While minimum LAI (4.42) was recorded under Control.

Table 2: Effect of integrated nutrient management leaf area index

S. N.	Treatments	Leaf Area Index		
T_1	Control	3.06	5.42	4.42
T_2	100% NPK (180:60:40)	3.33	6.03	5.11
T_3	Seed treatment with *Azotobacter* @200 g/10 Kg seeds	3.51	6.91	5.84
T_4	Seed treatment with *Azospirillum* @200 g/10 Kg seeds	3.64	7.06	6.16
T_5	Seed treatment with *Azospirillum* + *Azotobacter*	2.86	5.34	4.15
T_6	50% NPK + Seed treatment with *Azotobacter*	3.14	5.82	4.93
T_7	50% NPK + Seed treatment with *Azospirillum*	3.38	6.55	5.73
T_8	50% NPK+ Seed treatment with *Azospirillum* + *Azotobacter*	3.58	6.96	5.94
T9	75% NPK+ seed treatment with *Azospirillum* + *Azotobacter*	2.61	5.07	3.98
T10	100%NPK+seed treatment with *Azospirillum* + *Azotobacter*	4.90	8.43	6.80
	CV%	0.06	0.17	0.14
	CD %	0.25	0.50	0.42

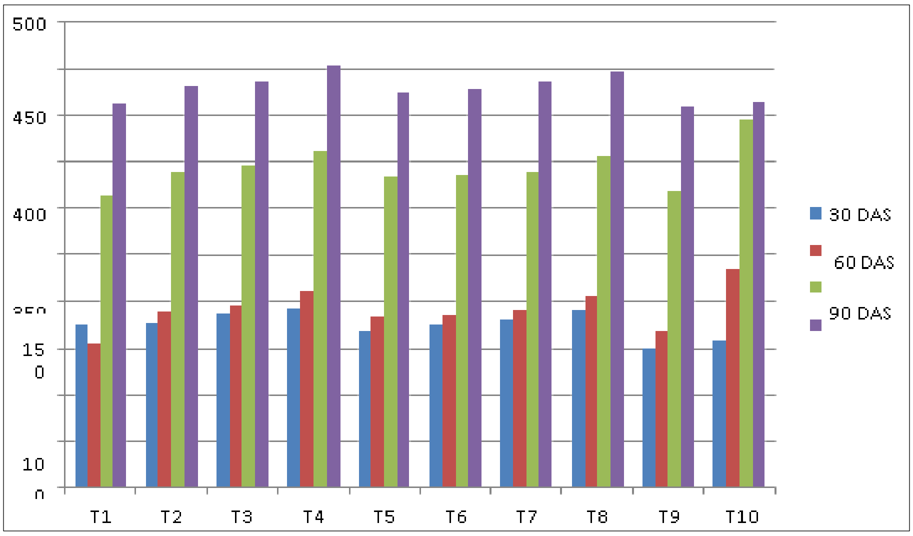

Fig 2: Effect of integrated nutrient management leaf area index

Grain yield the data on seed yield as affected by different INM treatments are presented in Table 4.14 and graphically depicted through the Figure 4.14.

It was evident from the data that grain yield of maize significantly varied due to different INM treatments. The grain yield of maize among all treatments was highest (33.98) under 100%NPK+grain treatment with *Azospirillum* + *Azotobacter* which is closely followed by 75% NPK+ grain treatment with *Azospirillum* + *Azotobacter* (33.27q/ha). While minimum (25.21) grain yield was recorded under control. In the present investigation the grain yield of maize was less than average because the crop was damaged due to attack of stem borer and cob borer resulted in reduction in yield.

Stover yield

The data on stover yield as affected by different INM treatments are presented in Table 4.15 and graphically depicted through the Figure 4.15 It was evident from the data that stover yield of maize significantly varied due to different INM treatments. The stover yield of maize among all treatments was significantly superior under the application of 100%NPK+grain treatment with *Azospirillum* + *Azotobacter* (107.61 q/ha) followed by 75% NPK+ grain treatment with *Azospirillum* + *Azotobacter* (105.75) while minimum Stover yield was recorded under control (89.58 q/ha).

Biological yield

The data on biological yield as affected by different INM treatments are presented in Table 4.16 nd graphically depicted through the Figure 4.16

It was evident from the data that biological yield of maize significantly varied due to different INM treatments. The Biological yield of maize among all treatments was significantly superior under the application of 100% NPK+grain treatment with *Azospirillum* + *Azotobacter* (141.59 q/ha) followed by 75% NPK+ grain treatment with *Azospirillum* + *Azotobacter* (139.02) while minimum biological yield was recorded under control (114.79 q/ha).

Harvest index

The data on harvest index as affected by different INM treatments are presented in Table 4.17 and graphically depicted through Figure 4.17

The ratio of economic yield to biological yield expressed in percentage was influenced by various treatments. The maximum harvest index was obtained 100% NPK+grain treatment with *Azospirillum* + *Azotobacter* (24.00) closely followed by 75% NPK+ grain treatment with *Azospirillum* + *Azotobacter* (23.93) while the minimum harvest index was recorded under water control (21.96).

Table 3: Treatment of grain yield, Stover yield and Harvest index

S. N.	Treatment	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield(q/ha)	Harvest index
T_1	Control	25.21	89.58	114.79	21.96
T_2	100% NPK (180:60:40)	25.9	90.14	116.04	22.32
T_3	Seed treatment with *Azotobacter* @200g/10Kg seeds	31.08	103.25	134.33	23.14
T_4	Seed treatment with *Azospirillum* @200g/10Kg seeds	30.84	102.08	132.92	23.2
T_5	Seed treatment with *Azospirillum* + *Azotobacter*	32.07	105.67	137.74	23.28
T_6	50% NPK + Seed treatment with *Azotobacter*	30.87	101.05	131.92	23.4
T_7	50% NPK + Seed treatment with *Azospirillum*	31.59	102.49	134.08	23.56
T_8	50% NPK+ Seed treatment with *Azospirillum* + *Azotobacter*	32.13	103.97	136.1	23.61
T_9	75% NPK+ seed treatment with *Azospirillum* + *Azotobacter*	33.27	105.75	139.02	23.93
T_{10}	100%NPK+seed treatment with *Azospirillum* + *Azotobacter*	33.98	107.61	141.59	24
	CV%	0.58	0.51	2.98	3.09
	CD @5%	1.73	1.51	1.22	5.77

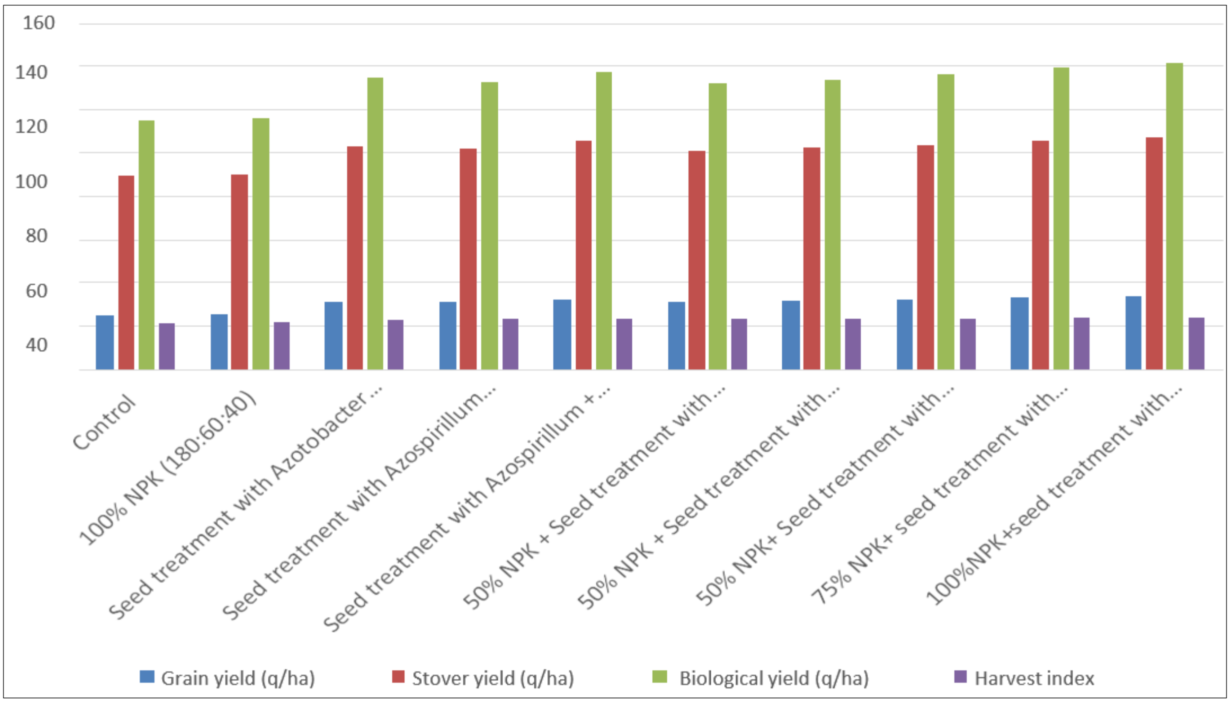

Fig 3: Treatment of grain yield, Stover yield and Harvest index

Protein content in grain (%) Data pertaining to the protein content in grain are presented in Table 4.10. The effect of INM practices did not exert any significant difference on the protein content in grain. However, the highest protein content (11.50%) in T_{10} 100% NPK+grain treatment with *Azospirillum* + *Azotobacter* while minimum (8.800) in control. 4.10 Nitrogen content in grain and stover (%) Data pertaining to the nitrogen content (%) in grain and stover are presented in Table 4.11. The effect of INM practices did not show any significant difference on the nitrogen content in grain and stover.

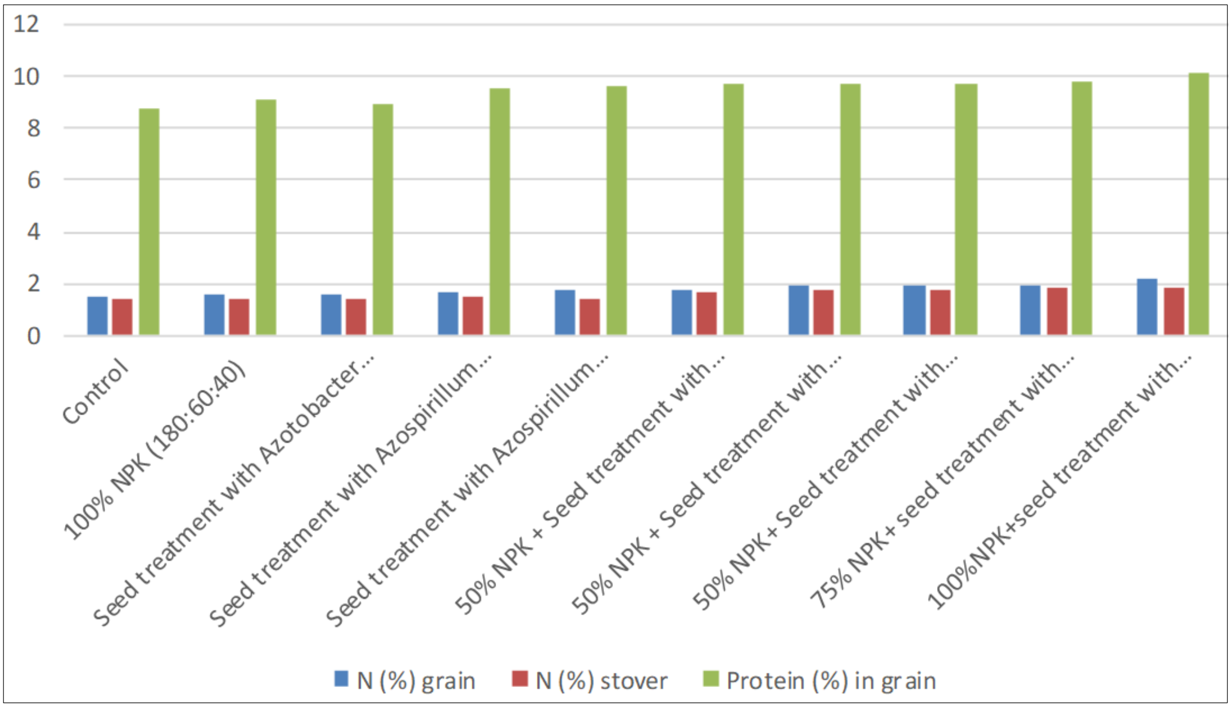

Fig 4: Grain, protein and Stover are presented

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