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Influence of integrated nutrient management practices on growth performance of mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2024-25 entitled "Influence of integrated nutrient management practices on growth performance of mustard (*Brassica juncea* L.)". The experiment was laid out in Randomized Block Design with eleven treatments and three replications. Among the treatments, application of 100% RDF was at par with treatments 75% RDF + *Azotobacter* + PSB + Consortia and 75% RDF + Consortia + PDKV Liquid Micro grade II significantly recorded highest plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of functional leaves, leaf area plant^{-1} (dm^2), leaf area index plant^{-1} and dry matter production plant^{-1} (g) were these treatments at par to each other.

Keywords: Mustard, *Azotobacter*, PSB, Consortia, PDKV Liquid Micro grade II, growth

Introduction
Mustard is the major *rabi* oilseed crop of India. Indian mustard [*Brassica juncea* (L.), Czern & Coss] is commonly known as rai. Middle East seems to be the place of origin since the putative parent species*; B. nigra* and *B. campestris* would have crossed. (Olson 1960, Mizushima and Tsunoda 1967). Its' seeds have an appropriate quantity of erucic acid 40-60% and linolenic acid 4.5-13%. The mustard oil is beneficial for human consumption and health since it is a rich source of unsaturated fatty acids. In terms of nutrients, seed meal contains 14-15% carbohydrates, 35-40% protein, 10-12% fibre, 4-6% ash, 1.0-1.5% vitamins and minerals and only 2-3% glucosinolate (Brar *et al*., 2016) [3].

India is the third largest producer of rapeseed-mustard after Canada, China and contributing to around 14% of world's total production. Of the total area and production under the nine oilseeds crops grown in India, rapeseed-mustard accounts for 30.3% of the acreage and 33.2% of the production as per the ICAR-Indian Institute of Rapeseed-Mustard Research, Bharatpur 2023-24. The average rapeseed-mustard yield is about 1443 kg ha^{-1} compared to the combined oilseeds crops average of 1314 kg ha^{-1}. Although rapeseed-mustard is cultivated in majority of states of the country, bulk of the production comes from Rajasthan (45.40%), Madhya Pradesh (13.28%) Uttar Pradesh (14.24%) Haryana (10.78%) and West Bengal (6.0%).

Chemical fertilizers cannot be totally excluded from usage in commercial agriculture. To maintain soil fertility and the intended level of crop output, however integrated applications of different fertilizer sources are required. Biofertilizers offer a cheaper low capital intensive and ecofriendly route to boosting farm productivity depending upon their activity of mobilizing different nutrients. Micronutrients offer numerous benefits for crop productivity under various climatic circumstances. The combined application of chemical fertilizers, bioinoculants and liquid micronutrients has considerable promises at different crop growth stages give best response to increase growth and growth attributes resulting to higher yield potential and safeguarding soil health.

Materials and Methods
The present experiment was conducted during the *rabi* season of 2024-25 at Agronomy Farm,

College of Agriculture, Nagpur. An experiment was laid out in Randomized Block Design consisting of eleven treatments *viz*., T_1- 100% RDF, T_2- 75% RDF + *Azotobacter*, T_3- 75% RDF + PSB, T_4- 75% RDF + Consortia, T_5- 75% RDF + *Azotobacter* + PSB, T_6- 75% RDF + *Azotobacter* + Consortia, T_7- 75% RDF + PSB + Consortia, T_8- 75% RDF + *Azotobacter* + PSB + Consortia, T_9- 75% RDF + *Azotobacter* + PDKV Liquid Micro grade II, T_{10}- 75% RDF + PSB + PDKV Liquid Micro grade II and T_{11}- 75% RDF + Consortia + PDKV Liquid Micro grade II which are replicated thrice. The gross plot size was 5.00 m × 4.50 m. In accordance with the treatments, the seed of mustard variety TAM 108-1 was sown in corresponding plots during first fourth night of November 2024 at a spacing 45 cm × 10 cm. Recommended dose of fertilizer with splitting dose of nitrogen and mustard seeds were treated with biofertilizers at the time of sowing. The foliar spray of PDKV liquid Micro grade II at vegetative stage and flowering stage DAS of mustard was applied. After 10 and 15 days of sowing, gap filling and thinning was done respectively. Biometric observation like the plant height was measured from the base of the plant to the tip of fully open leaf on the main shoot with average height of five plants was taken as plant height in centimeters, number of primary branches arising from plant were recorded and secondary branches are side branches that grows out from primary branches and they are crucial for increasing plants overall yield, number of functional leaves arising from plant were recorded, leaf area was measured with the help of leaf area meter (dm^2), leaf area index (LAI) of functional leaves was periodically calculated by dividing the leaf area by area occupied by each plant and five representative plants from each plot were uprooted for recording dry matter accumulation.

Results and Discussion

Growth attributes

Plant height (cm)

The application of 100% RDF (T_1) recorded significantly highest plant height of 182.47 cm over rest of the treatments and found at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}) at harvest. The significant increase in plant height might be due to the ready availability of nutrients from different sources of fertilizer and enhanced to increased metabolic activity, stimulated the root growth resulting in enhanced uptake of nutrients. The findings were accordance with Patle *et al*., (2022) [7] and Tripathy *et al*., (2023) [10].

Number of primary branches plant^{-1}

Maximum no. of primary branches plant^{-1} (5.60) was recorded with the application of 100% RDF (T_1) at harvest of overall treatments and being at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}). Increases in number of primary branches plant^{-1} might be due to greater availability of nutrients, form of primary nutrient sources which helped in acceleration of various metabolic processes. The same results were reported by Meena *et al*., (2013) [4] and Annupriya (2022) [1].

Number of secondary branches plant^{-1}: Application of 100% RDF (T_1) recorded significantly highest number of secondary branches plant^{-1} (14.67) overall treatments and found at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}) at harvest. This increase in number of secondary branches plant^{-1} because of the plants in those treatments have more amount of nutrients in readily available form which helped in acceleration of various metabolic processes and N and P favoured the better absorption of nutrients coupled with proper distribution. The results were matched with same trend recorded by Annupriya (2022) [1] and Patle *et al*., (2022) [7].

Number of functional leaves plant^{-1}

Maximum no. functional leaves plant^{-1} (21.17) was recorded by the application of 100% RDF (T_1) at 90 DAS of overall treatments and it was at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}). The increase in number of functional leaves might be due to adequate nutrient supply, particularly nitrogen (N) and phosphorus (P) which are crucial for vegetative growth. This enhances the number, longevity and physiological activity of functional leaves in mustard. These results are in conformity with the findings of Sunil Kumar *et al.,* (2016) [9], Annupriya (2022) [1] and Tripathy *et al*., (2023) [10].

Leaf area plant^{-1} (dm^2)

Application of 100% RDF (T_1) recorded significantly highest leaf area plant^{-1} (3.72 dm^2) and found at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}) at 90 DAS. Increase in leaf area of mustard due to improving nutrient availability, especially nitrogen, which directly influences vegetative growth and leaf expansion. The similar observations are noted by Tripathy *et al*., (2023) [10] and Rhakho *et al*., 2024 [8].

Leaf area index (LAI)

Application of 100% RDF (T_1) recorded significantly highest leaf area index (0.83) and it was at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}) at 90 DAS. The increase in LAI with 100% RDF application is attributed to enhanced nutrient availability, leading to improved plant growth and leaf development. The similar observations were noted by Sunil Kumar *et al*., (2016) [9] and Tripathy *et al*., (2023) [10].

Dry matter accumulation plant^{-1} (g)

The highest dry matter production plant^{-1} (41.15 g) was significantly recorded by application of 100% RDF (T_1) over all other treatments, but it was at par with 75% RDF + *Azotobacter* + PSB + Consortia (T_8) and 75% RDF + Consortia + PDKV Liquid Micro grade II (T_{11}) at harvest. This may be due to an adequate and balanced supply of nitrogen (N), that enhance photosynthetic activity, leaf expansion and root development**,** all contributing to greater dry matter accumulation. The above results are correlated with findings of Sunil Kumar *et al.,* (2016) [9], Vinay Singh and R. B. Singh (2020) [12] & Vikram Bharati *et al.,* (2022) [11].

Table 1: Growth and growth parameters of mustard as influence by various treatments

Treatments	Plant height (cm)	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of functional leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Leaf area index (LAI)	Dry matter accumulation plant^{-1} (g)
	At harvest	At harvest	At harvest	90 DAS	90 DAS	90 DAS	At harvest
T_1	182.47	5.60	14.67	21.17	3.72	0.83	41.15
T_2	160.63	3.97	10.44	16.40	2.62	0.58	29.50
T_3	153.27	3.47	9.03	15.90	2.39	0.53	27.57
T_4	155.71	3.67	9.67	16.23	2.46	0.55	28.40
T_5	167.77	4.67	12.30	17.53	2.95	0.66	33.71
T_6	171.60	4.70	13.04	17.87	2.98	0.66	34.10
T_7	166.04	4.60	11.93	17.33	2.89	0.64	32.51
T_8	180.02	5.43	14.27	20.30	3.58	0.79	39.92
T_9	165.58	4.50	11.63	16.97	2.69	0.60	30.43
T_{10}	163.81	4.44	11.30	16.73	2.64	0.59	29.64
T_{11}	178.84	5.17	13.97	19.77	3.13	0.70	36.94
SE (m) ±	3.15	0.29	0.39	0.98	0.22	0.05	2.29
CD at 5%	9.29	0.86	1.15	2.90	0.65	0.14	6.78
GM	167.79	4.56	12.02	17.84	2.91	0.65	33.04

Conclusion

Application of 100% RDF shows higher growth and growth attributing characters *viz*., plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of functional leaves, leaf area plant^{-1} (dm^2), leaf area index and dry matter production plant^{-1} (g) which comparable with treatment 75% RDF + *Azotobacter* + PSB + Consortia and 75% RDF + Consortia + PDKV Liquid Micro grade II as this was at par to each other.

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