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Response of nutrient management and bio-fertilizer for enhancing growth and yield of mustard (*Brassica juncea* L.)

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Abstract
The present study was conducted during Rabi season of 2021-22 at the Student Instructional Farm of Chandra Shekhar Azad University Agriculture & Technology, Kanpur, Uttar Pradesh with the objectives to find out suitable fertilizer dose with bio-fertilizer on growth and yield of mustard crop**.** The experiment was laid out in a Factorial Randomized Block Design with three replication. The experiment was comprised of sixteen treatment combinations in which four levels of nutrient management *viz*., Control, 75% RDF, 100% RDF, 125% RDF and four bio-fertilizer *viz*., Control, Azotobacter @10 ml kg^{-1} seed, PSB @10 ml kg^{-1} seed, Azotobacter @5 ml + PSB @5 ml kg^{-1} seed. The result showed that among the different recommended dose of fertilizers, applied of 125% RDF gave significantly better growth attributes, yield attributes and yields in compared to control, 75% and 100% RDF, respectively. The percentage increment of 125% RDF over no nutrients supply, 75% RDF and 100% RDF were 38.51%, 19.75% and 10.95% in respect of grain yield, 38.98%, 16.84% and 9.38% in stover yield, 35.16%, 17.60 and 9.80% in biological yield and 2.38%, 1.73% and 9.80% in harvest index, respectively. Among the different levels of bio-fertilizers, application of Azotobacter @5 ml + PSB @5 ml kg^{-1} seed gave significantly higher growth attributes, yield attributes and yields in compare to all rest, respectively. The increment evaluated in grain yield (24.27, 14.62 and 7.29%), straw yield (25.80, 12.81 and 6.42%) in biological yield (26.74, 13.31 and 6.62%) and in harvest index (1.93, 1.09 and 0.60%) over control, Azotobacter @10 ml kg^{-1} and PSB @10 ml kg^{-1} seed, respectively. Therefore, higher growth attributes, yield attributes and yields of Indian mustard were achieved by application of 125% recommended dose of fertilizer and inoculation with Azotobacter @5 ml + PSB @5 ml kg^{-1} seed over rest treatment, respectively.

Keywords: Nutrient management, Azotobacter, PSB, Mustard

Introduction
In India, its cultivation is mainly confined to Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Assam, Bihar, Gujarat and West Bengal. The important rapeseed and mustard growing countries of the world are India, Canada, China, Pakistan, Bangladesh and Sweden. India is the fourth-largest contributor of oilseeds in the world and rapeseed and mustard contributes about 28.6% of total oilseeds production. After soybean and palm oil, it is the third important oilseeds in the world. Oilseed crops are the most important commercial crops in India. Indian mustard (*Brassica juncea* L.) is the most popular one among different species of rapeseed and mustard grown in India. Oilseed cultivation is undertaken across the country in about 27.04 million ha. Largely under rain-fed area covering 72% and producing around 33.42 million tonnes of oilseed during 2019-20. Estimate production rapeseed and mustard are 11.46 million tonnes during 2021-22 (Anonymous 2022) [2]. The key principle behind nutrient management is balancing soil nutrient inputs with crop requirements. Nutrients like nitrogen, phosphorous and potassium are needed in large quantities by the plants. Bio-fertilizer has been proved as the cheapest source of nitrogen and phosphorous for mustard crop. Indian soil in general and lacking in effective and specific strains of PSB and Azotobacter which are responsible of increasing the number of such microorganism in soil or rhizosphere and consequently improve the extent of microbiologically fixed nitrogen for the plant growth. They are used either to fix nitrogen or to solubilize plant nutrients like phosphate.

Materials and Method

A field experiment was conducted during *Rabi* season of 2021-22 at the Student Instructional Farm of Chandra Shekhar Azad University Agriculture & Technology Kanpur, (Uttar Pradesh). The soil of experimental field was sandy loam in texture, pH is slightly alkaline (7.3), low in organic carbon ((0.42), available nitrogen (218.0 kg ha^{-1}), available phosphorus (16.0 kg ha^{-1}), available potassium (143.0 kg ha^{-1}) and available sulphur (11.0 kg^{-1}). The experiment was laid out in a Factorial Randomized Block Design with three replications in which four Nutrient management *viz*., Control, 75% RDF, 100% RDF, 125% RDF and inoculation with four Bio-fertilizer *viz*., Control, Azotobacter @10 ml kg^{-1} seed, PSB @10 ml kg^{-1} seed, Azotobacter @5 ml + PSB @5 ml kg^{-1} seed. Azad Mahak variety of mustard was sown with seed rate 6 kg ha^{-1}. The seeds were placed at depth 3 to 4 cm with inter row spacing of 45 cm and covered with soil. The recommended dose of fertilizer 120:40:40, N:P:K, Phosphatic and potassium fertilizer was applied as a basal dose with split dose of nitrogen fertilizer as per treatment. Urea, DAP and MOP were used as source of fertilizer. While, Azotobacter and PSB was used treatment wise. Seed was sown in 31 Oct. 2021 with seed drill and harvested at 23 March, 2022. Other cultural activities were adopted as per recommendation of the crop.

Results and Discussion

Growth attributes

The results revealed that growth attributes *viz*., plant population, plant height (cm), fresh weight (g), dry weight (g), number of branches $plant^{-1}$ were significantly increased with respect to application of 125% recommended dose of fertilizer compare to control, 75% and 100% RDF, respectively in Table 1. The maximum plant population (14.29 m^{-2}), plant height (144.86 cm), fresh weight (34.26 g), dry weight (27.24 g), number of primary branches (10.43), number of secondary branches (14.29), number of tertiary branches (5.97) were recorded in 125% RDF. While, the minimum plant population (10.41), plant height (107.60 cm), fresh weight (25.00 g), dry weight (19.88 g), number of primary branches (7.60), number of secondary branches (10.41), number of tertiary branches (4.68) were recorded in control treatment. The application of different level of nutrients (NPK), favourably influenced the growth attributes supportive its well established role in proper growth and development. The increase growth parameters with adequate application of NPK give result of enhancement of in cell multiplications, cell elongation and cell expression in plant body. A strong and positive relationship between LAI and dry matter accumulation show highest value up to recommended dose of fertilizer. The similar results were also reported by Meena *et al.* (2018) [5], Mohapatra *et al.* (2019) [6].

The growth attributes *viz*., plant population, plant height (cm), fresh weight (g), dry weight (g), number of branches $plant^{-1}$ were significantly increased with respect to application of Azotobacter @5 ml + PSB @5 ml kg^{-1} seed over rest treatment, respectively. The result showed that plant population plant height, fresh weight, dry weight, number of primary branches, number of secondary branches, number of tertiary branches were recorded in Azotobacter @5 ml + PSB @5 ml kg^{-1} seed. While, the minimum plant population, plant height, fresh weight, dry weight, number of primary branches, number of secondary branches, number of tertiary branches were recorded in control treatment. This may be due to ability of nitrogen fixing and phosphorous mobilising of such bacteria and increasing availability of nitrogen and phosphorous to the crop which resulted better growth and development of crop. This result is close to Reddy *et al.* (2018) [8]

Yield attributes

The data revealed that yield attributes *viz*., number siliqua $plant^{-1}$, number of seeds $siliqua^{-1}$, test weight (g) was significantly increased with respect to application of 125% recommended dose of fertilizer (120:40:40, N:P:K) other rest treatment, respectively. The tune of siliqua $plant^{-1}$ (333.51), seeds $siliqua^{-1}$ (7.91), test weight (4.16 g) were maximum observed in 125% RDF, whereas, the minimum number of siliqua $plant^{-1}$ (243.22), seeds $siliqua^{-1}$ (5.77), test weight (3.68 g) were observed in control treatment. Supply of NPKS and better availability of sufficient amount of plant nutrients through out growth period especially at critical period of crop growth which has resulted better plant vigour and superior yield attributes, number of siliqua plant-1, number of seeds siliqua-1, test weight. These results are in accordance with findings of Jat *et al.* (2017) [4], Ahmad *et al.* (2019) [1].

The results revealed that yield attributes *viz*., number siliqua $plant^{-1}$, number of seeds $siliqua^{-1}$**,** test weight (g) were significantly increased with respect to application of Azotobacter @5 ml + PSB @5 ml kg^{-1} seed. The maximum number of siliqua $plant^{-1}$, seeds $siliqua^{-1}$ and test weight were observed in Azotobacter @5 ml + PSB @5 ml kg^{-1} seed, whereas the minimum number of siliqua $plant^{-1}$, seeds $siliqua^{-1}$ and test weight were observed in control treatment. The beneficial effect of bio-fertilizer inoculation on various yield attributes have been similar result found in Chandan *et al.* (2019) [3], Vijayeswarudu *et al.* (2021) [9], Patel *et al.* (2022) [7].

Yields

The results reported that yield (q ha^{-1}) *viz*., grain yield, stover yield, biological yield and harvesting index (%) were found to be significant under 125% recommended dose of fertilizer than control, 75% and 100% RDF dose, respectively. The percentage increments of 125% RDF over no nutrient management were 38.51%, 33.99%, 35.16% and 3.39% in grain yield, straw yield, biological yield and harvest index, respectively. The increased in seed yield and stover yield might be due to remarkable improvement in the growth and yield attributes, its expression was observed with their integrated influence with the increment in supply of essential nutrients (NPK) to mustard. These results are in agreement with findings of Yadav *et al.* (2017) [10], Ahmad *et al.* (2019) [1] and Patel *et al.* (2022) [7].

The results reported that yield (q ha^{-1}) *viz*., grain yield, stover yield, biological yield and harvesting index (%) were found to be significant under Azotobacter @5 ml + PSB @5 ml kg^{-1} seed with percentage increments over control of 29.24% in grain yield, 25.80% in stover yield, 26.73% in biological yield and 1.93% in harvesting index in study year, respectively. Yield is the resultant outcome of the effect of various growth and yield parameters, this similar results were found by Yadav *et al.* (2010) [10], Reddy *et al.* (2018) [8].

Table 1: Effect of nutrient management and bio-fertilizer on growth yield potential of mustard

Treatment	Growth attributes						Yield attributes			Yield			
	Plant height (cm)	Fresh weight (g)	Dry weight (g)	Primary branches	Secondary branches	Tertiary branches	Siliqua plant^{-1}	Seeds siliqua^{-1}	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Nutrient management													
Control	107.17	25.00	19.88	7.60	10.41	4.51	243.22	5.77	3.68	13.53	37.70	51.23	26.40
75% RDF	122.47	28.92	23.00	8.80	12.05	5.22	281.36	6.68	3.87	15.65	43.23	58.88	26.57
100% RDF	132.63	31.20	24.80	9.51	13.03	5.64	304.16	7.22	3.99	16.89	46.18	63.06	26.77
125% RDF	144.86	34.26	27.24	10.43	14.29	6.19	333.51	7.91	4.16	18.74	50.51	69.24	27.03
S.E.(d)±	4.074	0.662	0.755	0.280	0.614	0.306	4.383	0.157	0.066	0.614	0.816	1.128	0.059
C.D. at 5%	8.322	1.353	1.541	0.572	1.254	0.624	8.953	0.321	0.136	1.254	1.667	2.303	0.121
Levels of Bio-fertilizer													
Control	110.33	25.89	20.59	7.88	10.80	4.68	252.26	5.73	3.53	14.01	38.99	53.00	26.42
Azotobacter @ 10ml kg^{-1} seed	124.72	29.19	23.21	8.89	12.19	5.28	284.46	7.62	3.90	15.80	43.48	59.28	26.64
PSB @10 ml kg^{-1} seed	132.32	31.19	24.80	9.49	13.00	5.64	303.75	7.21	4.07	16.88	46.09	62.96	26.77
Azotob. @5 ml + PSB @ 5ml kg^{-1} Seed	139.76	33.10	26.31	10.06	13.79	5.97	321.79	7.64	4.20	18.11	49.05	67.17	26.93
S.D.(d)±	4.074	0.662	0.755	0.280	0.614	0.306	4.383	0.157	0.066	0.614	0.816	1.128	0.059
C.D. at 5%	8.322	1.353	1.541	0.572	1.254	0.624	8.953	0.321	0.136	1.254	1.667	2.303	0.121

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