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**Research Communication**

# Quality and profitability of Indian mustard (*Brassica juncea*) as affected by nutrient-management practices under irrigated condition

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## ABSTRACT

A field experiment was carried out during the winter season (*rabi*) of 2010 at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh, to study, the effect of nutrient-management practices on productivity, economics and quality of Indian mustard [*Brassica juncea* (L.) Czernj & Cosson] under irrigated condition. Eight treatment combinations, *viz.* control, $N_{67.5}P_{30}$ [75% recommended dose of nitrogen and phosphorus (RDNP)], $N_{90}P_{40}$ (100% RDNP), $N_{112.5}P_{50}$ (125% RDNP), *Azotobacter* + phosphate solubilising bacteria (PSB) (AP), $N_{67.5}P_{30}$ + AP, $N_{90}P_{40}$ + AP, $N_{112.5}P_{50}$ + AP, were laid out in 3 times replicated under randomized block design. Application of 125% RDNP (112.5 kg N and 50 kg $P_2O_5$/ha) being at par with 100% RDNP under conjunctive use of *Azotobacter* and PSB recorded the maximum growth parameters, *viz.* plant height (177.3 cm), dry-matter accumulation (64.3 g/plant), primary branches/plant (7.67), secondary branches/plant (6.73) and yield attributes, *viz.* siliquae/plant (140.7), length of siliqua (4.78 cm), seeds/siliqua (12.12) and 1000-seed weight (4.89 g) resulted in 89 and 17.8% higher seed yield (1.72 t/ha) over the control (no NP) and 100% RDNP alone, respectively. However, application of 100% RDNP (90 kg N and 40 kg $P_2O_5$/ha) along with dual inoculation of *Azotobacter* and PSB besides improving quality as well as oil content of Indian mustard (cv. 'Ashirwad') under irrigated condition, also registered maximum benefit: cost ratio (1.79).

***Key words :*** Bio-fertilizers, Fertility levels, Mustard, Nutrient removal, Quality

Indian mustard is an important winter season (*rabi*) oilseed crop of eastern Uttar Pradesh. The differential trends in seed yield of the crop under a particular agro-climatic condition have been noticed due to varying moisture and nutrient status of soil. It is highly responsive to plant nutrients, especially nitrogen and phosphorus, which involves activating the metabolic activity, transformation of energy, chlorophyll and protein synthesis, and stimulating vigorous root system and helps in improving the seed weight, respectively. Application of bio-fertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation. *Azotobacter* shows the maximum response to various yield attributes as well as disease intensity for *Alternaria* blight, white rust and stag head formation (Narula *et al.,* 1993). Phosphate-solubilizing bacteria (PSB) provides alternative biotechnology solution in sustainable agriculture to meet the P demand of the plant. These organisms in addition to providing P to the plants also facilitate plant growth by different mechanism (Dubey *et al*., 1997). Indian mustard requires relatively large amount of nutrients for realization of yield potential and supply of its through chemical fertilizers are scarce and costly, now it is necessary to use them economically in combination with bio-fertilizers. Moreover, with increase in irrigated area in most parts of the country including eastern Uttar Pradesh, it becomes imperative to work out the response of Indian mustard to nitrogen, phosphorus along with bio-fertilizers application under irrigated condition. Keeping this in view, the present investigation was carried out to study the effect of bio-fertilizers and fertility levels on growth, yield, quality and nutrient removal by irrigated Indian mustard.

A field experiment was conducted during the winter season (*rabi*) of 2010 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, (25°18' N, 83°03' E 128.93 m above the mean sea-level in north-eastern plains zone). The soil was sandy loam, neutral (pH 7.3), low in organic carbon (0.42%) and available nitrogen (187.72 kg N/ha) and medium in avail-

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able phosphorus (17.50 kg P/ha). The total rainfall received during the crop growth was 22.1 mm. The weekly mean maximum and minimum temperature during the experimentation ranged from 17.5 to 35.0°C and 4.8 to 19.3°C, respectively. The experiment was laid out in randomized block design comprising 8 treatment combinations, *viz.* [Control, $N_{67.5}P_{30}$ (75% RDNP), $N_{90}P_{40}$ (100% RDNP), $N_{112.5}P_{50}$ (125% RDNP), *Azotobacter* + phosphate solubilising bacteria PSB (AP), $N_{67.5}P_{30}$ + AP, $N_{90}P_{40}$ + AP, $N_{112.5}P_{50}$ + AP] and replicated thrice. The 100% recommended dose of nitrogen and phosphorus (RDNP) was 90 kg N and 40 kg $P_2O_5$/ha. Full dose of phosphorus and half dose of nitrogen as per the treatment in the form of diammonium phosphate and urea, respectively, and a uniform dose of potassium 40 kg/ha to all treatments in the form of muriate of potash were applied below the seeds at the time of sowing of crop. Remaining half dose of nitrogen was applied as top-dressing in the form of urea after one month of sowing, respectively. The size of the plot was 6 m × 4 m. Indian mustard 'Ashirwad' seeds were treated with *Azotobacter chroococcum* (HUAZ-1) and phosphate-solubilising bacteria [PSB; *Bacillus aeruginosa* (BHUPSB-01)] both @ 20g/kg seed and sown manually by using a rate of 5 kg/ha on 6 November 2010 in the fertilized row, at 45 cm × 15 cm spacing. Plant population were maintained by thinning 15 days after germination. The crop was grown under irrigated condition and 3 irrigations were applied at 30, 75 and 90 days after sowing (DAS) to maintain optimum soil moisture for plant growth. To protect crop from aphids (*Lipaphis erysimi*), Dimecron was sprayed @ 250 ml/ha during pod formation stage. Two weedings were done manually at 25 and 45 days. The observations recorded were plant growth parameters, yield attributes, seed yield, oil content, fatty acids and economics. Oil content in seed and fatty acids in oil were determined by the method of AOAC (1970) and GLC (Appleqvist, 1968), respectively. Seed and stover samples were dried, processed and analyzed for their total N content by micro-Kjeldahl's and P was estimated by Vanadomolybdo-phosphoric acid-yellow colour method. Nutrient removal was estimated by multiplying the content with the oven-dry weight of biological yield. Protein content in seed (%) was worked out by multiplying the nitrogen content in seed with the multiplication factor 6.25. The crop was harvested when 80% siliquae turned yellowish brown on 7 April 2011 to prevent shattering loss. The economics was calculated by considering the market price of mustard and cost of cultivation.

Application of 90 kg N and 40 kg $P_2O_5$ (100% RDNP) and 112.5 kg N and 50 kg $P_2O_5$ (125% RDNP) both under dual seed inoculation with *Azotobacter* and PSB, and 112.5 kg N and 50 kg $P_2O_5$/ha alone being statistically at par with each other and exhibited more plant height, leaf-area index, dry-matter accumulation, chlorophyll content (SPAD value) and number of primary and secondary branches compared to the control (no NP and bio-fertilizers) (Table 1). Seed inoculation with *Azotobacter* + PSB along with 112.5 kg N and 50 kg $P_2O_5$/ha improved the leaf-area index by 46.8%, dry-matter accumulation by 21.3%, primary branches by 48.4% and secondary branches by 73.9% compared to the control. Arya *et al.* (2007) also reported increased growth in response to nitrogen, phosphorus, bio-fertilizers and vermicompost in mustard. This might be owing to the synergistic effect of nitro-

**Table1.** Effect of nitrogen, phosphorus and bio-fertilizers on growth parameters and yield attributes of irrigated Indian mustard

| Treatment | Growth parameters | | | | | | Yield attributes | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Plant height at harvesting (cm) | Leaf-area index at 60 DAS | Dry-matter accumulation at harvesting (g/plant) | Chlorophyll content (SPAD value) at 60 DAS | Primary branches/ plant at 90 DAS | Secondary branches/ plant at 60 DAS | Siliquae/ plant | Length of siliqua (cm) | Seeds/ siliqua | 1000-seed weight (g) |
| Control | 116.1 | 3.01 | 53.0 | 29.0 | 5.17 | 3.87 | 108.7 | 4.08 | 9.69 | 3.75 |
| $N_{67.5}P_{30}$ (75% RDNP) | 161.2 | 3.45 | 55.0 | 33.3 | 5.70 | 4.91 | 116.4 | 4.28 | 10.08 | 4.28 |
| $N_{90}P_{40}$ (100% RDNP*) | 167.4 | 3.86 | 58.2 | 36.9 | 6.23 | 5.30 | 121.3 | 4.34 | 10.28 | 4.62 |
| $N_{112.5}P_{50}$ (125% RDNP) | 176.2 | 4.37 | 61.3 | 40.0 | 7.17 | 6.30 | 138.3 | 4.76 | 11.70 | 4.81 |
| *Azotobacter* + PSB (AP) | 132.1 | 3.17 | 54.5 | 29.6 | 5.47 | 4.67 | 111.8 | 4.20 | 9.76 | 4.00 |
| $N_{67.5}P_{30}$ + AP | 164.9 | 3.63 | 56.7 | 35.1 | 5.93 | 5.17 | 117.8 | 4.37 | 10.17 | 4.61 |
| $N_{90}P_{40}$ + AP | 175.7 | 4.32 | 60.7 | 39.6 | 6.87 | 6.13 | 136.8 | 4.52 | 11.64 | 4.78 |
| $N_{112.5}P_{50}$ + AP | 177.4 | 4.42 | 64.3 | 40.3 | 7.67 | 6.73 | 140.8 | 4.78 | 12.12 | 4.89 |
| SEm± | 1.2 | 0.05 | 1.25 | 0.37 | 0.40 | 0.41 | 2.06 | 0.12 | 0.48 | 0.07 |
| CD (P=0.05) | 3.7 | 0.16 | 3.79 | 1.12 | 1.20 | 1.25 | 6.25 | 0.36 | 1.47 | 0.21 |

*100% RDNP (Recommended dose of nitrogen and phosphorus): 90 kg N and 40 kg $P_2O_5$/ha; AP, Seed inoculation with *Azotobacter* and PSB bio-fertilizers; DAS, days after sowing

gen on chlorophyll content, cell-division, photosynthetic rate and root activities of plants, resulting higher removal of nutrient and thereby increasing the growth parameters. Nitrogen and phosphorus plays an important role in increasing the plant height and foliage development by providing the energy and stimulating cell-division and elongation (Devlin and Witham, 1986). Seed inoculation with *Azotobacter* and PSB significantly increased the growth parameters in respective of nitrogen and phosphorus levels. The favourable effect of bacterial inoculation could be attributed to increase in N supply in inoculated plots due to N-fixation ability of these bacteria. This explanation was given by Singh and Sinsinwar (2006). Further, PSB also significantly increase the growth of mustard because it enhanced the availability of insoluble P and gave constant supply of P throughout growth of the crop. This result is accordance with that of Nagdive *et al.* (2007).

Siliquae/plant, length of siliqua, seeds/siliqua and 1000-seed weight were significantly more under dual inoculation of seed with *Azotobacter* and PSB with 112.5 kg N and 50 kg $P_2O_5$/ha which was at par with dual inoculation of *Azotobacter* and PSB under 90 kg N and 40 kg $P_2O_5$ and application of 112.5 kg N and 50 kg $P_2O_5$/ha alone (Table 1). The increase in siliquae/plant might be owing to increase in number of branches under high fertility levels and bio-fertilizers inoculation. The increase in yield owing to application of nitrogen and phosphorus might be attributed to cumulative effect of increase in siliquae/plant, seeds/siliqua, siliqua length and 1,000-seed weight. The results confirm the findings of Singh *et al.* (2010) in mustard. The seed and stover yields of Indian mustard were significantly obtained maximum under the application of *Azotobacter* + PSB + 90 kg N and 40 kg $P_2O_5$/ha. It could be ascribed to better transformation of growth and yield attributes into yield. The results are in conformity with Arya *et al.* (2007), as they found 50% RDF + FYM at 5 t/ha + bio-fertilizers enhanced yield of mustard under intercropping with chickpea.

The oil content in mustard seeds trend to decrease with increase in level of fertility up to 112.5 kg N and 50 kg $P_2O_5$/ha under combined inoculation of *Azotobacter* and PSB (Table 2). The reduction in oil content was due to higher rate of nitrogen appears to be due to conversion of carbohydrates into protein. The maximum protein content was recorded in the application of highest fertility level (125% RDNP) along with dual inoculation of *Azotobacter* and PSB. Higher fertility level in combination with biofertilizers manifested higher protein content in seed over lower fertility level either with or without bio-fertilizers. This seems to be due to more accumulation of nitrogen in seed under higher supplies of nutrients, therefore it increases the proteinaceous substance in seed and decreases the oil content in seed (Yadav *et al*., 2010). In general, application of P has no significant effect on oil and protein content. This may be due to less formation of lecithin, a form of phospholipids favoured by P application. Further, increased in oil yield was attributed to increase in seed yield. These results confirm the findings of Bahl *et al.* (1997) in sunflower with 30 kg $P_2O_5$/ha. The highest oil content was found under the dual inoculation of seed with *Azotobacter* and PSB along with 67.5 kg N and 30 kg $P_2O_5$/ha. Inoculation of seed with *Azotobacter* and PSB enhanced protein content and oil content in seed, respectively (Abraham and Lal, 2002). Application of nitrogen, phosphorus and bio-fertilizers also significantly influenced the composition of fatty acids in oil. Useful fatty acids of

**Table 2.** Effect of nitrogen, phosphorus and bio-fertilizers on yield, harvest index, quality parameters, total nutrient removal and economics of irrigated Indian mustard

| Treatment | Yield (t/ha) | | Quality parameters | | | | | Total nutrient removal (kg/ha) | | Net returns | Benefit : cost ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seed | Stover | Oil content (%) | Protein content (%) | Oleic acid (%) | Linoleic acid (%) | Erucic acid (%) | Nitrogen (N) | Phosphorus (P) | ($\times 10^3$ ₹/ha) | |
| Control | 0.91 | 2.57 | 33.1 | 14.3 | 8.6 | 12.1 | 50.2 | 32.5 | 16.2 | 9.8 | 0.81 |
| $N_{67.5}P_{30}$ (75% RDNP) | 1.17 | 3.59 | 39.3 | 18.0 | 8.8 | 13.6 | 49.3 | 50.7 | 23.9 | 14.4 | 1.03 |
| $N_{90}P_{40}$ (100% RDNP*) | 1.46 | 4.07 | 38.4 | 18.7 | 9.0 | 14.8 | 48.7 | 65.9 | 30.4 | 20.7 | 1.44 |
| $N_{112.5}P_{50}$ (125% RDNP) | 1.71 | 4.27 | 37.3 | 19.1 | 9.5 | 16.1 | 48.4 | 76.8 | 35.1 | 26.1 | 1.76 |
| *Azotobacter* + PSB (AP) | 0.97 | 2.71 | 34.6 | 15.6 | 8.8 | 12.3 | 49.7 | 37.0 | 18.0 | 11.2 | 0.92 |
| $N_{67.5}P_{30}$ + AP | 1.40 | 3.94 | 40.2 | 18.5 | 9.1 | 14.1 | 49.5 | 62.0 | 28.7 | 19.8 | 1.41 |
| $N_{90}P_{40}$ + AP | 1.68 | 4.24 | 38.1 | 19.2 | 9.3 | 15.8 | 48.6 | 75.2 | 34.2 | 25.8 | 1.79 |
| $N_{112.5}P_{50}$ + AP | 1.72 | 4.36 | 36.9 | 19.3 | 9.6 | 16.5 | 47.8 | 79.9 | 36.8 | 26.4 | 1.78 |
| SEm± | 0.03 | 0.07 | 0.64 | 0.24 | 0.14 | 0.25 | 0.83 | 1.01 | 0.40 | - | - |
| CD (P=0.05) | 0.10 | 0.21 | 1.93 | 0.71 | 0.47 | 0.71 | 2.5 | 3.05 | 1.23 | - | - |

*100% RDNP (Recommended dose of nitrogen and phosphorus): 90 kg N and 40 kg $P_2O_5$/ha; AP, Seed inoculation with *Azotobacter* and PSB bio-fertilizers

mustard oil such as oleic and linoleic acid contents increased, whereas undesirable constituents such as erucic acid decreased with increasing doses of nitrogen and phosphorus up to 90 kg N and 40 kg $P_2O_5$/ha under dual inoculation of *Azotobacter* and PSB after that the significant response was not found.

Increasing fertility levels significantly enhanced the removal of N and P by crop in respective of the bio-fertilizers. The maximum nitrogen and phosphorus removal was observed by the highest fertility level (125% RDNP) under dual inoculation of seed with *Azotobacter* and PSB (Table 2). The higher removal of N and P by crop is closely correlated with their increase availability in soil by fertilization due to increase in yields as well as increased content of nutrients both in seed and stover. Tomar *et al*. (1997) also reported increase in nutrients owing to N application. The use of PSB as inoculants increases the P removal by plants. The cost of cultivation varied according to different nutrient-management practices (Table 2). The net returns and benefit: cost ratio increased with increasing levels of N and P application either with or without *Azotobacter* and PSB correspondingly enhanced the gross return. The maximum net returns and benefit: cost ratio was recorded under 112.5 kg N and 50 kg $P_2O_5$ and 90 kg N and 40 kg $P_2O_5$/ha fertility level, respectively, each in conjunction with dual inoculation of seed with *Azotobacter* and PSB.

It was concluded that to obtain maximum benefit: cost ratio and improving the quality of produce, dual inoculation of seed with *Azotobacter* and PSB along with 90 kg N and 40 kg $P_2O_5$/ha should be applied in Indian mustard 'Ashirwad' under irrigated condition.

## REFERENCES


Abraham, T. and Lal, R.B. 2002. Sustainable enhancement of yield potential of mustard [*Brassica juncea* (L.) Czernj. & Cosson] through integrated nutrient management in a legume based cropping system for the inceptisol. *Cruciferae Newsletter* **24** : 99–100.

AOAC. 1970. *Official Methods of Analysis*. Association of Official Analytical Chemistry, Washington DC, USA. 174 p.

Appleqvist, L.A. 1968. Rapid method of lipid extraction and fatty acid ester preparation for seed and leaf tissue with special remarks on preventing the accumulation of lipid contaminate. *Ark Kanic* **28**: 351–70.

Arya, R.L., Varshney, Jay, G. and Kumar, Lalit. 2007. Effect of integrated nutrient application in chickpea + mustard intercropping system in the semi-arid tropics of North India. *Communications in Soil Science and Plant Analysis* **38**(1–2): 229–40.

Bahl, G.S, Pasricha, N.S. and Ahuja, K.L. 1997. Effect of fertilizer nitrogen and phosphorus on grain yield, nutrient uptake and oil quality of sunflower. *Journal of Indian Society of Soil Sciences* **45**(2): 292–96.

Devlin, R.M. and Witham, F.H. 1986. *Plant Physiology,* edn 4. CBS Publishers & Distributors, New Delhi, India.

Dubey, A.V., Vaishya, U.K., Bapat, P.N. and Tomar, V.S. 1997. Microbial solubilization of rock phosphate: an alternative phosphorus source for mustard crop. *JNKVV Research Journal* **31**(1–2): 54–55.

Nagdive, S.J., Bhalerao, P.D. and Dongarwar, U.R. 2007. Effect of irrigation and integrated nutrient management on growth and yield of Indian mustard (*Brassica juncea*). *Annals of Plant Physiology* **21**(2): 182–85.

Narula, N, Gupta, P.P., Kumar, P.R. and Lakshminarayana, K. 1993. Field response of Indian mustard (*Brassica juncea*) to inoculation of soil isolates and analogue resistant mutants of *Azotobacter chroococcum. Annals of Biology* **9**(1): 144–48.

Singh, Raju and Sinsinwar, B.S. 2006. Effect of integrated nutrient management on growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea*) in eastern part of Rajasthan. *Indian Journal of Agricultural Sciences* **76**(5): 322–24.

Singh, Yogeshwar, Singh, Tarkeshwar, Singh, U.N. and Rajput, P.K. 2010. Effect of nutrient management on yield, quality and economics of irrigated Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences* **80**(8): 691–94.

Tomar, T.S., Singh, Subey, Kumar, Sandeep and Tomar, Savita. 1997. Response of Indian mustard to nitrogen, phosphorus and sulphur fertilization. *Indian Journal of Agronomy* **42**(1): 148–51.

Yadav, R.P., Tripathi, M.L. and Trivedi, S.K. 2010. Yield and quality of Indian mustard (*Brassica juncea*) as influenced by irrigation and nutrient levels. *Indian Journal of Agronomy* **55**(1): 56–59.