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Effect of Nutrient Management Practices on Productivity and Profitability of Indian Mustard (*Brassica juncea*) Under Irrigated Condition

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A field experiment was carried out during the winter (*rabi*) seasons of 2010-2011 and 2011-2012 at Banaras Hindu University, Varanasi, to study the effect of nutrient management practices on the productivity and profitability of Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] under irrigated condition. The experiment was laid out in randomized block design comprised eight treatment combinations in three replications. The study revealed that conjunctive use of *Azotobacter* + PSB seed treatment + 100% (N + P_2O_5) recorded maximum growth parameters *viz.* plant height, number of functional leaves, dry matter accumulation and number of branches, yield attributes *viz.* number of siliquae, length of siliqua, seeds/siliqua and 1000-seed weight and seed as well as stover yields remained at par with 50% (N + P_2O_5), *Azotobacter* + PSB seed treatment 75% (RDNP). The maximum gross return (' 29,680 and 43,282) and net return (' 15,717 and 25,600) were obtained with *Azotobacter* + PSB + 100% RDNP, however maximum output: input ratio (1.16 and 1.50) was recorded under *Azotobacter* + PSB + 75% RDNP.

Key words: Biofertilizers, Fertility levels, Mustard and Yield.

Inspite of cultivation of number of oilseed crops, country meets 50% of its domestic requirements through import. One of the main reasons for this inadequate carrying capacity is their low productivity and stagnation or decline in area under principal oilseed crops such as, rapeseed-mustard and groundnut. With burgeoning population, improved living standard and purchasing power of the people, the demand of vegetable oil in the country is increasing at the rate of about 4-6% (Agarwal, 2007).Therefore, there is urgent need to improve the productivity of oilseed crops to bridge up the current demand-supply gap.

Mustard is the second most important oilseed crop after soybean in the country and has also been cultivated on significant area in north India since last one decade. Sustainability of increased mustard production is as important as improving the production. Sustainable production requires efficient use of inputs including adequate and balanced fertilization, while regression analysis shows that the partial factor productivity of fertilizers has been continuously declining. The efficiency of fertilizer nitrogen is only 40-50%, phosphorus 15-20% and sulphur 10-12% and this could be enhanced by efficient use of inputs (Hegde and Sudhakara Basu, 2004). The differential trends in seed yield of Indian mustard under a particular agro-climatic condition have been noticed due to varying moisture and nutrient status of soil. It is responsive to plant nutrients especially nitrogen,

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phosphorus and sulphur. Application of bio-fertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation. *Azotobactor* is non-symbiotic nitrogen fixing agro-microbe having potential to fix considerable quantities of atmospheric nitrogen in the rhizosphere of non-legumes. *Azotobacter* also showed maximum response to various yield attributes as well as disease intensity for *Altenaria* blight, white rust and stage head formation (Narula *et al*., 1993). Phosphate Solublising 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*., 2000). Besides biofertilizers, major nutrients like nitrogen and phosphorous play important role in increasing the quality of mustard. Nitrogen affects the uptake of other essential nutrients and it helps in the better partitioning of photosynthates to reproductive parts which increase the seed: stover ratio (Tomar *et al*., 1997). Keeping this in view, the present investigation was carried out to study the effect of nutrient management practices on productivity and profitability of Indian mustard under irrigated condition.

MATERIALS AND METHODS

Site Description

A field experiment was carried out during the winter (*rabi*) seasons of 2010-2011 and 2011-2012 at Agricultural Research Farm, Banaras Hindu University, Varanasi is situated at $25^0$18' North latitudes, $83^0$03' East longitudes and at an altitude of 128.93 meter above the mean sea levels in the north-eastern plains zone. The soil was sandy loam in texture, neutral in reaction (pH 7.3), low in organic carbon (0.42%) and available nitrogen (187.72 kg/ha) and medium in available phosphorus (18.50 kg/ha). The total rainfall received during crop season 2010-11 and 2011-2011 was 22.10 and 23.00 mm. The experiment was laid out in randomized block design comprised eight treatment combinations [T_1- Control, (without N and P), T_2-50% (N + P_2O_5), T_3-75% (N + P_2O_5), T_4-100% (N + P_2O_5), T_5-*Azotobacter* + PSB seed treatment, T_6-*Azotobacter* + PSB seed treatment + 50% (N + P_2O_5), T_7-*Azotobacter* + PSB seed treatment + 75% (N + P_2O_5), T_8-*Azotobacter* + PSB seed treatment + 100% (N + P_2O_5)] and replicated thrice. The recommended dose of fertilizer for the mustard was N_{80} $P_2O_{5\ 40}$. Urea and dia-ammonium phosphate were used as sources of nitrogen and phosphorus, respectively. The seeds were inoculated with *Azotobactor* and PSB as per treatment and sown in earmarked plots. Indian mustard variety 'Ashirwad' was treated with *Azotobacter* and PSB as per treatment and sown manually by using a seed rate of 5 kg/ha on 15 and 16 November of the first and second year of experiments, respectively in the fertilized row at row spacing of 30 cm. The crop was grown under irrigated condition and two irrigations were applied to one month interval after sowing to maintain optimum soil moisture for plant growth. To protect crop from aphid (*Lipaphis erysimi*) Dimethoate was sprayed @ 250 ml/ha during pod formation stage. Two weeding was done manually at 30 and 45 DAS. The observation recorded were yield attributes, yield and economics at harvest. The organic carbon, available N, P, K and S in soil were determined as per standard procedures. The crop was harvested at 80 per cent siliquae turn yellowish brown on the second week of March both the year to prevent shattering. The economics was calculated by considering the marketing price of mustard and cost of cultivation during 2011 and 2012. Data obtained from various observations were analysis as per the standard analysis of variance (ANOVA) procedure for randomized block design given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth, Yield and Quality

Successive increase in the biofertilizers and fertility levels significantly improve the growth parameters *viz.* plant height, number of functional leaves/plant, leaf area index, dry matter accumulation, number of braches (Table 1). Increase in plant height, number of primary and secondary branches, number of functional leaves, leaf area index, dry matter accumulation, chlorophyll content were recorded more under combine inoculation of *Azotobacter* + PSB +100% N and P_2O_5 remained at par with 100% (N + P_2O_5) and *Azotobacter* + PSB seed treatment + 75% (N + P_2O_5) over rest of the treatments. These results are

Table 1. Effect of nutrient management practices on growth parameters of Indian mustard under irrigated condition

Treatment	Plant height (cm)		Primary branches /plant at 90 DAS		Secondary branches /plant at 90 DAS		Functional leaves /plant at 60 DAS		Leaf area index at 60 DAS		Dry matter accumulation (g/plant) at harvest		Chlorophyll Content (SPAD value) at 60 DAS	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T1	116.1	117.1	5.17	5.87	3.87	3.98	14.30	14.68	3.01	3.06	53.00	53.87	29.03	29.14
T2	161.2	161.8	5.70	5.86	4.91	4.97	15.97	16.03	3.45	3.59	55.00	56.12	33.31	33.89
T3	167.4	168.2	6.23	6.75	5.30	5.56	16.40	16.79	3.86	3.89	58.23	59.24	36.91	37.03
T4	176.2	177.5	7.17	8.23	6.30	7.12	18.07	19.86	4.37	4.46	61.30	63.12	39.96	41.65
T5	132.1	133.4	5.47	5.68	4.67	4.87	14.80	14.98	3.17	3.19	54.53	55.23	29.55	29.86
T6	164.9	166.8	5.93	5.98	5.17	5.45	16.17	16.45	3.63	3.64	56.67	56.87	35.1	35.56
T7	175.7	176.2	6.87	7.12	6.13	6.68	17.96	18.96	4.32	4.39	60.73	62.35	39.60	41.23
T8	177.4	179.6	7.67	8.3	6.73	7.65	18.4	19.98	4.42	4.52	64.30	66.30	40.27	42.10
SEm±	1.2	1.25	0.40	0.41	0.41	0.43	0.38	0.40	0.05	0.06	1.25	1.27	0.37	0.38
CD(P= 0.05)	3.7	3.76	1.20	1.24	1.25	1.29	1.15	1.19	0.16	0.18	3.79	3.80	1.12	1.13

Table 2. Effect of nutrient management practices on yield attributes and yields of Indian mustard under irrigated condition

Treatment	Siliquae/plant		Siliqua length (cm)		Seed/siliqua		1000-seed weight (g)		Seed yield (kg/ha)		Stover yield(kg/ha)		Harvest Index(%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T1	112.47	136.30	4.15	4.30	9.87	10.00	3.80	4.00	922	750	3895	4128	19.12	15.38
T2	122.15	147.20	4.75	4.90	11.20	11.50	4.30	4.60	1046	1101	4150	4445	20.19	19.82
T3	144.33	169.30	4.80	4.90	12.13	12.40	4.50	4.80	1389	1445	4864	4973	22.24	22.51
T4	150.33	175.90	4.88	5.00	12.87	13.70	4.78	5.00	1536	1591	5124	5275	23.11	23.21
T5	117.80	142.80	4.55	4.70	10.73	11.00	4.13	4.40	993	1048	3947	4238	20.15	19.81
T6	127.98	153.00	4.78	4.90	11.67	11.90	4.40	4.70	1133	1189	4479	4501	20.2	20.91
T7	149.40	175.30	4.87	5.00	12.53	12.80	4.71	5.00	1487	1543	4980	5262	23.06	22.67
T8	192.53	196.70	4.98	5.10	13.83	14.30	4.92	5.10	1604	1624	5334	5381	23.13	23.23
SEm±	4.07	4.14	0.17	0.17	0.37	0.33	0.22	0.18	61	59	167.77	142	0.99	0.89
CD=(0.05)	11.91	12.11	0.49	0.48	1.09	0.96	0.64	0.52	178	174	490.91	417	2.9	2.61

Table 3. Effect of nutrient management practices on quality parameters and economics of Indian mustard under irrigated condition

Treat-ment	Quality Parameters Oil Content (%)		Oil yield (kg/ha)		Cost of cultivation		Gross return (‘/ha)		Net return (‘/ha)		B:C Ratio		Crop Productivity (kg/ ha/day)		Crop Profitability (‘/ ha/day)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T1	33.10	33.20	248	306	8749	8349	17051	20822	8302	8354	0.95	0.67	8.38	6.82	75	76
T2	39.31	39.40	411	433	11519	11361	19343	29747	7823	14508	0.68	0.95	9.51	10.01	71	132
T3	38.40	38.46	533	556	12721	18199	25698	38599	12977	22159	1.02	1.35	12.63	13.13	118	201
T4	37.33	37.36	573	595	13923	25640	28416	42422	14493	24781	1.04	1.40	13.96	14.47	132	225
T5	34.61	34.64	344	363	9156	13085	18364	28321	9209	15446	1.01	1.20	9.03	9.53	84	140
T6	40.29	40.35	456	480	11559	17695	20964	31965	9405	16686	0.81	1.09	10.30	10.81	86	152
T7	38.12	38.16	567	589	12761	26567	27513	41195	14751	24715	1.16	1.50	13.52	14.02	134	225
T8	36.93	36.95	592	600	13963	23918	29680	43282	15717	25600	1.13	1.45	14.58	14.76	143	233
SEm±	0.64	0.64	16	19	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	1.93	1.93	50	56	-	-	-	-	-	-	-	-	-	-	-	-

corroborating with the finding of Singh *et al.* (2010). This might be due to the synergistic effect of nitrogen on chlorophyll content, cell division, photosynthetic rate and root activities of plants, resulting higher removal of nutrient and thereby increasing the growth and yield attributes. Nitrogen and phosphorous 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 inoculations of *Azotobacter* + PSB significantly increase the growth *viz.* number of branches of plant. The favorable effect of bacterial inoculation could be attributed to increase in N supply in inoculated plots due to N-fixation ability of theses bacteria. This explanation was given by Singh and Sinsinwar (2006).

Siliquae/plant, length of siliqua, seed/ siliqua and 1000-seed weight and harvest index were significantly more under dual inoculation of seed with *Azotobacter* + PSB with 100% N and P_2O_5/ha which is at par with 100% (N + P_2O_5) and *Azotobacter* + PSB seed treatment + 75% (N + P_2O_5) (Table 2). The increase in siliqae/plant may be explained due increase in number of branches under high fertility levels and biofertilizers inoculation. The increase in yield due to application of nitrogen and phosphorous may be attributed to cumulative effect of increase in siliquae/plant, seed/siliqua, siliqua length and 1000-seed weight. The results are in conformity with Singh *et al*. (2010).

Application of higher rate of markedly increased almost all the yield attributes and yield due to optimum plant development and better translocation of photosynthates to the site of pod formation. This confirms the finding of Tomar *et al*. (1997). Seed inoculation with *Azotobacter* + PSB significantly increased yield attributes. The seed and stover yield obtained higher due to application of *Azotobacter* + PSB +100% N and P_2O_5 remain at par with 100% (N and P_2O_5) and *Azotobacter* + PSB with 75% N and P_2O_5/ha in both the years of the experimentation. It could be ascribed to better transformation of growth and yield attributes into yield. Similar result was obtained by Arya *et al*. (2007).

The oil percent in mustard seeds trend to decrease with increase in level of fertility up to *Azotobacter* + PSB seed treatment + 100% N + P_2O_5 (Table 3). The reduction in oil is due to higher rate of nitrogen appears to be due to conversion of carbohydrates into protein. This seems to be due to more accumulation of nitrogen in seed under higher supplies of nutrients. In general, application of P has no significant effect on oil. This may be due to less formation of lecithin a form of phospholipids favored by P application. Oil yield significantly increased by P levels. This increased in oil yield was attributed to increase in seed yield. These results are conformity with the findings of Bhat *et al*. (2006). The highest oil content was found under the dual inoculation of seed with *Azotobacter* + PSB seed treatment + 50% (N + P_2O_5) and T_2-50% (N + P_2O_5)/ha oil content of seed increased due to dual inoculation of *Azotobacter* + PSB. Inoculation of PSB also increased the oil content of mustard. This result is accordance with findings of Abraham and Lal (2002).

Economics

Among the nutrient sources, maximum gross return, net return and B:C ratio crop productivity and crop profitability were recorded with *Azotobacter* + PSB + 100% N and P_2O_5, closely followed by 100% (N and P_2O_5), while B: C ratio, crop productivity and crop profitability was also at par with 75% RDF + seed inoculated of *Azotobactor* + PSB (Table 3). This behavior of economic parameters due to integrated use of chemical fertilizers along with bio-fertilizers was due to changes is marginal seed yield of the crop with successive increase in fertilizer nutrient and relative costs of inputs in relation to output. Thus, incremental higher yield with low cost of bio-fertilizers gave higher net return and B: C ratio. These results are in agreement with the findings of Singh and Sinsinwar (2006), Tripathi *et al.* (2010) and Meena *et al*. (2013).

CONCLUSIONS

Based on two years results, it is inferred that integrated nutrient management practices in mustard with 100% recommended dose of N and P fertilizers superimposed with seed inoculation of *Azotobactor* and PSB together is a viable option for enhancing the productivity and profitability of mustard in sustainable manner.

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