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Research Paper

Effect of chemical and bio-fertilizers on productivity, profitability and quality of Indian mustard (*Brassica juncea*) in Vertisols

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ABSTRACT

A field experiment was conducted during *rabi* season of 2009-10 and 2010-11 on clay loam soils at Kota (Rajasthan) to find out optimum dose of chemical fertilizers with biofertilizers for increasing the productivity, profitability and quality of Indian mustard [*Brassica juncea* (L.) Czern & Coss]. Application of 100 % RDF($N_{80}P_{17.5}S_{60}$) + seed inoculation with *Azotobacter+ PSB* (AP) significantly increased number of primary and secondary branches/ plant, number of siliquae/plant, test weight, seed and stover yield, net returns (₹37200/ha), B: C ratio (2.64), oil content and oil yield (1,034 kg/ha) over control. Maximum uptake of nutrients (NPS) was recorded with 100 % RDF + AP, in seed and stover over rest of the fertility levels. The next best fertility treatment was 100 % RDF or 75 % RDF + biofertilizers.

Key words : Biofertilizer, Chemical fertilizer, Indian mustard, Nutrient uptake and Yield

Use of improved crop varieties without concomitant use of nutrients or fertilizers leads to nutrient mining and nutrient imbalance, resulting in present day crisis of low soil fertility, hidden hunger and low factor productivity. Sustainability of increased mustard production is as important as improving the production 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 sulphur10-12 % and this could be enhanced by efficient use of inputs (Hegde and Sudhakara Basu, 2004 a).

Rajasthan is a prime leading state in rapeseed mustard cultivation and occupies maximum 2.21 m ha acreage and 2.91 mt production with average productivity 1316 kg/ha (Annonymous, 2009-10). Although a number of factors are responsible for low productivity mainly imbalance fertilization. To enhance productivity of this crop, use of balanced fertilization by application of nitrogen, phosphorus, sulphur along with bio-fertilizers *viz*., *Azotobacter* and *phosphate solubilizing bacteria* (PSB) is of great significance, so as to attain maximum economic yield without any deleterious effect on soil properties or ecological balance. Bio-fertilizers have the potential to solubilize/ mobilize major nutrients such as nitrogen and phosphorus in addition to micro nutrients and thus act as nutrient flow regulator in nature. Azotobacter is a non-symbiotic nitrogen fixing agro- microbe having potential to fix considerable quantities of atmospheric nitrogen in the rhizosphere of non-legumes. Besides nitrogen fixation, azotobactor synthesizes various growth promoting subtances such as vitamins of B group, nicotinic acid, biotic, gibberellins and antifungal compounds. *Azotobactor* inoculation a improved the crop productivity 0-25 % over the control in the absence of any amendment and by 8.75 % in the presence of NPK (Narula, 2000). Phosphate solubilizing bacterium (PSB) has a capacity to render the insoluble soil phosphorus into plant available form because of their ability to secrete various organic acids (Ram *et al.*, 1999 and Gautam and Pant 2002). Results of several experiments revealed that *Brassica* crops respond appreciably to nitrogen fertilization (Rathore and Manohar, 1990). Sulphur fertilizer, besides enhancing yield and quality of crops, enhances nutrient uptake and fertilizer use efficiency through interaction of S with other fertilizer nutrients (Hegde and Sudhakara Basu, 2004 a; Hegde and Murthy, 2005; Tondon and Messick, 2007). Meager use of the RDF with bio-fertilizer in mustard, the bio-fertilizer inoculation by way of nitrogen fixation, production of growth hormones, antifungal substances and siderophores favorable effect on growth and ultimately enhanced the crop. Though many studies have been carried out in mustard

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crop, but the location specific study on integrated nutrient management for the farmers of Chambal Command Areas of Rajasthan is wanting. Therefore, a study was initiated to evaluate the various integrated nutrient management packages on the productivity, profitability and quality of Indian mustard.

MATERIALS AND METHODS

A field experiment was conducted during the winter seasons of (*Rabi*) 2009-10 and 2010-11 at Agricultural Research Station, Kota. The soil of the experimental field was clay loam, slightly alkaline in reaction (pH 7.6), low in available phosphorus (10.2 kg/ha), sulphur (10.0 kg/ha) and medium in organic carbon (0.57 %), available nitrogen (318 kg/ha), available potassium (235 kg/ha). The experiment was laid out in a randomized block design comprised of eight treatments *viz.*, control, *Azotobacter* + *PSB* (AP), 50 % RDF, 50 % RDF + AP, 75% RDF, 75 % RDF +AP, 100 % RDF and 100 % RDF +AP with three replications. The mustard variety "Bio 902" was sown in the second week of October, at a row to row spacing of 30 cm. The total rainfall received during the crop growth was 40.6 in 2009-10 and 157.9 mm in 2010-11. The mean daily maximum temperature of Kota ranges from 24.5^{0}C in the month of January to 42.6^{o}C in the month of May, whereas minimum temperature ranges from 10.6^{o}C in January to 19.7^{o}C in May. The recommended dose of fertilizer for the mustard was $N_{80}P_{17.5}S_{60}$. Full dose of P, S and half dose of nitrogen fertilizers were drilled just before the sowing in the form of urea, DAP and gypsum and remaining half dose of nitrogen was applied after first irrigation in earmarked plots. The seeds were inoculated with *Azotobacter* and *PSB* as per treatment and sown in earmarked plots. All standard agronomic practices were followed to harvest good crop yield and the crop was adequately protected from insect-pests and diseases. The observation of growth parameters, yield attributes and yields were recorded at the time of harvest and yields were converted into kg/ha. Oil content was analyzed by standard procedures of Nuclear Magnetic Resonance Method at DRMR, Bharatpur (Rajasthan).

RESULTS AND DISCUSSION

Growth and yield attributes

In 2 years mean data on growth parameters i.e. primary and secondary branches differed significantly due to graded fertility treatments (Table 1). Maximum and significantly higher plant height, primary and secondary branches/plant were recorded in treatment 100 % recommended dose of fertilizer (RDF) + seed inoculation with *Azotobacter* + *PSB* (AP) remained at par with 100 % RDF over rest of the treatments, except secondary branches/ plant also found at par with 75 % RDF +AP. Response of mustard to optimum nutrients revealed that plant height, number of primary and secondary branches/plant increased with RDF over control and 50 % RDF along with seed inoculations. Application of 100 % RDF ($N_{80}P_{17}.{}_5S_{60}$) along with seed inoculations of AP significantly gave higher siliquae/plant over rest of the treatments, which was higher to the tune of 165.4 % over control. Whereas, 100 % RDF + AP remained on par statistically with 100 % RDF alone gave significantly higher values of seeds/ siliqua and test weight over rest of the treatments except 75 % RDF + AP also found at par with 100 % RDF + AP. The per cent increase was observed to the tune of 11.53 and 11.29 and 18.07 and 16.67 over control and *Azotobacter* + *PSB* alone, respectively. This might be due to increased availability of nutrients leading to high accumulation of net photo-synthates with optimum dose of NPS along with bio-fertilizers and availability of energy sources for prolonged time. Thus, better proliferation of roots and increased uptake of nutrients enhanced growth

Table 1. Effect of chemical and bio-fertilizer on growth, yield attributes and yields of mustard (Pooled mean data of 2 years)

Treatment	Plant height at harvest (cm)	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant	Seeds/ siliqua	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Control	158.1	3.17	8.20	162.67	13.87	4.15	1.37	2.87	32.30
Azotobacter + PSB (AP)	162.3	3.44	8.70	175.84	13.90	4.20	1.48	3.08	32.35
$N_{40}P_{8.7}S_{30}$(50% RDF)	165.7	4.06	8.97	197.84	14.37	4.40	1.72	3.57	32.52
$N_{40}P_{8.7}S_{30}$+ AP	170.9	4.54	10.00	230.84	14.54	4.63	2.12	4.32	32.92
$N_{60}P_{13.1}S_{45}$ (75% RDF)	173.5	4.41	9.64	218.00	14.47	4.53	2.02	4.11	32.90
$N_{60}P_{13.1}S_{45}$+ AP	178.3	4.82	10.67	256.84	14.67	4.74	2.28	4.62	33.03
$N_{80}P_{17.5}S_{60}$(RDF)	181.2	5.07	10.50	259.67	15.40	4.80	2.39	4.81	33.13
$N_{80}P_{17.5}S_{60}$+ AP	185.5	5.31	10.80	281.67	15.47	4.90	2.51	5.04	33.21
SEm$\pm$	2.30	0.15	0.16	6.27	0.20	0.09	0.06	0.12	0.22
CD (P=0.05)	6.50	0.43	0.48	18.46	0.58	0.25	0.16	0.31	NS

AP= Seed inoculation with *Azotobacter* and *PSB* bio-fertilizers and yield attributing characters. Similar findings were also reported by Mandal and Sinha (2002) and Shukla *et al*. (2002).

Yield and economics

Application of increasing dose of chemical fertilizers from control to 100 % RDF and combined application of RDF with *Azotobacter* + *PSB* significantly increased seed and stover yields of mustard (Table 1). Recommended dose of fertilizer ($N_{80}P_{17\cdot5}S_{60}$) + seed inoculated with *Azotobacter* + *PSB* gave maximum seed and stover yields, which was comparable with 100 % RDF and recorded 5.02 and 4.78%, respectively, whereas, 75% RDF ($N_{60}P_{13.1}S_{45}$) +AP also recorded significantly higher seed and stover yield over control, 50 % RDF, 50 % RDF + AP and 75 % RDF alone but was found statistically at par with 50 % RDF + AP. It registered 66.42 and 60.97 % increase over control. The yield is directly dependent on various growth and yield parameters, its expression was observed with their integrated influence with the increment in supply of essential nutrients to Indian mustard, their availability, acquisition, mobilization into the plant tissues increased and thus improved growth and yield component and finally the yield. The results are in agreement with the findings of Singh and Sinsinwar (2006).

Among the nutrient sources, maximum net return and B: C ratio were recorded with 100 % RDF + seed inoculation of *Azotobacter* + *PSB* closely followed by 100 % RDF, whereas B: C ratio was also at par with 75 % RDF + seed inoculated of *Azotobacter* + *PSB* (Table 2). 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) and Tripathi*et al.* (2010).

Quality

Indian mustard fertilized with 100 % RDF along with seed inoculation with bio-fertilizers recorded significantly higher oil content and yield than that of lower doses of chemical fertilizers with bio-fertilizers except 100 % RDF and 75 % RDF +AP for oil content and 100 % RDF for oil yield was found statistically at par (Table 2) . The increase was found to the magnitude of 486 kg/ha oil yield over control. The increase in the oil content with higher dose of sulphur supplied with N and P may be attributed to its role in oil synthesis and S containing amino acids, which are precursors for the biosynthesis of glucosinolates. The results are in agreement with the findings of Chauhan *et al.* (1996) and Hegde and SudhakaraBabu, 2004b.

Nutrients uptake

Nutrient uptake by crop varied significantly due to different fertilizer levels (Table 2). The highest nutrient uptake (N, P and S) by mustard was noted with the application of 100 % RDF + seed inoculation with *Azotobacter* + *PSB* (AP) compared to lower fertility levels and control, except S uptake by seed and stover was found at par with 100 % RDF. The treatment 100 % RDF + AP recorded higher uptake to the tune of 137.6 and 159.2 % for N, 105.1 and 98.4 % for P and 144.0 and 186.4 % for S in seed and stover over control, respectively. This increase in N, P and S uptake could be ascribed partly to variation in the availability of these nutrients in the soil and plants thus, ultimately increased uptake of this nutrients. These findings were also similar to Shukla *et al.*, 2002.

Two years results inferred that integrated nutrient management in mustard with 100 % recommended dose of N, P and S fertilizers superimposed with seed inoculation of

Table 2. Effect of chemical–and bio-fertilizer on profitability, quality and nutrient uptake of mustard (Pooled mean mean of 2 years)

Treatment	Net returns (× 10^3 ₹/ha)	B: C ratio	Oil content (%)	Oil yield (kg/ha)	Nutrient uptake (kg/ha)					
					N		P		S	
					Seed	Stover	Seed	Stover	Seed	Stover
Control	16.3	1.38	40.0	548	39.4	17.9	7.8	6.1	5.0	4.4
Azotobacter + PSB (AP)	18.4	1.56	40.4	597	44.0	19.6	8.5	6.7	5.6	5.0
$N_{40}P_{8.7}S_{30}$(50% RDF)	22.4	1.73	40.7	701	55.4	23.4	10.2	7.9	7.2	7.1
$N_{40}P_{8.7}S_{30}$+ AP	30.5	2.35	40.9	867	68.8	28.9	12.9	9.8	9.3	9.2
$N_{60}P_{13.1}S_{45}$ (75% RDF)	27.8	2.06	40.8	822	70.2	28.7	12.5	9.5	9.2	9.5
$N_{60}P_{13.1}S_{45}$+ AP	33.2	2.45	41.0	935	83.5	32.7	14.5	10.9	10.7	11.0
$N_{80}P_{17.5}S_{60}$(100% RDF)	34.8	2.48	41.2	982	87.8	34.5	15.2	11.3	11.3	11.8
$N_{80}P_{17.5}S_{60}$+ AP	37.2	2.64	41.3	1034	93.6	36.4	16.0	12.1	12.2	12.6
SEm$\pm$	1.2	0.09	0.11	23.0	1.55	0.55	0.26	0.19	0.35	0.28
CD (P=0.05)	3.3	0.26	0.31	66.5	4.70	1.66	0.79	0.57	1.07	0.84

Initial values: N 318.5, P 10.2, K 235, S 10.0 kg/ha, pH 7.56, OC 0.57%

Azotobacter + *Phosphorus Solubilizing Bacteria* (PSB) is a viable options for enhancing the productivity and profitability of mustard in sustainable manner.

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