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Response of Indian mustard (*Brassica juncea* L.) to different levels of organic manures and bio-fertilizers

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Abstract
A field experiment was conducted during the *rabi* 2015-16 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh to study the ‘‘Response of Indian mustard (*Brassica juncea* L.) to different levels of organic manures and bio-fertilizers’’. The experiment was comprised of sixteen treatment combinations in which four levels of organic manure *viz*., no organic manure, FYM @ 5.0 t/ha, vermicompost @ 1.0 t/ha & castor cake @ 1.0 t/ha and four levels of bio-fertilizer *viz*., no inoculation, inoculation with Azotobacter spp. @ 10 ml/kg seed, inoculation with PSB spp. @ 10 ml/kg seed & inoculation with Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed). The experiment results revealed that application of FYM @ 5.0 t/ha enhanced growth parameters *viz.*, plant height, number of primary & secondary branches per plant; yield attributes *viz.*, number of siliquae per plant and number of seed per siliqua and ultimately higher seed and stover yield with higher net returns of 82037 Rs/ha and B: C ratio 2.97 over control (no organic manures). Seed inoculation with azotobacter spp. + PSB spp. (each @ 10 ml/kg seed) promoted growth parameters *viz.*, number of primary & secondary branches per plant; yield attributes *viz.*, number of siliquae per plant and number of seed per siliqua and ultimately higher seed and stover yield with higher net returns of 86629 Rs/ha and B: C ratio 3.40 over control (no inoculation).

Keywords: Bio-fertilizers, Indian mustard, Growth, Organic manures, Yield

Introduction
Oilseed crops play the second important role in the Indian agricultural economy next to food grains in terms of area and production. Indian mustard (*Brassica juncea* L.) is the most popular one among different species of rapeseed and mustard in India. Nutrients management is one of the most important agronomic factor that affects the Indian mustard. But Application of all the needed nutrients through chemical fertilizer had deleterious effect on soil fertility leading to unsustainable yields, while integration with organic manures and bio-fertilizers would be able to maintain soil fertility and sustain crop productivity. Organic manures are considered helpful in improving the physical and nutritional status of the soil and also enhance the activity of soil microflora. They also add considerable amount of major nutrients in the soil besides improving the soil properties. Further, decomposition of organics in the soil leads to different types of biological reactions which are helpful in preventing various disease causing pathogens (Ramesh *et al*., 2010) [7]. Bio-fertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of crop. They contain microorganisms which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes. Hence the present investigation was aimed to study the ‘‘Response of Indian mustard (*Brassica juncea* L.) to different levels of organic manures and bio-fertilizers’’

Material and Method
A field experiment was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* season, 2015-16. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.38 dS/m and organic carbon 0.61 %. The soil was low in available nitrogen (249.00 kg/ha) and medium in available phosphorus (39.60 P_2O_5 kg/ha) while medium in available potash (245.36 K_2O kg/ha). The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The experiment was comprised of sixteen treatment combinations in which four levels of organic manure *viz*., no organic manure, FYM @ 5.0 t/ha, vermicompost @ 1.0 t/ha & castor cake @ 1.0 t/ha and four levels of bio-fertilizer *viz*., no inoculation, inoculation with Azotobacter spp. @ 10 ml/kg seed, inoculation with PSB spp. @ 10 ml/kg seed & inoculation with Azotobacter spp. + PSB spp.

(each @ 10 ml/kg seed). Indian mustard variety (cv. Gujarat Mustard-3) was sown with seed rate of 3 kg/ha. The seeds were placed at depth of 3 to 4 cm with inter row spacing of 45 cm and covered the seed with the soil. The common fertilizer dose of 50-50-00 N-P_2O_5-K_2O kg/ha was applied as basal in all treatments. Urea and DAP were used as source of fertilizers. While organic manures like FYM, castor cake and vermicompost were applied before sowing in furrows as per treatments. The seeds were inoculated by Azotobacter spp. and PSB spp. as per treatments. The inoculated seeds were then dried in shade and used immediately for sowing. Besides a light irrigation was given just after sowing, and six post sowing irrigation were given to crop. Five plants were randomly tagged in each treatment per replication and data were recorded with respect to various growths and yield attributes *viz.* plant height at 60 DAS, 90 DAS & harvest, number of primary & secondary branches per plant, number of siliquae per plant and number of seeds per siliqua. The economics was workout on current market price basis.

Results & Discussion

Effect of organic manures

A perusal of data in Table-1 shown that growth parameters *viz.*, plant height at 60 DAS, 90 DAS & harvest and numbers of primary & secondary branches per plant were significantly influenced by organic manure levels. Significantly the highest value of these growth parameters were observed with application of FYM @ 5.0 t/ha (M_1) which remained statistically at par with application of vermicompost @ 1.0 t/ha (M_2) and castor cake @ 1.0 t/ha (M_3). Improvement in these parameters due to organic manures might be due to supply of plant nutrients including micronutrients, improvement in soil physical and biological properties and increased availability of nutrients. Thus, favourable influence of nutrients to produce larger cell with thinner cell wall and its contribution in cell division and cell elongation which improved vegetative growth and ultimately increased plant height and number of primary & secondary branches per plant. The similar results were found by De and Sinha (2012) [1], Yadav *et al.* (2013) [11] and Kansotia *et al.* (2015) [2].

The data in Table-1 noticed that numbers of siliquae per plant and numbers of seed per siliqua were significantly influenced by application of FYM @ 5.0 t/ha (M_1) which remained statistically at par with application of vermicompost @ 1.0 t/ha (M_2) and castor cake @ 1.0 t/ha (M_3). Application of FYM @ 5.0 t/ha (M_1) significantly increased seed yield and stover yield as compared to other treatments. The increase in seed yield due to application of FYM might be due to the fact that application of organic manure favorably improved the nutritional environment thereby resulting in better growth and development leading to higher yield attributes and yield. These results are in close agreement to Singh *et al.* (2013) [8], Yadav *et al.* (2013) [11] and Lepcha *et al.* (2015) [3].

Effect of bio-fertilizers

Scrutiny of data in Table-1 revealed that numbers of primary & secondary branches per plant were significantly influenced by bio-fertilizers levels. Significantly the highest value of these growth parameters were observed under treatment (B_3) inoculation with Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed) which remained statistically at par with inoculation with Azotobacter spp. @ 10 ml/kg seed (B_1) and inoculation with PSB spp. @ 10 ml/kg seed (B_2). Application of bio-fertilizers helps in secretion of growth promoting substances, which lead to better root development, transportation of water, uptake and decomposition of nutrients. The present results are also in agreement with the finding of Mahboobeh and Jahanfar (2012) [4], Premi *et al.* (2012) and Meena *et al.* (2014) [5].

In the present investigation, significantly increased numbers of siliquae per plant, numbers of seed per siliqua, seed yield and stover yield (Table-1) were recorded under treatment (B_3) inoculation with Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed) which remained statistically at par with inoculation with Azotobacter spp. @ 10 ml/kg seed (B_1) and inoculation with PSB spp. @ 10 ml/kg seed (B_2). This might be due to significant improvement in overall growth of the plant by virtue of increased photosynthetic rate. Thus, greater availability of photosyntyhates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased no. of siliquae per plant and no. of seed per siliqua with these levels of bio-fertilizers. Crop yield is function of several yield components on complementary interaction between vegetative and reproductive growth of the crop. The present findings are within the close vicinity of those reported by Yadav *et al.* (2010) [10], Mahboobeh and Jahanfar (2012) [4], Meena *et al.* (2014) [5] and Solanki *et al.* (2015) [9].

Table 1: Growth, yield attributes and yields of Indian mustard as influenced by different levels of organic manures and bio-fertilizers

Treatments	Plant height (cm)			No. of branches/plant		No. of siliquae/ plant	No. of seed/ siliqua	Seed yield (kg/ha)	Stover yield (kg/ha)
	At 60 DAS	At 90 DAS	At harvest	Primary	Secondary				
Organic manures (M)									
M_0 : No organic manures	101.17	136.25	160.58	4.57	12.38	199.92	11.83	1931	4094
M_1 : FYM @ 5.0 t/ha	119.08	153.83	179.08	5.50	13.55	225.67	13.17	2252	4403
M_2 : Vermicompost @ 1.0 t/ha	114.75	149.08	173.33	5.46	13.30	213.67	12.50	2217	4328
M_3 : Castor cake @ 1.0 t/ha	113.42	148.42	172.75	5.09	12.86	209.75	12.50	2199	4293
S.Em.±	2.62	3.11	3.48	0.14	0.28	5.90	0.29	58.55	74.99
C.D. at 5%	7.58	8.98	10.05	0.42	0.81	17.04	0.84	169.10	216.58
Bio-fertilizers (B) (Seed treatment)									
B_0 : No inoculation	106.75	141.42	165.92	4.81	12.33	199.50	11.83	1952	4095
B_1 : Azotobacter spp. @ 10 ml/kg seed	112.75	147.17	171.17	5.14	12.84	209.17	12.50	2195	4293
B_2 : PSB spp. @ 10 ml/kg seed	113.50	148.67	172.50	5.16	13.40	216.25	12.58	2220	4347
$B_=$: Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed)	115.42	150.33	176.17	5.52	13.52	224.08	13.08	2232	4383
S.Em.±	2.62	3.11	3.48	0.14	0.28	5.90	0.29	58.55	74.99
C.D. at 5%	NS	NS	NS	0.42	0.81	17.04	0.84	169.10	216.58
Interaction									
(OXB)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.11	7.34	7.03	9.66	7.47	9.63	8.07	9.43	7.07

DAS: Days after sowing FYM: Farm yard manure PSB: Phosphate solubilizing bacteria

Economics

The data in Table-2 clearly indicated that the highest net return of 82037 Rs/ha and BCR of 2.97 were accrued with the application of FYM @ 5.0 t/ha (M_1). With regard to bio-fertilizers levels, seed inoculation with Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed) (B_3) gave the highest net returns of 86629 Rs/ha and BCR of 3.40.

Table 2: Economics of different treatments

Treatments	Gross Return (Rs/ha)	Cost Cultivation (Rs/ha)	Net Return (Rs/ha)	BCR
Organic manures (M)				
M_0 : No organic manures	106575	36027	70549	2.95
M_1 : FYM @ 5.0 t/ha	123756	41719	82037	2.97
M_2 : Vermicompost @ 1.0 t/ha	121820	43996	77824	2.76
M_3 : Castor cake @ 1.0 t/ha	120796	45135	75661	2.67
Bio-fertilizers (B) (Seed treatment)				
B_0 : No inoculation	107682	36027	71655	2.96
B_1 : Azotobacter spp. @ 10 ml/kg seed	120619	36031	84587	3.34
B_2 : PSB spp. @ 10 ml/kg seed	121983	36031	85951	3.38
B_3 : Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed)	122665	36035	86629	3.40

Conclusion

On the basis of the results from the one year experimentation, it can be concluded that higher production and net returns of Indian mustard (cv. Gujarat Mustard-3) under South Saurashtra Agro-climatic Zone can be achieved by application of FYM @ 5.0 t/ha and inoculation with Azotobacter spp. + PSB spp. (each @ 10 ml/kg seed).

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