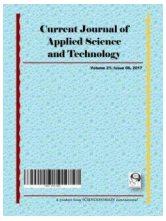

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Organic Manure & Biofertlizers: Effect on the Growth and Yield of Indian Mustard (*Brassica juncea* L.) Varieties

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Authors' contributions

This work was carried out in collaboration between all authors. Author OB designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors LA and AH managed the analyses of the study. Author EPL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Research Farm of Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18 to study the organic manures and biofertilizers: Effect on the growth and yield of Indian mustard varieties. The experiment was laid out in a randomized block design with three replications. The treatments consisted of five mustard varieties and 10 fertilizer treatments. The result of the study revealed that the variety Rani recorded significantly tallest plant highest, number of primary branches, number of siliquae/ plant, seeds per siliqua, seed and straw yields, whereas secondary branches were significantly highest with variety yellow Goldey. Amongst fertilizer treatments T_7 (75% N through vermicompost + *Azotobacter*) produced significantly tallest plants, the highest number of primary

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and secondary branches/plant high yield attributing characters, seed and stover yield. The mustard variety Rani Supplied with 75% N through vermicompost + *Azotobacter* realised the highest gross, net returns and benefit cost ratio.

Keywords: Growth; biofertilizers; seed yield; vermicompost & benefit cost ratio.

1. INTRODUCTION

Amongst seven edible oilseeds cultivated in India, rapeseed- mustard occupy an important position in daily diet and shares 27.8% in India's oilseed economy. It is grown in diverse agro-climatic conditions ranging from northern-eastern, north-western hills to southern parts. The crop is mostly grown under rainfed conditions which results in the lower productivity as compared to the irrigated conditions. The available evidence indicate that under intensive cultivation even the balanced use of chemical fertilizers alone cannot improve the productivity. Besides, use of higher nitrogen rates cause environmental pollution especially to ground water, soil acidification as well as increased denitrification resulting in a higher emission of N_2O to atmosphere which may impact global warming. In addition, the escalating prices of chemical fertilizers is unaffordable to the farmers for limiting its judicious use. These facts warrant the use of organic fertilizers which while improving the quality and productivity of crop also improve the physical status of soil. No doubt the relative availability of motives lower in organic manures which may reduce crop yield. It is imperative that an integrated nutrient supply system involving a combination of chemical organic sources and biofertilizers which is the best option for meeting out the nutrient requirement of crop. Moreover, use of high yielding genotypes is considered first and foremost step for generating sound and stable production technology. In view of these facts, the study was undertaken for improving the quality and productivity of Indian mustard (*Brassica juncea* L.) varieties by using chemical fertilizers, organic manures and biofertilizers.

2. METHODOLOGY

A field experiment was conducted at the Research Farm of Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during Rabi seasons of 2016-17 and 2017-18 to study the organic manures and biofertilizers: Effect on the growth and yield of Indian mustard (*Brassica juncea* L.) varieties. The experiment consisted of two factors viz., 5 varieties (V_1 = Rudra 99D, V_2 = Shikhar, V_3 = Rani, V_4 – Varuna and V_s = Yellow Goldey) and 10 fertilizer treatments (T_1 = control, T_2 = RDF, T_3 = 75% N through FYM, T_4 = 75% N through Vermicompost, T_5 = 50% N through FYM+ *Azotobacter*, T_6 = 50%N Through FYM+ PSB, T_7 = 50% N through vermicompost + *Azotobacter*, T_8 = 50% N Through Vermicompost + PSB, T_9 = 25% N through FYM + *Azotobacter* + PSB and T_{10} = 25% N through vermicompost + *Azotobacter* + PSB. The experiment was laid out in a factorial randomized block design with replicated thrice, mustard seed at the rate of 25kg/ha was sown in lines at a row spacing of 30 cm as per treatment. After thinning twice the plant to plant, distance was maintained at 15 cm. The crop was harvested on 2-2-2017 and 4-2-2018 and threshed on 10-2-2017 and 12-2-2018 during 2016-17 and 2017-18, respectively. The data collected on various parameters was analysed by the method given by[1] and pooled seed and stover yield was analysed by the method given by[2]. The benefit cost ration was determined on the basis the cost of inputs and outputs prevalent market rates.

3. RESULTS AND DISCUSSION

The data revealed that amongst different varieties, V_3 (Rani) recorded significantly tallest plants, highest number of primary branches/plant and highest number of days taken for flower appearance and 20 % flowering and more flowering duration (Table 1&2), highest number of siliquae/plant, seeds/siliqua. (Table 3), However, number of secondary branches/plant were significantly highest in yellow goldey variety. The results are in conformity with the findings of[3] who reported significantly higher plant height and branches/plant in Pusa Bold and Varun varieties, respectively compared to other varieties.

Table 1. Plant height at harvest as affected by varieties and fertilizers/biofertilizers

Treatment	Plant height (cm)		Number of primary branches/plant		Number of secondary branches/plant	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Varieties						
V_1	145.5	146.1	5.77	5.88	5.06	5.22
V_2	141.8	142.5	5.37	5.51	4.61	4.74
V_3	147.1	148.4	6.09	6.31	5.26	5.40
V_4	143.4	144.7	5.53	5.68	4.89	5.04
V_5	91.0	92.9	4.72	4.87	6.26	6.38
SE (m) ±	**1.873**	**1.938**	**0.089**	**0.096**	**0.078**	**0.089**
CD (P=0.05)	**5.26**	**5.44**	**0.25**	**0.27**	**0.22**	**0.25**
Fertilizers/ Biofertilizers						
T_1	12.5	124.4	3.98	4.03	3.60	3.72
T_2	137.5	138.7	6.58	6.75	6.06	6.13
T_3	129.1	130.3	4.44	4.61	4.10	4.25
T_4	129.3	130.7	4.66	4.82	4.26	4.40
T_5	140.1	141.2	6.78	6.96	6.74	6.86
T_6	134.2	135.1	5.64	5.81	5.36	5.50
T_7	142.1	143.3	6.98	7.15	6.84	6.97
T_8	134.3	135.5	5.76	5.93	5.46	5.61
T_9	133.3	134.4	4.94	5.11	4.80	4.94
T_{10}	134.3	1.5.7	5.16	5.33	4.94	5.08
SE (m) ±	**2.643**	**2.736**	**0.128**	**0.189**	**0.110**	**0.128**
CD (P=0.05)	**7.42**	**7.68**	**0.36**	**0.39**	**0.33**	**0.36**

V_1 = Rudra 99-D	T_1 = control	T_2 = RDF (NPK)
V_2 = Shikhar	T3 = 75%N Through FYM	T_4 = 100%N Through Vermicompost
V_3 = Rani	T_5 = 50%N Through FYM+ *Azotobacter*	T_6 = 50%N Through FYM+ PSB
V_4 = Varuna	T_7 = 50%N Through vermicompost + *Azotobacter*	T_8 = 50%N Through Vermicompost + PSB
V_5 = Yellow Goldy	T_9 = 25% N through FYM + *Azotobacter*+ PSB	T_{10} = 25% N through vermicompost + *Azotobacter* + PSB

The significant variations amongst the varieties with regard to growth parameters could be attributed to their genetic potential [4] also found significant variation in the yield contributing characters of mustard (*Brassica juncea* L.) varieties. The result (Table 4) showed that the mean seed and stover yields were significantly highest in Rani Variety and the magnitude of increase was to the tune of 16.30 and 13.37 percent, respectively over Shikhar variety. The highest yield obtained in Rani variety could be attributed to higher siliquae number plant and seeds /siliquae. These results are in line with those of [6] seed yield obtained in varieties RH8814 and RL1, respectively which can be attributed to more number of siliquae/plant and seeds / siliquae.

3.1 Effect of Fertilizers

The results indicated the amongst different fertilizer treatments, application of 75% N through vermicompost + *Azotobacter* recorded significantly highest plant height, primary and secondary branches /plant, highest number of days taken for flowering appearance, 50% flowering and highest flowering duration on (Tables 1 and 2). The reasons for better growth and development could be attributed to increased availability nitrogen to the plants through vermi- compost and *Azotobacter*. They play important role in development of roots and increased microbial activity because of balanced mutational environment both in soil rhizosphere and plant system. These results are in agreement with those of [5]. The yield contributing characters viz; number of siliquae /plant and seeds /siliquae were significantly highest with application of 75% N through vermin compost + *Azotobacter* (Table 3).

Better growth and development due to increased supply of nitrogen and other nutrients, both macro and micro nutrients, from vermicompost

Table 2. Flowering duration (Days) of mustard as affected by varieties and inorganic, organic and biofertilizers

Treatment	Flower appearance (DAS)		Flower appearance DAS		50% flowering DAS	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Varieties						
V_1	14.00	14.00	57.00	57.00	67.00	68.00
V_2	12.00	11.00	55.00	54.00	63.00	62.00
V_3	14.00	15.00	58.00	58.00	68.00	68.00
V_4	13.00	13.00	56.00	56.00	65.00	65.00
V_5	13.00	13.00	56.00	57.00	65.00	65.00
SE (m) ±	**0.420**	**0.488**	**1.976**	**0.933**	**1.299**	**1.193**
CD (P=0.05)	**1.18**	**1.37**	**2.74**	**2.62**	**3.45**	**3.35**
Fertilizers/ Biofertilizers						
T_1	12.00	11.00	54.00	54.00	62.00	62.00
T_2	14.00	14.00	57.00	57.00	67.00	67.00
T_3	13.00	13.00	55.00	56.00	64.00	63.00
T_4	13.00	13.00	55.00	56.00	64.00	63.00
T_5	14.00	14.00	58.00	58.00	68.00	69.00
T_6	13.00	13.00	56.00	55.00	65.00	65.00
T_7	14.00	15.00	59.00	59.00	69.00	70.00
T_8	13.00	13.00	56.00	55.00	65.00	65.00
T_9	13.00	13.00	57.00	57.00	66.00	66.00
T_{10}	13.00	13.00	57.00	57.00	66.00	66.00
SE (m) ±	**0.595**	**0.687**	**1.375**	**1.314**	**1.731**	**1.685**
CD (P=0.05)	**1.67**	**1.93**	**3.86**	**3.69**	**4.86**	**4.73**

V_1 = Rudra 99-D	T_1 = control	T_2 = RDF(NPK)
V_2 = Shikhar	T3 = 75%N Through FYM	T_4 = 75%N Through Vermicompost
V_3 = Rani	T_5 = 50%N Through FYM+ *Azotobacter*	T_6 = 50%N Through FYM+ PSB
V_4 = Varuna	T_7 = 50%N Through vermicompost + *Azotobacter*	T_8 = 50%N Through Vermicompost + PSB
V_5 = Goldy Yellow	T_9 = 25% N through FYM + *Azotobacter*+ PSB	T_{10} = 25% N through vermicompost + *Azotobacter* + PSB

Table 3. Number of siliquae/plant and seeds/siliquae as affected by varieties and fertilizer/ biofertilizers

Treatment	Number of siliquae/plant		Number of seeds/siliquae		1000-seed weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Varieties						
V_1	138.4	139.7	9.48	9.63	4.11	4.12
V_2	126.4	127.9	9.24	9.37	3.98	4.00
V_3	143.4	144.9	9.70	9.84	4.17	4.19
V_4	133.4	135.0	9.31	9.47	4.03	4.04
V_5	135.4	136.9	9.38	9.52	4.03	4.05
SE (m) ±	**1.539**	**1.713**	**0.081**	**0.089**	**0.748**	**0.032**
CD (P=0.05)	**4.32**	**4.81**	**0.23**	**0.25**	**NS**	**NS**
Fertilizers/ Biofertilizers						
T_1	117.4	118.8	8.69	8.82	3.55	3.56
T_2	137.4	138.7	9.63	9.77	4.378	4.39
T_3	127.4	128.6	8.92	9.06	3.82	3.83
T_4	129.4	130.7	9.04	9.18	3.87	3.88
T_5	146.4	147.8	9.89	10.02	4.39	4.40
T_6	138.4	139.6	9.29	9.42	3.97	3.97
T_7	150.4	151.5	9.95	10.09	4.46	4.47
T_8	137.4	138.6	9.42	9.57	4.03	4.04
T_9	132.4	137.8	9.65	9.79	4.11	4.12
T_{10}	139.4	140.8	9.78	9.94	4.16	4.17
SE (m) ±	**2.176**	**2.418**	**0.117**	**0.124**	**0.089**	**0.092**
CD (P=0.05)	**6.12**	**9.79**	**0.33**	**0.34**	**0.25**	**0.26**

V_1 = Rudra 99-D	T_1 = control	T_2 = RDF (NPK)
V_2 = Shikhar	T3 = 75%N Through FYM	T4 = 75%N Through Vermicompost
V_3 = Rani	T_5 = 50%N Through FYM+ *Azotobacter*	T_6 = 50%N Through FYM+ PSB
V_4 = Varuna	T_7 = 50%N Through vermicompost + *Azotobacter*	T_8 = 50%N Through Vermicompost + PSB
V_5 = Goldy Yellow	T_9 = 25% N through FYM + *Azotobacter*+ PSB	T_{10} = 25% N through vermicompost + *Azotobacter* + PSB

Table 4. Seed and stover yield (q/ha) as affected by varieties and fertilizers/biofertilizers

Treatment	Seed yield (q/ha)		Stover yield (q/ha)		Harvest index (%)		Biological yield (q/ha))	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Varieties								
V_1	11.61	11.92	31.14	31.94	27.17	27.72	42.76	43.00
V_2	10.13	10.41	27.55	28.36	26.88	27.46	37.68	37.91
V_3	11.81	12.10	31.41	32.20	27.32	27.83	43.22	43.48
V_4	11.45	11.72	30.68	31.48	27.18	27.66	42.13	42.37
V_5	11.53	11.80	30.75	31.57	27.25	27.76	42.27	42.50
SE (m) ±	**0.099**	**0.114**	**0.302**	**0.004**	**0.310**	0.315	**0.392**	**0.360**
CD (P=0.05)	**0.28**	**0.32**	**0.85**	**0.94**	**NS**	**NS**	**1.10**	**1.01**
Fertilizers/ Biofertilizers								
T_1	9.05	9.35	24.78	25.63	26.73	27.42	33.86	34.10
T_2	11.85	12.15	31.53	32.34	27.32	27.85	43.38	43.63
T_3	10.58	10.86	28.80	29.65	26.84	27.38	39.41	39.66
T_4	10.90	11.27	29.84	30.65	26.92	27.44	40.83	41.07
T_5	12.05	12.33	31.70	32.49	27.56	28.05	43.72	43.69
T_6	11.26	11.56	30.32	31.14	27.07	27.69	41.59	41.74
T_7	12.16	12.45	32.92	33.74	26.97	27.47	45.08	45.32
T_8	11.50	11.80	30.15	30.96	27.61	28.16	41.65	41.90
T_9	11.78	12.06	31.40	32.23	27.27	27.77	43.19	43.42
T_{10}	11.84	12.13	31.52	32.34	27.31	27.82	43.36	43.60
SE (m) ±	**0.139**	**0.160**	**0.427**	**0.474**	**0.438**	**0.445**	**0.556**	**0.506**
CD (P=0.05)	**0.39**	**0.45**	**1.20**	**1.33**	**NS**	**NS**	**1.56**	**1.42**

V_1 = Rudra 99-D	T_1 = control	T_2 = RDF (NPK)
V_2 = Shikhar	T3 = 75%N Through FYM	T_4 = 75%N Through Vermicompost
V_3 = Rani	T_5 = 75%N Through FYM+ *Azotobacter*	T_6 = 50%N Through FYM+ PSB
V_4 = Varuna	T_7 = 75%N Through vermicompost + *Azotobacter*	T_8 = 50%N Through Vermicompost + PSB
V_5 = Goldy Yellow	T_9 = 25% N through FYM + *Azotobacter*+ PSB	T_{10} = 25% N through vermicompost + *Azotobacter* + PSB

and *Azotobacter* might have increased the siliquae number/plant and seed per siliquae. The results are in conformity with those of [6]. The study revealed that application of 75% N through vermicompost + *Azotobacter* significantly increased the mean seed and the stover yields of mustard (Table 4) and the magnitude of in curse was to the tune of 33.69 and 32.26 percent respectively ever control treatment. It is reported that some of the biofertilizers produce growth hormones viz; IAA, gibberellins which make soil nutrients available to the crop [7]. These hormones stimulate root growth and development with better height interception and greater uptake of nutrients which ultimately improve seed yield. Further vermicompost and FYM are good substitute for biofertilizer give buffering tendency which increase fertilizer use efficiency. The supply of micronutrients make phosphate in soil available to plants. Earlier [8] and [9] have also stated that organic manures used alone or in combination with synthetic fertilizers increased seed yield of oil seed crops. The study revealed that mustard variety Rani supplied with 75% N through vermicompost + *Azotobacter* realised highest

Table 5. Economics of mustard (Rs/ha) as affected by varieties, inorganic/organic fertilizers and biofertilizers

Treatment	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefits cost ratio (on per Rs. Invested)
V_1T_1	51103.00	20800.00	30303.00	1.46
V_1T_2	66159.50	23988.00	42171.50	1.76
V_1T_3	59889.00	24196.00	35693.00	1.47
V_1T_4	61660.50	24500.00	37960.50	1.52
V_1T_5	67242.50	24347.00	42895.50	1.76
V_1T_6	63220.50	24247.00	38973.50	1.61
V_1T_7	68069.50	24500.00	43569.50	1.78
V_1T_8	64911.50	24400.00	40511.50	1.66
V_1T_9	66341.50	24398.00	41943.50	1.72
V_1T_{10}	66359.50	24500.00	41859.50	1.71
$V2T_1$	43958.50	20800.00	23158.50	1.11
V_2T_2	59080.00	23988.00	35.42.00	1.46
V_2T_3	51207.00	24196.00	27011.00	1.12
V_2T_4	54023.50	24500.00	29523.50	1.20
V_2T_5	59348.00	24347.00	35001.00	1.44
V_2T_6	55606.00	24247.00	31359.00	1.29
V_2T_7	59940.00	24500.00	35440.00	1.45
V_2T_8	56017.00	24400.00	31617.00	1.29
V_2T_9	58212.00	24398.00	33814.00	1.38
V_2T_{10}	58580.00	24500.00	34080.00	1.39
V_3T_1	48150.00	20800.00	27350.00	1.31
V_3T_2	67148.00	23988.00	43160.00	1.80
V_3T_3	60878.00	24196.00	36682.00	1.52
V_3T_4	62649.50	24500.00	38149.50	1.56
V_3T_5	68231.50	24247.00	43884.50	1.80
V_3T_6	64209.00	24247.00	39962.50	1.65
V_3T_7	69058.50	24500.00	44558.50	1.82
V_3T_8	66150.50	24400.00	41750.50	1.71
V_3T_9	67330.50	24398.00	42932.50	1.76
V_3T_{10}	67648.50	24500.00	43148.50	1.76
V_4T_1	50491.50	20800.00	29691.50	1.43
V_4T_2	65548.00	23988.00	41560.00	1.73
V_4T_3	58725.00	24196.00	34529.00	1.43
V_4T_4	61041.50	24500.00	36541.50	1.49
V_4T_5	66866.00	24347.00	42519.00	1.75
V_4T_6	62624.00	24247.00	38377.00	1.58
V_4T_7	67458.00	24500.00	42958.00	1.75
V_4T_8	63285.00	24400.00	38885.00	1.59
V_4T_9	64730.00	24398.00	40332.00	1.65
V_4T_{10}	65048.00	24500.00	40548.00	1.65
V_5T_1	51203.50	20800.00	30403.50	1.46
V_5T_2	66010.00	23988.00	42022.00	1.75
V_5T_3	59187.00	24196.00	34991.00	1.45
V_5T_4	61003.50	24500.00	36503.50	1.49
V_5T_5	67078.00	24347.00	42731.00	1.75
V_5T_6	63.86.00	24247.00	38839.00	1.60
V_5T_7	67920.00	14500.00	43420.00	1.77
V_5T_8	63747.00	24400.00	39347.00	1.61
V_5T_9	65192.00	24398.00	40794.00	1.67
V_5T_{10}	65510.00	24500.00	41010.00	1.67

** The rates of inputs and outputs used are as per prevalent market rates*

Input costs				Output costs	
Tractorization	=	4000/ha	*Azotobacter* = 100/ha	Selling price of seed	5000/q
Seed material	=	300/ha	PSB = 900/ha	Stover	150/a
Labour	=	13800/ha			
NPK (RDF)		3488/ha			
FYM (75% through FYM)	=	3396/ha			
Vermicompost (75%N through vermicompost)	=	3600/ha			

returns of Rs. 69058.50/ha, net returns of Rs. 44558.50/ha and benefit cost ratio of Rs. 1.80 (Table 5) have also recorded highest net returns and benefit cost ratio in mustard crop fertilised with 75% RDF + FYM + *Azotobacter* + PSB.

4. CONCLUSION

The study concludes with the results that Indian mustard variety Rani supplied with 75% N through vermicompost + *Azotobacter* produces the highest growth and yield characters as well highest economic returns and benefit cost ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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