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Productivity and profitability of Indian mustard (*Brassica juncea* L.) under different nutrient management practices

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Abstract
A field experiment was conducted during rabi season of 2020-21 on loamy sand of Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to assess the impact of vermicompost, biofertilizer and nitrogen levels on growth, yield and economics of mustard. The soil was low in organic carbon (0.17%) and available nitrogen (168 kg/ha), medium in available phosphorus (35.6 kg/ha) and high in potassium (251 kg/ha). The experiment was laid out in Randomized Block Design (factorial concept) and replicated thrice. Twelve treatment combinations consisting three levels of vermicompost, two levels of biofertilizer and two levels of nitrogen were embedded. The results indicated that significantly higher yield parameters *viz*., number of siliquae per plant (258.70, 244.48, 249.13), number of seeds per siliqua (13.05, 12.38, 12.63), length of siliqua (5.33, 5.13, 5.20 cm) and test weight (5.07, 4.99, 5.03 g) with application of 2 t/ha vermicompost, Azotobacter chroococcum inoculation @ 5 ml/kg seed and 100% RDN, individually. Combined application of 2 t/ha vermicompost + 100% RDN produced significantly higher seed yield (2104 kg/ha) and stover yield (4475 kg/ha) being at par with treatment combination 1 t/ha vermicompost + 100% RDN and 2 t/ha vermicompost + 75% RDN. Thus, it is concluded that for securing higher yield mustard crop should be fertilized with 50 kg nitrogen per ha (three splits, i.e. 50% as basal and 25% each after 25 and 55 DAS) along with 1 t/ha vermicompost and 50 kg phosphorus per ha as basal in loamy sand.

Keywords: Profitability, mustard, nutrient, management, practices, *Brassica juncea* L.

Introduction

Mustard oil mainly used for cooking, frying and in pickles. Oil is also used in preparing vegetable ghee, hair oil, medicines, soaps, lubricating oil and in tannin industries. India is the third largest rapeseed-mustard producer in the world after Canada and China. In India, mustard is growing 59.77 lakh hectares with annual production of about 84.29 lakh tonnes and an average productivity of about 1410.3 kg/ha.

Vermicompost is rich source of nutrients containing 1.25 per cent N, 0.30 per cent P, 0.70 per cent K, 0.01 per cent Cu, 0.18 per cent Fe, 0.005 per cent Zn (Sinha *et al.* (2009) [10]. Besides these, vermicompost also improves soil aeration, reduction of soil erosion, reduces evaporation losses of water, accelerates the process of humification, stimulates the microbial activity, deodourification of obnoxious smell, destruction of pathogens, detoxification of pollutant in soil *etc*. (Manna and Biswas, 1996) [6]. Bio-fertilizers are also known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco-friendly but can't replace chemical fertilizers at any cost which are indispensable for getting maximum crop yields. They supplement to chemical fertilizers for meeting the integrated nutrient demand of the crops is need of hour. Application of bio-fertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation. Nitrogen (N) is the most important nutrient, and being a constituent of protoplasm and protein, it is involved in several metabolic processes that strongly influence growth, productivity and quality of crops (Kumar *et al*. 2000) [5]. N efficiency decreases with increase in N application (Chamoro *et al*. 2002) [2]. Increasing N application also reduces oil content (Singh and Singh 2005) [9]. Since N fertilizers are costly, poor NUE is of great concern and therefore, attempts are needed to improve the contribution of applied N to production of grain and this approach will reduce the environmental and production costs in agriculture.

Material and Methods

The present investigation was carried out during *rabi* season of the year 2020-21 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Agricultural University, Sardarkrushinagar. The soil of the experiment field was lomay sand in texture, low in organic carbon (0.17%) and available nitrogen (168 kg/ha), medium in available phosphorus (35.6 kg/ha) and high in potassium (251 kg/ha). Twelve treatments were laid out in randomized block design (with factorial concept) with three replications. The experiment comprising three levels of vermicompost [No Vermicompost (Control), 1 t/ha and 2 t/ha], two levels of biofertilizer (Without *Azotobacter* and With *Azotobacter chroococcum* inoculation @ 5 ml/kg seed) and two levels of nitrogen (75% RDN and 100% RDN). The mustard variety GDM 4 was sown on 3rd November 2020 at 45 cm row to row spacing.

Results and Discussion

Effect of vermicompost

Number of siliquae per plant (258.70) and seeds per siliqua (13.05) significantly affected by 2 t/ha vermicompost compared with 1 t/ha vermicompost and no vermicompost and it was recorded significantly at par with treatment V_2 (1 t/ha vermicompost). This might be due to application of vermicompost which caused significant improvement in overall growth of the crop expressed in terms of plant height and number of branches per plant by virtue of increased photosynthetic efficiency. Thus, greater availability of metabolic activity and nutrients to develop reproductive structures seems to have resulted in increased number of siliquae per plant and seeds per siliqua. The present findings are within the close proximity of Singh *et al.* (2014) [8]. Significantly higher seed yield (2081 kg/ha) and stover yield (4453 kg/ha) was recorded with application of 2 t/ha vermicompost compared to 1 t/ha vermicompost and no vermicompost. From this result it may be inferred that the positive influence of vermicompost was due to adequate supply of nutrients in root zone and plant system. The increased availability of these nutrients in the root zone coupled with increased metabolic activity at cellular levels might have synthesized more photosynthates and their accumulation in various plant parts. This result was corroborated by Parihar *et al.* (2014) [7].

Maximum gross realization (₹ 112756) and net realization (₹ 73546) were received by application of 2 t/ha vermicompost. Whereas highest benefit: cost ratio (2.19) found under no vermicompost.

Effect of biofertilizers

Various yield attributing characters *viz*., number of siliquae per plant, number of seeds per siliqua length of siliqua and test weigh as well as seed yield, stover yield and harvest index were statistically not affected by different levels of biofertilizer.

The results are conformity with Bera *et al*. (2014) [1]. Maximum gross realization (₹ 102536), net realization (₹ 69455) and benefit: cost ratio (2.09) were received by application B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed).

Effect of nitrogen levels

Number of siliquae per plant (249.13) and number of seeds per siliqua (12.63) also significantly affected by treatment N_2 (100% RDN) compared with treatment N_1 (75% RDN). It cause about significant improvement in overall growth of the crop expressed in terms of plant height and number of branches per plant by virtue of increased photosynthetic efficiency. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased number of seeds per siliqua. The present findings are within the close proximity of Dawson *et al.* (2009) [3]. Significantly higher seed yield (1923 kg/ha) and stover yield (4181 kg/ha) was recorded with application of treatment N_2 (100% RDN) compared to treatment N_1 (75% RDN). Yield is the resultant outcome of the effect of various growth factors and yield parameters. With the increment in supply of nitrogen to Indian mustard, nutrient availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth attributes and yield components and finally seed and stover yield. It was confined with the findings of Dongarkar *et al.* (2005) [4]. Maximum gross realization (₹ 104512), net realization (₹ 71350) and benefit: cost ratio (2.15) was received by application of 100% RDN.

Interaction effect

Interaction effect of vermicompost and nitrogen levels treatment combination V_3N_2 (2 t/ha vermicompost along with 100% RDN) recorded significantly higher number of siliquae per plant (274.25) but it remained statistically at par with treatment combinations V_2N_2 (1 t/ha vermicompost along with 100% RDN) which recorded (259.08). Interaction effect of vermicompost and nitrogen levels treatment combination V_2N_2 (1 t/ha vermicompost along with 100% RDN) recorded significantly higher number of seeds per siliqua (13.45) but it remained statistically at par with treatment combinations V_3N_2 (2 t/ha vermicompost along with 100% RDN) and V_3N_1 (2 t/ha vermicompost along with 75% RDN) which recorded 13.00 and 13.10 respectively. Application @ 2 t/ha vermicompost along with 100% RDN recorded significantly higher seed yield (2104 kg/ha) being at par with treatment combinations V_2N_2 (1 t/ha vermicompost along with 100% RDN) and V_3N_1 (2 t/ha vermicompost along with 75% RDN) which recorded 2038 and 2028 kg/ha seed yield, respectively. Interaction effect of vermicompost and nitrogen also found significant for stover yield where treatment combination V_3N_2 (2 t/ha vermicompost along with 100% RDN) recorded significantly higher stover yield (4475 kg/ha) but it remained statistically at par with treatment combinations V_2N_2 (1 t/ha vermicompost along with 100% RDN) and V_3N_1 (2 t/ha vermicompost along with 75% RDN) which recorded 4455 and 4431 kg/ha stover yield, respectively. Application of 2 t/ha vermicompost (V_3) along with application of *Azotobacter chroococcum* inoculation @ 5 ml/kg seed (B_2) and 100% RDN (N_2) recorded maximum gross realization (₹ 116024/ha) but application of 1 t/ha vermicompost (V_2) along with application of *Azotobacter chroococcum* inoculation @ 5 ml/kg seed (B_2) and 100% RDN (N_2) recorded maximum net realization (₹ 81264/ha) and benefit cost ratio (2.45)

Table 1: Effect of integrated nutrient management on yield and yield attributes of mustard

Treatments	No. of siliquae per plant	No. of seeds per siliqua	Length of siliqua (cm)	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	HI (%)
A. Vermicompost							
V_1: No vermicompost	220.47	11.09	4.92	4.77	1578	3558	30.78
V_2: 1 t/ha vermicompost	241.91	12.25	5.07	4.95	1845	3991	31.68
V_3: 2 t/ha vermicompost	258.70	13.05	5.33	5.07	2081	4453	31.95
S.Em. ±	6.17	0.34	0.13	0.12	49	121	0.78
C.D. at 5%	18.08	0.98	NS	NS	143	355	NS
B. Biofertilizer							
B_1: No biofertilizer	236.25	11.88	5.08	4.88	1783	3883	31.48
B_2: *Azotobacter chroococcum*	244.48	12.38	5.13	4.99	1886	4118	31.45
S.Em. ±	5.03	0.27	0.10	0.10	40	99	0.64
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
C. Nitrogen levels							
N_1: 75% RDN	231.60	11.64	5.01	4.84	1747	3821	31.37
N_2: 100% RDN	249.13	12.63	5.20	5.03	1923	4181	31.57
S.Em. ±	5.03	0.27	0.10	0.10	40	99	0.64
C.D. at 5%	14.77	0.80	NS	NS	117	290	NS
Significant interactions							
V × N	Sig.	Sig.	NS	NS	Sig.	Sig.	NS

Table 2: Interaction effect of various levels of vermicompost and nitrogen on yield and yield attributes of mustard

Treatments	Number of siliquae per plant		Number of seeds per siliqua		Seed yield (kg/ha)		Stover yield (kg/ha)	
Vermicompost (V)	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
V_1	226.89	214.06	10.76	11.42	1530	1627	3504	3612
V_2	224.75	259.08	11.04	13.45	1653	2038	3527	4455
V_3	243.16	274.25	13.10	13.00	2028	2104	4431	4475
S.Em. ±	8.7		0.47		69		171	
C.D. at 5%	25.6		1.39		203		502	
C.V.%	8.89		9.58		9.23		10.48	

Table 3: Effect of vermicompost, biofertilizer and nitrogen on economics of mustard

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	B: C Ratio
A. Vermicompost levels						
V_1: No vermicompost	1578	3558	86016	26950	59066	2.19
V_2: 1 t/ha vermicompost	1845	3991	100232	33080	67152	2.03
V_3: 2 t/ha vermicompost	2081	4353	112756	39210	73546	1.87
B. Biofertilizer levels						
B_1: No Biofertilizer	1783	3883	96916	33078	63838	1.92
B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	1886	4118	102536	33081	69455	2.09
C. Nitrogen levels						
N_1: 75% RDN	1747	3821	94992	32997	61995	1.87
N_2: 100% RDN	1923	4181	104512	33162	71350	2.15

Table 4: Effect of vermicompost, biofertilizer and nitrogen on economics of mustard

Treatment	Treatment combinations	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization(₹/ha)	Cost of cultivation (₹/ha)	Net Realization (₹/ha)	B: C Ratio
T_1	$V_1B_1N_1$	1498	3489	81878	26866	55012	2.05
T_2	$V_1B_1N_2$	1567	3523	85396	27031	58365	2.16
T_3	$V_1B_2N_1$	1561	3518	85086	26869	58217	2.17
T_4	$V_1B_2N_2$	1687	3699	91748	27034	64714	2.39
T_5	$V_2B_1N_1$	1594	3455	86610	32996	53614	1.62
T_6	$V_2B_1N_2$	1971	4294	107138	33161	73977	2.23
T_7	$V_2B_2N_1$	1712	3597	92794	32999	59795	1.81
T_8	$V_2B_2N_2$	2104	4614	114428	33164	81264	2.45
T_9	$V_3B_1N_1$	1996	4295	108390	39126	69264	1.77
T_{10}	$V_3B_1N_2$	2075	4238	112226	39291	72935	1.85
T_{11}	$V_3B_2N_1$	2120	4567	115134	39129	76005	1.94
T_{12}	$V_3B_2N_2$	2132	4712	116024	39294	76730	1.95

Conclusion
In light of the results obtained from this experiment, it is concluded that for securing higher yield, mustard crop grown on loamy sand should be fertilized with 50 kg nitrogen per ha (three splits, *i.e* 50% as basal and 25% each 25 and 55 DAS) along with 1 t/ha vermicompost and 50 kg phosphorus per ha as basal application.

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