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Productivity and profitability of Indian mustard under different organic nutrient management practices in Semi-arid region

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Abstract

A field experiment was conducted to study the effect of the different organic nutrient sources on productivity and profitability of Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. Eight treatments having three organic sources viz., farmyard manure, vermicompost and poultry manure with or without biodynamic manure 500 and 501 was laid out in a randomized block design replicated thrice. The organic source comprising combined application of poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 produced significantly higher seed yield (1966 kg ha^{-1}) and stover yield (5169 kg ha^{-1}) to the tune of 78.7 and 52.4 per cent higher over control, respectively. Growth and yield attributes viz., plant height (161.5 cm), number of branches per plant (5.2), length of siliqua (6.0 cm), number of siliqua per plant (235.6), number of seeds per siliqua (15.4) and test weight (5.1 gm) of mustard were significantly higher with poultry manure @ 1.7 t/ha + BD 500 + BD 501 over the no manure application and superior over rest organic treatments. Application of poultry manure @ 1.7 t/ha + BD 500 + BD 501 gave highest net return (Rs. 51204 ha^{-1}) and B: C ratio (2.9).

Keywords*: Biodynamic manure, FYM, mustard, poultry manure, seed yield and vermicompost*

Introduction

Organic farming is a production system that avoids the use of synthetic chemical fertilizers, pesticides and growth regulators hormones and raises the crops with use of organic manure, crop rotation, legumes, green manures and biological pest control. Continuous use of inorganic fertilizers has not only brought about loss of vital soil fauna and flora but also resulted in loss of secondary nutrients and micronutrients. Various organic technologies have been utilized for about 600 years to make agriculture sustainable while conserving soil, water, energy and biological resources (Pimentel *et al.*, 2005). Organic farming is gaining gradual momentum across the world. In India, about 1180000 hectare area is under organic farming with 677257 numbers of certified organic farms (Willer, 2011). Biodynamic farming, i.e., combining biological and dynamic agriculture practices, has recently emerged as an advancement of organic agriculture. Just as organic farming, the product of biodynamic agriculture are nutritionally superior and they taste better than the conventional food (Steiner, 1996), besides having the potential to mitigate some of the negative effects of chemical agriculture.

Oilseed *Brassicas*, collectively known as rapeseed-mustard are important oilseed crops of India and stand second after soybean in production among the eight annual edible oilseeds cultivated in our country. Among oilseed *Brassica* species, major area is under *B. juncea* which contributes about 80% of the total rapeseed-mustard production in the country. All oilseed *Brassicas* are cultivated in about 6.18 million ha with 7.36 million tonnes production of oilseed contributing about 26.8% and 24.7% of the total oilseed production and acreage, respectively in the country with the average productivity of 1190 kg/ha (AICRPRM, 2009). *B. juncea* requires relatively large amount of nutrients for realization of yield potential but inadequate supply often leads to low productivity (Tripathi *et al.*, 2010). Under such situation, organic resources such as farmyard

manure (FYM) and biofertilizers like *Azospirillum* and phosphate solubilizing microorganism (PSM) can be exploited to boost the production and to improve fertilizer use efficiency. In fact, fertilizers no doubt played a key role in agricultural production and changed country from a region of food scarcity to food sufficiency. But chemical fertilizers have also contributed significantly towards the pollution of water, air and soil. So the current trend is to explore the possibility of supplementing chemical fertilizers with organic ones which are eco-friendly and cost-effective (Datta *et al.*, 2009). Farmyard manure improves soil quality apart from supplying all essential nutrients and enhancing the activity of microorganisms. The one of the constraint in increasing the area under organic mustard production is lack of suitable organic production practices for different agro-climatic regions. The present investigation was aimed to study the influence of biodynamic preparations and organic manures on growth, yield and economics of mustard in semi arid region of Rajasthan, India.

Materials and Methods

A field experiment was conducted during *Rabi* season of 2012-13, 2013-14 and 2014-15 at Dryland Farming Research Station, Arjia, Bhilwara of Maharana Pratap University Agriculture and Technology, Udaipur (Rajasthan), India. The region has a semi-arid climate characterized by extremes of temperature in both summer and winter with average annual rainfall of about 657.7 mm mostly received in rainy season from July to September. The soil of the experimental field was sandy-loam in texture having pH 8.18, low in organic carbon (0.39 per cent), available nitrogen (165.0 kg ha^{-1}) and medium in available phosphorus (18.0 kg ha^{-1}), high in available potassium (365.0 kg ha^{-1}) and deficient in DTPA extractable iron (3.2 ppm) and zinc (0.46 ppm). The experiment was laid out in a randomized block design with eight treatments and three replications. The eight treatments consists of T_1- FYM @ 12 t/ha, T_2- Vermicompost @ 4 t/ha , T_3- Poultry manure @ 1.7 t/ha, T_4- FYM @ 12 t/ha + BD 500 + BD 501, T_5- Vermicompost @ 4 t/ha+ BD 500 + BD 501, T_6- Poultry manure @ 1.7 t/ha + BD 500 + BD 501, T_7- FYM @ 6 t/ha + BD 500 + BD 501 and T_8- Absolute control (No manure). The gross plot size was 3.0X 4.5 m.

Two biodynamic formulations (BD 500 and BD 501) sourced from the SUPA Biotech (P) Ltd., Nainital, India were tried. BD 500 (horn manure preparation), the "prime starter of biodynamic," is prepared by stuffing the dung of a lactating cow into a horn and burried in the soil during the autumn equinox (September) and taken out during the spring equinox (March). The humified dung from horn is stored in an earthen pot away from sunlight. For preparing the spray solution for one ha, 62.5 g of this martial was dissolved in 40 L of warm (40^0C) water with continuous stirring for 1hour (alternately in clock wise and anti-clock wise directions). The liquid mixture was sprinkled as big droplets on soil surface in the evening on day before sowing. For the treatments based on biodynamic calendar, BD 500 was applied on i.e. during the lunar descending period, when the effects are supposedly better (Briton, 1998).

BD 501 is "cow horn silica" and is made from quartz crystals ground to alum power consistency, stuffed into a cow horn, buried during spring equinox, and taken out during autumn equinox. The material, stored in glass bottle, and exposed to the sun by the windowsill was used to prepare the BD 501 spray solution by dissolving 2.5 g in 40 L of water, which was prepared for spray in a similar way as that of BD 500. Within an hour, the mixture was sprayed as a fine mist on the plant foliage (i.e. before 9.00 am). The application dates corresponded to days when moon was opposite to Saturn in the biodynamic calendar.

FYM, vermicompost and poultry manure were applied before the sowing. Nitrogen content in different organic manures was taken in to consideration to against quantities in different organic sources. FYM contained 0.51% N, 0.21% P and 0.49% K. Poultry manure contained 3.5% N, 1.5% P and 2.4% K. Vermicompost had 1.49% N, 0.89% P and 1.2% K. Mustard variety Laxmi was sown at 30 cm row spacing. Seeds were treated by *Trichoderma harzianum* @ 8 g kg^{-1} seed. Application of BD 500 was done twice first on evening prior to a day before sowing and 30 days after sowing. BD 501 was sprayed four times viz., at 2-4 leaf stage and latter on at branching, pre-flowering and seed formation stage. For organic

management of crop, neem cake @ 200 kg ha^{-1}, *Trichoderma harzianum* @ 2 kg incubated in 200 kg FYM, neem seed kernel extract spray (5%) at 45 and 60 DAS, fresh neem leaf spray (10%) along with 0.2% garlic spray and milk whey (10%) spray were done to control insect and pest of crop during cropping season. All the agronomic practices were carried as per recommendation of organic farming. Production efficiency (kg $ha^{-1}day^{-1}$) was calculated by dividing final grain ha^{-1} by total life period (days) of crop. Economic efficiency (Rs ha^{-1} day^{-1}) was calculated by dividing net monetary returns ha^{-1} by total life period (day) of crop.

Results and Discussion

Growth and yield attributes

Three year pooled analysis data on growth and yield attributes are depicted in Table 1 revealed that application of poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 recorded the highest plant population (10.9) in one meter row length. Although, the differences in plant population of Indian mustard due to different organic treatments were found statistically non-significant over control during the experimentation years. However, the plant population varied from 9.4 to 10.9 per meter row length. Plant height of mustard was found statistically significant and maximum plant height of 161.5 cm was recorded in treatment T_6 where BD 500 + BD 501 applied along with poultry manure @ 1.7 t/ha which was closely followed by vermicompost @ 4 t/ha+ BD 500 + BD 501 (158.0 cm). All the organic treatment gave higher plant height and was found statistically significant over control (Table 1). Increase in plant height of mustard with application of enriched compost and biodynamic preparation is due to increased availability of nutrients to be an

Table 1: Effect of organic treatments on growth and yield attributes of mustard (Pooled of 3 years)

Treatments	Plant population (one meter length)	Plant height (cm)	No. of Branches /plant	Length of siliqua (cm)	No. of siliqua /plant	No. of seeds /siliqua	Test weight (g)
T_1- FYM @ 12 t/ha	10.1	153.9	4.6	5.6	191.0	14.3	4.7
T_2- Vermicompost @ 4 t/ha	10.1	154.6	4.6	5.6	192.0	14.5	4.7
T_3- Poultry manure @ 1.7 t/ha	10.3	156.1	4.8	5.7	196.6	14.7	4.9
T_4- FYM @ 12 t/ha + BD 500 + BD 501	10.6	157.7	4.9	5.8	211.0	15.0	4.9
T_5- Vermicompost @ 4 t/ha + BD 500 + BD 501	10.6	158.0	4.9	5.9	215.1	15.1	4.9
T_6- Poultry manure @ 1.7 t/ha + BD 500 + BD 501	10.9	161.5	5.2	6.0	235.6	15.4	5.1
T_7- FYM @ 6 t/ha + BD 500 + BD 501	9.9	149.0	4.3	5.4	173.8	13.3	4.6
T_8- Absolute control (No manure)	9.4	142.8	3.9	5.1	162.1	12.6	4.3
S Em±	0.2	1.3	0.1	0.1	2.7	0.2	0.1
CD (0.05)	NS	4.1	0.2	0.2	8.1	0.5	0.2
CV (%)	4.6	2.6	4.8	3.0	4.1	3.6	3.1

account of its pivotal role in early formation of roots and their proliferation with increased microbial availability. This might have improved effective utilization of soil nutrients by crop. Lal *et al.* (2002) also found that with increased rates of organic manure application resulted in better plant growth as indicated by increase in plant height and number of leaves per plant.

The yield attributes viz., length of siliqua, siliquae/ plant, seeds/siliqua and 1000-seed weight of Indian mustard differed significantly with the application of different organic nutrient sources during all the three years (Table 1). Application of poultry manure @ 1.7 t/ha + BD 500 + BD 501 gave the maximum number of branches per plant (5.2) and were found significantly in pooled data analysis. Three year pooled data analysis also indicated that the mean highest number siliqua per plant (235.6) and were found statistically higher with application of BD 500+ BD 501+ poultry manure @ 1.7 t/ha. Similarly, maximum number of seeds per silique (15.4) was found with the treatment T_6. The test weight was also recorded significantly highest in treatment T_6 (5.2 g) over all the treatments. This might be due to large availability of nutrients which in turn promoted growth as well as yield attributing characters. Further, physiological role of N and P supplied by FYM and compost in enhancing growth parameters might have led to increased yield attributes and there by yield of crop at application of organic manure. This is attributed to better growth of plants and higher yield by slow release of nutrients for absorption with additional nutrients like gibberellins, cytokinin, and auxins, by the application of organic inputs. These findings are in accordance with the findings of Patel *et al.*, 2014 and Patil *et al.*, 2013. Choudhary and Suresh Kumar (2013) also reported that organic source of nutrient increased the growth; yield attribute, and yield as well as nutrient uptake by maize crop.

Yield

The pooled mean seed and stover yields increased significantly with application of poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 by 78.7 % and 52.4 %, respectively (Table 2). It was recorded that treatment T_6 gave 23.1 per cent significantly higher yield over traditionally available organic source (T_1). This increase could be owing to higher availability of nutrients under poultry manure application. Pooled data analysis presented in Table 2 revealed that different treatments of organic manure had significantly effect on the seed and straw yield of mustard during all three year of experimentation. The maximum seed yield of 1966 kg/ha was recorded with the application of poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 followed by treatment T_5 i.e. vermicompost @ 4 t/ha+ BD 500 + BD 501 (1870 kg/ ha). Similarly, the maximum straw yield was recorded with application of poultry manure @ 1.7 t/ha alongwith biodynamic manure 500 + BD 501. Higher growth and higher values of yield components due to higher concentration and fast release of nutrients in poultry manure might have resulted in higher seed yield under this treatment. Jayshree and George (2006) have reported the similar results in chilli with application of two biodynamic preparations (BD 500 and BD 501 by). Previous research on effect of organic manures in enhancing crop and soil productivity have been reported by Pimentel *et al.*, 2005 and Patil *et al*., 2010. They have reported that importance of organic farming is understandable given the important role soil organic matter plays in maintaining soil productivity through multiple functions. Our results are in accordance with the findings of Patel *et al.*, 2014; Meena *et al*., 2013; Saini *et al.*, 2013 and Patil *et al.*, 2013. In light of above evidences, it seems that application of biodynamic preparations in combination with organic manures might have resulted in enhancing yield attributes and yield of Indian mustard under organic production system. The results on seed yield thus confirmed the trend observed earlier in the yield attributing characters. With the increment in supply of essential nutrients to Indian mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved yield components and finally the yield. These results are in conformity with those of Singh and Sinsinwar (2006) and Datta *et al.* (2009).

Table 2: Effect of organic treatments on yield of mustard (Pooled of 3 years)

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Production efficiency (kg ha^{-1}day^{-1})	Cost of cultivation (Rs. ha^{-1})	Net return (Rs ha^{-1})	B: C ratio	Economic efficiency (Rs ha^{-1} day^{-1})
T_1	1597	4176	5773	12.43	26806	36284	2.35	283.1
T_2	1651	4234	5885	12.85	34419	30683	1.90	239.4
T_3	1676	4466	6142	13.04	24671	41528	2.68	323.7
T_4	1820	4747	6566	14.15	27487	44029	2.60	342.9
T_5	1870	4919	6789	14.55	35955	37817	2.06	294.9
T_6	1966	5169	7134	15.28	26207	51204	2.95	398.8
T_7	1391	3905	5297	10.83	24682	30606	2.23	238.9
T_8	1100	3392	4492	8.57	19486	18573	1.95	144.8
S Em±	32.76	83	89.81	0.25	-	-	-	-
CD (0.05)	99.37	253	272.41	0.77	-	-	-	-
CV (%)	6.02	5.71	4.48	6.01	-	-	-	-

Production efficiency

Different organic nutrient management practices have significantly influenced production efficiency of mustard crop. Data pertaining to production efficiency are presented in Table 2 revealed that treatment T_6 i.e. poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 produced the highest production efficiency 15.3 kg ha^{-1}day^{-1} followed by vermicompost @ 4 t/ha+ BD 500 + BD 501 (T_5). Supply of optimum nutrients through treatment T_6 i.e. poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 may be responsible for good productivity.

Economics

Data pertaining to economics of three year study are depicted in Table 2. Among the different organic treatments, the cost of cultivation varied from Rs. 19486 to Rs. 35955 ha^{-1} with a maximum with vermicompost @ 4 t/ha+ BD 500 + BD 501 (T_5). Input costs of some of the organic treatments were more than the control due to higher cost of organic manures. The net return ranged from Rs. 18573 ha^{-1} to Rs. 51504 ha^{-1} with the variation of benefit: cost ratio of 2.0 to 3.0. The maximum net return (Rs.51204 ha^{-1}) and benefit: cost ratio (3.0) were recorded with the application of poultry manure @ 1.7 t/ha along + BD 500 + BD 501 (T_6). Similarly, application of poultry manure @ 1.7 t/ha along + BD 500 + BD 501 (T_6) gave the highest economic efficiency Rs. 398.8 ha^{-1} day^{-1} which was superior to other organic nutrient treatments. Integration of organic manure along with biodynamic manure 500 and 501 had a marked effect on benefit cost ratio and net return. Jayathilake *et al*. (2003) also reported higher net returns and benefit: cost ratio by organic manure.

Conclusion

On the basis of three year results, It can be concluded that poultry manure @ 1.7 t/ha along with biodynamic manure 500 + BD 501 was found superior and recorded significantly higher seed yield of mustard followed by vermicompost @ 4 t/ha+ BD 500 + BD 501. Thus, the applications of poultry manure @ 1.7 t/ha along with BD 500 and BD 501 is essential for exploiting the production potential of Indian mustard.

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