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Review/Overview

Effect of integrated nutrient management on growth, yield, quality and nutrient uptake of Indian mustard (*Brassica juncea*) in arid zone of Rajasthan

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2009–10 and 2010–11 to study the effect of farmyard manure (FYM) and nutrients on growth, yield, quality and nutrient uptake of Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson]. Treatments consisted of 3 levels each of FYM (0, 10 and 20 t FYM/ha) and nutrients (0, 40 kg N + 20 Kg P_2O_5 and 80 kg N + 40 Kg P_2O_5/ha) were evaluated thrice in a factorial randomized block design. The plant height, dry matter accumulation, primary and secondary branches/plant, chlorophyll content in fresh leaves, siliquae/plant, seeds/siliqua, 1,000-seed weight and seed and stover yields were significantly higher under incorporation of 20 t FYM/ha over 10 t FYM/ha. Plant height, dry matter accumulation, chlorophyll content, siliquae/plant, seeds/siliqua, 1,000-seed weight, seed and stover yield, nutrient uptake, oil content and oil yield increased significantly up to 80 kg N + 40 Kg P_2O_5 /ha.

Key words: Crop management, Fertility level, FYM, Indian mustard, Integrated nutrient management, Yield

In India, rapeseed-mustard group of crops is grown in about 6.51 million ha with total production of about 7.67 million tonnes and an average productivity of 1,179 kg/ha (GoI, 2010–11). In Rajasthan, rapeseed-mustard occupies prime place amongst all the oilseed crops grown in the state, occupying an area of 3.07 million ha and a production of 4.62 million tonnes (Directorate of Agriculture, 2011–12). Rajasthan ranks first both in area and production of mustard in the country. The productivity is quite lower than developed countries mainly due to sub-optimal application of fertilizers and cultivation on marginal lands in rainfed conditions. In plant nutrition, organic matter of a soil is the key property that decides the availability status of essential nutrients. Integrated nutrient management system through efficient use of organic matter, besides improving soil physical condition and conservation of moisture, can substantially enhance crop production. The nutrient supply, the flows and the nutrient added should be managed properly to achieve as high yield as possible under the climatic circumstances while minimizing environmental pollution (Finck, 1998). The use of organic manure (FYM) or other farm waste is the tool to improve the physical, chemical and biological properties of the soil. Farmyard manure (FYM) being the source of all essential elements, improves soil organic matter and humus part of soil. FYM also plays important role inhabitating beneficial bacteria thus making the nutrients available to crops.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi*) seasons of 2009–10 and 2010–11 at College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan. The soil was loamy sand (83.3% sand, 10.2% silt and 6.3% clay), slightly above neutral in reaction (pH 7.8), low in organic carbon (0.07%), available nitrogen (90.1 kg/ha), available phosphorus (16.2 kg/ha) and medium in available potassium (190.4 kg/ha). The content of N, P and K in farmyard manure (FYM) was 0.52, 0.20 and 0.58% respectively. The FYM was applied 25 days before sowing of crop. The total rainfall received during the *rabi* season of 2009–10 and 2010–11 was 2.5 and 32.2 mm respectively. Hoeing and weeding was done twice during the crop growing season. Besides pre-sowing irrigation, 5 irrigations were applied as per requirement of crop using sprinkler irrigation method. One spray of dimethoate 30 EC @ of 1.0 litre/ha in 1,000 litres water was done to protect the crop from

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aphids. The preceding crops were pearlmillet in 2009 and mothbean in 2010.

Treatments consisting of 3 levels each of FYM (0, 10 and 20 t/ha) and nutrients (0, 40 kg N + 20 kg P_2O_5 kg/ha and 80 kg N + 40 kg P_2O_5 kg/ha), which were replicated thrice in a factorial randomized block design during both the years. Mustard 'Bio-902' was sown on 21 and 23 October of 2009 and 2010 using seed rate @ 4.0 kg/ha with row spacing of 30 cm and harvested on 20 and 26 March of 2010 and 2011 respectively. Observations were recorded on plant height, dry matter accumulation, leaf chlorophyll content, siliquae/plant, seeds/sliquae, 1,000-seed weight, seed and stover yield, harvest index, oil content and oil yield and nutrient uptake in seed and stover. Five random plants from each plot were uprooted and later cleaned and observations like plant height, dry matter and chlorophyll content at peak growth stage (60 DAS) were recorded and averaged. Yield attributes were recorded at harvest to assess the contribution towards yield. Total siliquae of 5 sampled plants were counted and expressed as number of siliquae/plant. The seeds/siliquae were the average of 10 random siliquae from 5 plants. The 1,000-seed were counted from the lot, weighed and expressed as 1,000-seed weight. The seed and stover yields were computed from the harvest of the net plots.

The seed from the seed lot was taken for estimation of seed quality like oil with the help of Soxhlet's extraction method (AOAC, 1960). The nutrient uptake (N, P and K content) were estimated from both seed and stover during both the years and its uptake were estimated with respective nutrient content. The data were analysed statistically (Panse and Sukhatme, 1985). Net returns were calculated by subtracting cost of cultivation from gross returns. The sale price of mustard seed was ₹ 24/kg and stover was ₹3.0/kg. Price of FYM was ₹400/tonne. Net returns and Net benefit: cost.

RESULTS AND DISCUSSION

Growth attributes

Highest plant height, dry matter accumulation, primary and secondary branches/plant and leaf total chlorophyll were obtained with 20 t FYM /ha, being significantly higher than no FYM application and 10 t FYM /ha respectively (Table 1). This would be expected since FYM supplied most plant nutrients having direct and indirect involvement in the availability of nutrients to crop plants (Singh and Pal, 2011). Application of 80 kg N + 40 kg P_2O_5/ha registered the highest values while lowest values were obtained under no-fertilizer application. The greater availability of nutrients in soil due to increasing fertilizer application might have enhanced meristematic activity (multiplication and elongation of cells) leading to increased plant height, branches and dry matter accumulation. Significant improvement in chlorophyll content in leaves might have resulted in better interception and utilization of radiant energy leading to higher photosynthetic rate and finally more accumulation of dry matter by the crop. Our results support the findings of Vivek *et al.* (2009).

Yield attributes and Yield

Application of 20 t FYM/ha recorded higher values for number of siliquae/plant, seeds/siliqua, 1,000-seed weight over preceding levels (Table 1). This may be ascribed to

Table 1. Effect of farmyard manure and nutrients on growth and yield attributes, total chlorophyll and oil content of Indian mustard (pooled over 2 years).

Treatment	Plant height (cm)	Dry matter accumulation/m row length (g/m^2)	Primary branches at harvest (No/plant)	Secondary branches at harvest (No/plant)	Total chlorophyll content (mg/g of fresh leaves)	Siliquae/ plant	Seeds/ siliqua	1,000-seeds weight (g)	Oil content (%)
Farmyard manure (t/ha)									
Control	175	210	4.9	12.1	1.72	169	11.7	4.1	34.47
10	181	222	5.6	12.8	1.78	199	12.7	4.6	36.06
20	188	231	6.1	13.3	1.83	214	13.9	5.0	36.82
SEm±	1.3	1.8	0.1	0.1	0.008	1.2	0.20	0.09	0.11
CD (P=0.05)	3.6	5.2	0.3	0.3	0.023	3.4	0.57	0.25	0.32
Nutrients (N + P_2O_5 kg/ha)									
Control	150	184	4.7	11.8	1.71	164	11.2	4.0	34.26
40 + 20	193	234	5.7	12.9	1.78	202	12.9	4.6	36.20
80 + 40	200	244	6.3	13.4	1.84	216	14.3	5.0	36.89
SEm±	1.3	1.8	0.1	0.1	0.008	1.2	0.20	0.09	0.11
CD (P=0.05)	3.6	5.2	0.3	0.3	0.023	3.4	0.57	0.25	0.32

overall improvements in vigour and crop growth. Since FYM contains almost all essential plant nutrients, its incorporation in soil promotes rapid vegetative growth and branching, thereby increasing the sink size in terms of flowering, fruiting and seed setting. The improved overall growth and profused branching owing to FYM application coupled with transport of photosynthates towards reproductive structures on the other hand, might have increased the yield attributes (Singh and Pal, 2011). The higher values of yield attributes is the result of higher nutrient availability resulted in better growth and more translocation of photosynthesis from source to sink (Tripathi *et al*., 2010). Significant increase in seed and stover yield (Table 2) was recorded with application of 20 t FYM/ha. The significant increase in seed yield with addition of FYM might be owing to their positive influence on maintaining balanced source–sink relationship which clearly evident from remarkable improvement in dry matter production, growth characters and yield attributes like siliquae/plant, seeds/siliqua and test weight, which eventually resulted in increased seed yield. The increase in stover yield with application of 20 t FYM/ha could be partly attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth (plant height and number of branches). Mustard responds well to fertilizer application and the increase due to each successive level of fertilizer applied was significant in number of siliquae/plant, number of seed/siliqua and test weight (Table 1). The positive effect of fertilizer application on yield-attributing characters of mustard seems to be due to cumulative effect on growth and vigour of plants. By virtue of increased supply of metabolites, there might have been significant improvement in dry matter production with increasing fertilizer application. Increased growth components owing to increased fertilizer levels might have provided stability in higher supply of photosynthates towards the sink (seeds/siliqua). The improvement in yield-attributing characters with fertilizer application is in close conformity with Vivek *et al.* (2009) and Mitra and Mandal (2012). Application of 80 kg N + 40 kg P_2O_5/ha registered the higher values over their preceding lower levels. Significant increase in seed yield (Table 2) of Indian mustard with increasing levels of fertilizer might be due to improvement in yield attributing character like siliquae/plant, seed/siliqua and test weight. Significant increase in stover and biological yield owing to fertilizer application might be because of increased dry matter, plant height and profused branching. Dadheech *et al.* (2009) and Babar and Dongale (2011), also reported Improvement in these characters with increasing fertilizer levels.

Interaction

Application of FYM and fertility had significant effect on siliquae/plant and seed yield showed that combined application of 20 t FYM in conjunction with 40 kg N + 20 kg P_2O_5/ha, being at par with 20 t FYM along with 80 kg N + 40 kg P_2O_5/ha gave significantly higher siliquae/plant and seed yield (Table 3), indicating a saving of 40 kg N + 20 kg P_2O_5/ha as a consequence of FYM addition. It may be attributed to improvement in nutritional environment in root zone, which encourage the proliferation of roots thereby facilitating more withdrawal of water and nutrients from larger areas and greater depths resulted in higher number of siliquae/plant and seed yield (Dadheech *et al.,* 2009).

Nutrient uptake and quality

Application of FYM at increasing rates significantly increased nutrient uptake of N, P and K in seed and stover

Table 2. Effect of farmyard manure and nutrients on seed, stover and oil yield and economics of Indian mustard (pooled over 2 years).

Treatment	Yield (t/ha)		Oil yield	Economics (×10³₹/ha)		
	Seed	Stover	(kg/ha)	Cost of cultivation	Net returns	Benefit: cost ratio
Farmyard manure (t/ha)						
Control	1.47	3.01	510.4	12.1	32.7	3.74
10	1.65	3.45	598.8	15.9	34.1	3.13
20	1.81	3.79	670.9	19.8	35.1	2.75
SEm±	0.018	0.023	5.1	-	0.33	0.02
CD (P=0.05)	0.051	0.067	14.9	-	0.96	0.06
Nutrients (N + P_2O_5 kg/ha)						
Control	1.38	2.87	474.6	15.0	26.9	2.90
40 + 20	1.73	3.53	629.6	15.7	36.4	3.36
80 + 40	1.82	3.85	675.9	16.8	38.5	3.36
SEm±	0.018	0.023	5.18	-	0.33	0.02
CD (P=0.05)	0.051	0.067	14.9	-	0.96	0.06

of mustard crop (Table 4). The positive influence of FYM application on nutrient content in the crop appears owing to improved nutritional level both in the root zone and plant system. The increased availability of these nutrients in root zone coupled with increased metabolic activity at cellular level might increased nutrient uptake and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of these nutrients to reproductive organs of the crop and ultimately increased the contents in seed and stover. Increased uptake of N, P and K seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content. Thus, positive impact of FYM application on both these aspects ultimately led to higher accumulation of nutrients. These results are in line with the findings of Chaurasia *et al*., (2009). Application of FYM @ 20 t FYM/ha significantly increased oil content and oil yield of seed. It might be owing to the unique role of organic matter in improving the nutritional environment of rhizoshere via improvement in nutrient availability. Thus, the balanced nutrient uptake by plant owing to enhanced level of FYM favoured enzymic activities responsible for oil synthesis. The increase in oil yield was the manifestation of increase in seed yield as well as its oil content due to applied FYM. (Mankotia and Sharma, 1996).

Successive increase in fertilizer application up to 80 kg N + 40 kg P_2O_5 /ha significantly increased nutrient uptake of N, P and K in seed and stover of Indian mustard. The significant increase in nutrient uptake might be due to greater availability of nutrients in soil applied through addition of fertilizers. The higher values of nutrient uptake in seed and stover of mustard was mainly attributed to the increased chemical fertilizer application. The balanced nutrition also enhanced the synergistic effect on uptake of other plant nutrients (Ahmad *et al*., 2007). Under high N supply, a large proportion of photosynthesis may have diverted to protein formation leaving a potential deficiency of carbohydrate to be degraded to 'acetyl co-enzyme A' for the synthesis of fatty acids. Further, a significant increase in oil content and oil yield due to phosphorus might be due to the fact that synthesis of fatty acids in plants occurs through conversion of acetyl co-enzyme A to malonyl co-enzyme A in presence of ATP and phosphate. Secondly, the higher oil content could be attributed to formation of more lecithin (Saxena *et al*., 2005).

Economics

The gross returns, net returns and benefit: cost ratio of the Indian mustard were influenced significantly by inte-

Table 3. Interactive effect of farmyard manure and nutrients on siliquae/plant and seed yield of Indian mustard (pooled over 2 years).

Farmyard manure (t/ha)	N + P_2O_5 (kg/ha)					
	Siliquae/ plant			Seed yield (t/ha)		
	Control	40 + 20	80 + 40	Control	40 + 20	80 + 40
Control	138.7	170.6	197.5	1.30	1.50	1.62
10	172.1	208.3	218.0	1.40	1.74	1.81
20	182.0	228.2	233.4	1.43	1.96	2.04
SEm±		2.1				0.03
CD (P=0.05)		6.0				0.09

Table 4. Effect of farmyard manure and nutrients on nutrient uptake of Indian mustard (pooled over 2 years).

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
	Seed	Stover	Seed	Stover	Seed	Stover
Farmyard manure (t/ha)						
Control	40.5	15.7	7.4	7.5	7.4	35.1
10	47.6	19.2	8.8	9.3	8.8	42.0
20	54.7	22.6	10.2	10.9	10.0	46.9
SEm±	0.6	0.3	0.1	0.1	0.1	0.4
CD (P=0.05)	1.9	0.8	0.4	0.3	0.3	1.1
Fertility (N + P_2O_5 kg/ha)						
Control	36.8	14.7	6.9	6.7	6.4	30.7
40 + 20	50.4	19.9	9.3	9.6	9.4	43.4
80 + 40	55.6	23.0	10.3	11.3	10.4	49.9
SEm±	0.6	0.3	0.1	0.1	0.1	0.4
CD (P=0.05)	1.9	0.8	0.4	0.3	0.3	1.1

grated nutrient management (Table 2). The mean cost of cultivation was observed maximum under 10 t FYM/ha and 80 kg N + 40 kg P_2O_5/ha. The net returns of Indian mustard was increased significantly due to incorporation of 10 t FYM/ha and 80 kg N + 40 kg P_2O_5/ha. The maximum B:C ratio was obtained under without application of FYM due to less cost of cultivation while significantly higher benefit: cost ratio was recorded with application of 40 kg N + 20 kg P_2O_5/ha.

Hence it may be concluded that growing of Indian mustard with incorporation of 20 t FYM/ha in conjunction with application of 80 kg N + 40 kg P_2O_5/ha holds great promise for increased productivity of mustard in arid zone of Rajasthan.

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