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Effect of integrated nutrient management on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea L.*).

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ABSTRACT

A field experiment was conducted at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar) during winter (Rabi) season 2015-16 on sandy loam soil to study the effect of Integrated nutrient management on, growth, yield, quality and nutrient uptake by Indian mustard (Brassica juncea L.).The experiment was laid out in randomized block design (RBD) comprising eleven treatments with three applications. The results revealed that the application of 75% RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter +PSB recorded maximum number of siliqua plant^{-1} (274.0), seeds siliqua^{-1} (12.44) and seed and stover yield (1.78t ha^{-1} and 6.15t ha^{-1}). Application of 75% RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter +PSB also recorded maximum utilization N, P and K by mustard crop. The maximum weight of 1000-seed of mustard was found with application of RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB. The crop quality in respect of oil and protein contents increased significantly with integrated use of 75% RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter +PSB. The phycochemical properties and available nutrients in soil also affected by application of different treatment combinations. The pH tended to decrease with the various treatments over control. Available NPK status also improved with the integrated use of nutrients and maximum values were recorded with 75% RDF + 40kg S + 5t vermi compost ha^{-1} + Azotobacter + PSB. The minimum values of yield attributes, seed and stover yields and uptake of nutrients were recorded under control.

Key words: Poultry manure, vermicompost, mustard, uptake, available nutrients

INTRODUCTION

India is the third largest producer of rapeseed-mustard with 68.2 lakh tonnes production however, the average yield of rapeseed-mustard in India is only 1089 kg/ha. Rapeseed -mustard are the major *Rabi* oilseed crops of India and stand next to groundnut in the oilseed economy and contributing 20 percent of the total oilseed production in India. In Bihar, crop brassicas are most important edible oilseed group of crops with predominance of Indian mustard followed by toria and yellow sarson. Rape-seed and mustard having area in 0.09 million hectare with 0.09 million tones production, however the average yield is about 1057 kg ha^{-1} in Bihar. Due to intensive cultivation and imbalanced and inadequate supply of fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in the nutrients, but also deteriorated the soil health resulting in decline in crop response. In order to bring the soil well supplied with all the essential plant nutrients, the organic manures being cheaper and eco-friendly could be the alternative to fertilizers for improving both crop productivity and sustainability of the systems. Integrated use of vermicompost with fertilizers, not only supplies macronutrients but also meet the requirement of micronutrients and maintains physico-chemical properties of soil. Poultry manure which is also a good source of organic matter plays a vital role in improving soil fertility and as it contains high quantity of nitrogen and phosphorus. Integrated use of nutrient is very essential approach, which not only sustains high crop production over the years but also improves soil health and ensures safer environment. Sulphur is also important element which increases yield attributes resultantly the yield of Indian mustard (Kumar *et al.* 2011) and also enhanced S uptake as well as oil content (Kumar and Trivedi, 2012, Singh *et al.* 2017). Biofertilizers can prove to be an effective low cost technology for the farmers. Thus, there is a need to improve the nutrient supply systems in terms of integrated nutrient management involving the use of fertilizers in conjunetion with

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organic manures and fertilizers. The objective of this study was to examine the effect of integrated nutrient management on yield, their attributing traits, nutrients uptake by Indian mustard and soil properties.

MATERIALS AND METHODS

A field experiment was conducted during winter (*Rabi*) season of 2015-16 at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar) situated at 25.98^0N latitude and 85.60^0E longitude and 52.18 meter above mean sea level. The experimental soil was sandy loam in texture, soil pH (8.6) indicating alkaline in reaction, EC 0.43 dSm^{-1}, $CaCO_3$ 274 g kg^{-1}, organic carbon 5.6 g kg^{-1} revealed medium in range and available Nitrogen 162 kg ha^{-1}, Phosphorus 8.6 kg ha^{-1}, Potassium 96.4 kg ha^{-1} and available sulphur 10.8 kg ha^{-1}. The experiment was laid out in randomized block design comprising eleven treatments *i.e.* T_1-Absolute Control, T_2-RDF(N,P,K)@80:40:40+40kg S ha^{-1}, T_3-RDF+40kg S+5t vermicompost ha^{-1}, T_4-RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter+PSB, T_5-RDF+40kg S+2t poultry manure ha^{-1}, T_6-RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB, T_7-75% RDF+40kg S ha^{-1}, T_8-75% RDF+40kg S+5t vermicompost ha^{-1}, T_9-75% RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter +PSB, T_{10}-75% RDF +40kg S+2t poultry manure ha^{-1}, T_{11}-75% RDF+40kg S+2t poultry manure ha^{-1}+Azotobacter+PSB with three replications. The mustard seeds were inoculated with Rhizobium and PSB as per treatments. The crop variety was Rajendra suphlam used as a test crop. The crop was sown in second week of December, 2015 and harvested at physiological maturity. Five plants were selected from each net plot to record growth and yield parameters and the grain and straw yield was recorded from the whole plot harvest. The seed and straw samples were analysed for their N, P, K and S content by adopting standard procedures (Jackson 1973). The uptake of nutrients in seed and stover was estimated by multiplying the seed and stover yield with the irrespective of nutrient concentration. Oil content in mustard grain was determined by using Soxhlet extraction method. Protein content in seed was computed by multiplying the total nitrogen content with 6.25. The oil and protein yield was calculated in seeds multiplied by oil and protein content divided by 100. The physicochemical properties and nutrients status of post harvest soil was determined as per standard methods (Jackson 1973). The data were statistically analysed using standard procedure of ANOVA.

RESULTS AND DISCUSSION

Yield attributes and yield

The data (Table 1) indicated that significant differences were observed in yield and yield attributes with various treatments. The length of siliqua had no significant response to different treatments. The maximum siliqua $plant^{-1}$ (27.40) was recorded with 75%RDF+40kg S +5t vermicompost ha^{-1}+ Azotobacter + PSB which was significantly superior over recommended dose of fertilizers. However, siliqua $plant^{-1}$ was at par with RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter+PSB, 75% RDF+40kg S^1+5t vermicompost ha^{-1}, RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB, & 75% RDF+40kg S+2t poultry manure ha^{-1}+Azotobacter+PSB, where treatments were integrated with organics and biofertilizers. Similar finding was also reported by Pal *et al.* (2008). Data showed (Table 1) that the highest seeds $siliqua^{-1}$ (12.44) was recorded with 75% RDF+40kgS +5t vermicompost ha^{-1}+Azotobacter +PSB followed by 75% RDF + 40 kg S + 2t poultry manure ha^{-1}+ Azotobacter + PSB (11.9) and 75%RDF+40kg S +2t poultry manure ha^{-1} (11.8) . The results showed that the use of 25% reduced quantity of NPK with organics and bio-fertilizers proved better combination in terms of seeds $siliqua^{-1}$. The similar finding was also reported by Rundal *et al.* (2013). The maximum 1000-seed weight (5.70g) was recorded in RDF + 40kg S + 2t poultry manure ha^{-1}+ Azotobacter+PSB followed by 100% RDF + 40 kg S + 2t poultry manure ha^{-1}+Azotobacter+PSB and it was increased 19.2.% over control. The recommended dose of fertilizers combined with sulphur and organics provided opportunity for seeds to grow their full potential, which reflected to increase in 1000-seed weight. Similar results have also been reported by Singh and Singh. (2017). The seed and stover yield of mustard increased significantly with all the treatments over control. The maximum (1.78t ha^{-1} and 6.15 t

ha^{-1}) and minimum seed and straw yield (0.87 t ha^{-1} and 3.27 t ha^{-1}) were recorded with 75% RDF + 40 kg S + 5t vermicompost + Azotobacter + PBS and control treatment respectively.. The variation in seed and stover yield was observed due to variation in treatment combinations. The increment in seed yield might be due to improvement in soil quality with the application of vermicompost and poultry manures and instant availability of nutrients from inorganic fertilizers. These finding are also reported by Saha *et al.* (2010). Similar results were also observed in stover yield (Table-1). The application of reduced quantity of chemical fertilizers along with organics and microbial inoculants gave better results in terms of yield and yield attributing traits and prove better sustainable integrated nutrients management option for farmers. The results indicated that the application of different treatments had significant effect on oil content over control (Table 2). The maximum oil content (40.9%) in mustard seeds was recorded with 75% RDF+40kg S +5t vermicompost ha^{-1}+ Azotobacter +PSB while, minimum (37.2%) in control treatment. Crop fertilized with 25% reduced quantity of chemical fertilizers combined with vermicompost and poultry manures inoculated with Azotobactor and PSB affected the quantity of mustard oil. The similar observation was made by Kumar and Trivedi (2012) and Gauri-Shankar *et al.* (2002). Protein content in mustard seed varied from 13.2 to 14.6% and maximum value was recorded with 75% RDF+40kg S +5t vermicompost ha^{-1}+ Azotobacter +PSB. Application of sulphur with RDF along with organics recorded increased amount of oil and protein content in mustard seed (Table 1). The similar findings were reported by Paliwal and Singh (2014) amd Singh *et al.* (2017). Similar results were observed with respect to oil and protein yield of mustard seed.

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

Treatments	Length of siliqua (cm)	Siliqua plant^{-1}	Seeds sili-qua^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})	Protein content in seed (%)	Protein yield (kg ha^{-1})
Absolute Control	4.37	168.6	10.2	4.78	0.87	3.27	37.2	322.9	13.2	114.9
RDF (80:40:40+40 kg S ha^{-1})	4.43	218.3	10.7	5.11	1.58	5.30	39.4	622.3	13.9	219.9
RDF+40kg S+5t Vermicompost ha^{-1}	4.49	263.3	10.8	5.30	1.67	5.53	39.6	664.0	14.2	238.7
RDF+40kg S+5t VC ha^{-1}+ Azot.+PSB	4.63	269.3	11.3	5.35	1.72	5.76	39.8	683.6	14.2	243.5
RDF +40kg S +2t poultry manure ha^{-1}	4.53	263.0	11.3	5.57	1.64	5.59	40.1	659.6	14.3	235.3
RDF+40kg S+2t PM ha^{-1}+ Azot.+PSB	4.53	265.3	11.8	5.70	1.67	5.83	40.8	682.8	14.4	241.6
75% RDF +40kg S ha^{-1}	4.37	235.3	11.7	5.13	1.56	5.34	39.5	615.6	13.8	215.9
75% RDF+ 40 kg S +5t VCt ha^{-1}	4.50	267.6	11.3	5.14	1.70	5.92	39.7	676.4	14.4	245.1
75% RDF +40 kg S +5t VC ha^{-}+Azot+PSB	4.60	274.0	12.4	5.10	1.78	6.15	40.9	729.4	14.6	260.6
75% RDF +40kg S +2 t PM ha^{-1}	4.43	243.6	11.8	5.10	1.63	5.60	39.3	642.9	14.1	230.9
75% RDF+40kg S + 2t PM ha^{-1}+Azot.+PSB	4.57	255.6	11.9	5.23	1.66	5.64	39.5	656.1	14.2	235.2
C.D. (P=0.05)	NS	14.2	1.1	0.43	0.059	0.26	0.8	28.6	0.3	10.9

VC=Vermicompost, PM=Poultry manure, Azot.= Azotobacter

Nutrient uptake

The uptake of nutrients in seed and stover by mustard crop increased significantly by using different treatments over absolute control (Table 2). Application of 75% RDF + 40 kg S + 5t vermicompost ha^{-1} + Azotobacter + PSB resulted significantly higher nutrients uptake by the mustard crops. The maximum N utilization by seed (41.7 k ha^{-1}) and stover (33.2 k ha^{-1}) was recorded with 75% RDF + 40kg S + 5t vermicompost ha^{-1}+ Azotobacter +PSB. Application of RDF + 40 kg S + 5t vermicompost ha^{-1}+ Azotobacter + PSB, RDF + 40kg S + 5t vermicompost ha^{-1}, RDF + 40 kg S+2t poultry manure ha^{-1}+ Azotobacter + PSB and 75% RDF+40kg S+5t vermicompost ha^{-1} also obtained at par results with 75% RDF + 40 kg S +5t vermicompost ha^{-1}+ Azotobacter + PSB. Application of either RDF or 25% reduced RDF also recorded significantly higher nutrients uptake by mustard seed and stover over control. Similar trend were also noticed in P & K uptake in seed and stover of mustard crops. Significantly higher P accumulation (8.7 and 15.3 kg ha^{-1}), K (15.1 and 91.6 kg ha^{-1}) in seed and straw were observed with 75% RDF+40kg S +5t vermicompost ha^{-1}+ Azotobacter +PSB. Sulphur is an important nutrient, which improves the quality of mustard. The similar results were reported by Singh *et al.*(2007). The maximum uptake of sulphur (13.3 k ha^{-1}) and (19.8 kg ha^{-1}) was registered in seed and stover with application of RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB and it ranged from 4.4 to 13.3 and 9.1 to 19.8 kg ha^{-1}. The uptake of nutrients by crops is attributed to increased nutrient concentration coupled with yield (Singh and Singh 2017).

Table 2: Effect of integrated nutrient management on uptake of N, P, K & S (kg ha^{-1}) in seed and stover of Indian mustard

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Absolute Control	18.4	13.0	3.2	5.5	7.2	43.8	4.4	9.1
RDF (80:40:40+40 kg S ha^{-1})	35.2	24.3	5.9	11.1	13.4	77.9	9.7	15.8
RDF+40kg S+5t Vermicompost ha^{-1}	38.2	26.6	6.5	12.2	14.7	82.4	10.7	17.2
RDF+40kg S+5t VC ha^{-1}+ Azot.+PSB	38.9	29.9	7.2	14.3	14.9	83.6	12.8	18.4
RDF +40kg S +2t poultry manure ha^{-1}	37.6	26.0	7.2	12.7	13.9	80.8	12.8	18.8
RDF+40kg S+2t PM ha^{-1}+ Azot.+PSB	38.7	30.3	6.7	15.1	14.4	86.3	13.3	19.8
75% RDF +40kg S ha^{-1}	34.5	24.1	6.6	11.7	12.9	77.5	11.2	17.0
75% RDF+ 40 kg S +5t VCt ha^{-1}	39.2	30.7	8.2	13.6	14.5	87.1	11.2	17.7
75% RDF +40 kg S +5t VC ha^{-1}+Azot. +PSB	41.7	33.2	8.9	15.3	15.1	91.6	12.3	17.1
75% RDF +40kg S +2 t PM ha^{-1}	36.9	28.6	7.2	11.7	14.3	82.3	11.6	14.6
75% RDF+40kg S + 2t PM ha^{-1}+Azot.+PSB	37.6	29.9	8.7	14.6	14.1	82.3	11.4	18.0
SEm±	1.2	1.8	0.2	1.2	0.5	3.4	0.4	0.7
C.D. (P=0.05)	1.6	2.4	0.3	1.7	0.6	4.7	0.6	1.0

Soil fertility

The soil pH and total soluble salts in soil after crop harvested tended to decrease due to integrated use of organic manures with chemical fertilizers. Among the treatments, minimum soil pH was recorded with 75%RDF+40kg S +5t vermicompost ha^{-1} which was at par with 75% RDF + 40 kg S+5t vermicompost ha^{-1}+ Azotobacter + PSB. The reduction in soil pH might be due to oxidation of sulphur and decomposition of vermicompost and poultry manures. Similar results were also recorded by Yadav *et al.* (2010). The electrical conductivity of soil after crop harvest was not affected significantly with application of different treatments. On the other hand, soil organic carbon content increased significantly with the integrated use of treatments. The maximum soil organic carbon content (7.6 g kg^{-1}) was recorded with RDF+40kg S+5t vermicompost ha^{-1}+ Azotobacter+PSB while minimum (5.6 g kg^{-1}) in control plot.

Table 3: Effect of integrated nutrient management on soil physicochemical properties and nutrients availability

Treatments	pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Bulk Density ($MG\ m^{-3}$)	$CaCO_3$ ($g\ kg^{-1}$)	WHC (%)	Available nutrients($kg\ ha^{-1}$)			
							N	P	K	S
Absolute Control	8.59	0.46	5.6	1.34	272	37.50	168.0	9.7	98.3	10.5
RDF (80:40:40+40 kg S ha^{-1})	8.54	0.41	6.8	1.33	268	37.89	178.6	10.8	106.7	14.5
RDF+40kg S+5t Vermicompost ha^{-1}	8.46	0.45	7.2	1.30	284	39.64	186.1	13.6	111.2	13.7
RDF+40kg S+5t VC ha^{-1}+ Azot.+PSB	8.52	0.42	7.6	1.30	273	40.32	188.0	14.1	117.2	15.7
RDF +40kg S +2t poultry manure ha^{-1}	8.46	0.43	7.2	1.32	288	39.62	186.0	12.6	108.7	14.6
RDF+40kg S+2t PM ha^{-1}+ Azot.+PSB	8.49	0.43	7.3	1.29	306	39.60	187.6	13.2	115.5	14.4
75% RDF +40kg S ha^{-1}	8.50	0.42	6.5	1.32	298	37.75	183.0	10.9	110.8	13.6
75% RDF+ 40 kg S +5t VCt ha^{-1}	8.45	0.41	6.6	1.29	305	40.47	179.2	13.4	112.1	14.0
75% RDF +40 kg S +5t VC ha^{-1}+Azot. +PSB	8.45	0.43	6.8	1.28	289	40.61	200.4	13.8	113.9	15.7
75% RDF +40kg S +2 t PM ha^{-1}	8.49	0.41	6.9	1.31	292	39.37	184.2	13.0	104.5	12.1
75% RDF+40kg S + 2t PM ha^{-1}+Azot.+PSB	8.50	0.40	7.3	1.29	268	39.59	194.6	12.6	109.2	15.4
SEm±	0.04	NS	0.2	0.025	9.8	0.79	2.86	0.52	1.09	0.27
C.D (P=0.05)	0.06	NS	0.3	0.034	13.4	1.08	3.90	0.71	1.48	0.37

The bulk density of soil decreased (Table 3) due to addition of vermicompost and poultry manure in various treatments. Similar observations were noticed by Pathak *et al.* (2015). The maximum value of $CaCO_3$ (306 g kg^{-1}) was obtained in RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB. Application of poultry manure might be added few quantity of calcium to the soil. The water retention increased on the addition of organic components in to the soils. The maximum water holding capacity (40.16%) was noticed with the application of 75% RDF + 40kg S + 5t vermicompost ha^{-1}+Azotobacter + PSB. The amounts of available N, P, K and S in soil after harvest were affected with application of different treatments. The available nitrogen in soil ranged from 178.6 to 200.4 kg ha^{-1}. The maximum value of available nitrogen (220.4 kg ha^{-1}) was noticed with 75%RDF + 40 kg S + 5t vermicompost ha^{-1} + Azotobacter + PSB, which was superior to other treatments except 75% RDF+40kg S+2t poultry manure ha^{-1}+Azotobacter+PSB might. The amount of available phosphorus in soil amongst the various treatments was observed except recommended dose offertilizers. Increased quantity of phosphorus was also noticed in PSB inoculated treatments. Application of RDF+40kg S+2t poultry manure ha^{-1}+ Azotobacter+PSB recorded highest amount of available potassium (115.5 kg ha^{-1}), whereas, maximum sulphur was noticed with 75%RDF+40kg S+5t vermicompost ha^{-1}+Azotobacter+PSB. The integrated approach of nutrients increased available potassium and sulphur in soil than recommended dose of fertilizers (Singh *et al.* 2017).

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