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Yield performance and nutrient uptake of Indian mustard (*Brassica juncea* L.) as influenced by integrated nutrient management

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ABSTRACT

Field experiment was conducted at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar (Odisha) during the consecutive two rabi seasons of 2010 and 2011 to study the effect of integrated nutrient management on yield performance and nutrient uptake of mustard [Brassica juncea (L.) Czern and Coss]. Experiment was laid out in a randomized block design, consisting eleven treatments viz., T_1 - RDF (N : P_2O_5 : K_2O @ 60 : 30 : 30 kg ha^{-1}), T_2 - RDF + S (40 kg ha^{-1}), T_3 - RDF + B (1 kg ha^{-1}), T_4 - RDF + lime (0.2 LR), T_5 - RDF + Zn-EDTA (0.5 kg ha^{-1} as foliar spray), T_6 - 75% RDF, T_7 - 75% RDF + FYM (5 t ha^{-1}), T_8 - 75% RDF + FYM (5 t ha^{-1}) + S (40 kg ha^{-1}), T_9 - 75% RDF + FYM (5 t ha^{-1}) + B (1 kg ha^{-1}), T_{10} -75% RDF + FYM (5 t ha^{-1}) + lime (0.2 LR), T_{11} - 75% RDF + FYM (5 t ha^{-1}) + Zn-EDTA (0.5 kg ha^{-1} as foliar spray), respectively replicated thrice. The soil was loamy sand in texture with pH 5.5, low in organic carbon and nitrogen, high in phosphorus and medium in potash. The results reveal that the treatment (T_{10}), which received 75 % RDF + FYM @ 5 t ha^{-1} + lime (0.2 LR) produced maximum number of effective siliqua (226 $plant^{-1}$), longest siliqua (4.4 cm), seeds $siliqua^{-1}$ (14.1), 1000 seed weight (4.35 g), highest seed and stover yield (1423 and 2759 kg ha^{-1}), respectively. Reduction of 25% fertilizer from the recommended dose (RDF) produced minimum yield of 973 kg ha^{-1} which was 8% less than RDF. The treatment (T_{10}) also absorbed 72 kg N, 13 kg P, 34 kg K, 17 kg S, 124 g B, 163 g Zn and 42 kg Ca ha^{-1}. So sound agronomic and environmentally acceptable integrated nutrient management practices are essential to achieve a reduction in fertilizer derived environmental risk while increasing the net return and crop productivity through nutrient use efficiency.

Keywords : Farm yard manure, INM, lime, siliqua

Rapeseed-mustard is the third important oilseed crop in the world after soybean and palm oil. In India, soybean, groundnut and rapeseed-mustard are the major oilseed crops contributing nearly 79 and 88% to its total acreage and production, respectively. During 2012-13, rapeseed -mustard contributed 22.4 and 24.2% to the total oilseeds acreage and production in India. The yield of rapeseed-mustard was 1176 kg ha^{-1} as compared to 969 kg ha^{-1} of the total oilseeds (DES, 2013). The share of oilseeds is 14.1% out of the total cropped area in India and rapeseed-mustard accounts for 3% of it.

In Odisha rapeseed and mustard is grown in an area of 116 thousand hectares (DAFP, 2012-13). The total production comes to 49 thousand tonnes with productivity of 422 kg ha^{-1}, which is much below the national average of 1176 kg ha^{-1}. 70 % of Odisha soils are acidic in nature and deficient in S (28 %), boron (44 %) and zinc (19 %). Under such situation application of organic source of amendments like farm yard manure (FYM) either alone or in combination with inorganic one like lime have been suggested for controlling acidity as well as nutrient availability (Mishra and Das, 2000). It is advisable to note that lime should be applied at 10 to 20 % LR dose mixing with FYM in rows, below the seeds or behind the plough at the time of sowing for exhibited better results (Mishra, 2004). Hence, an attempt was made to assess the response of Indian mustard to integrated nutrient management (INM) for obtaining better results under such situation of Odisha.

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MATERIALS AND METHODS

Field experiment was conducted during two consecutive *rabi* seasons of 2010-11 and 2011-12 at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. It is located at $20^0$152 North latitude , 85^0 522 East longitude and an altitude of 25.9 m above the mean sea level. The soil of the experimental field was loamy sand with pH 5.5, organic carbon 0.36% and 161, 57 and 101 kg/ha available nitrogen, P and K, respectively. The experiment was laid out in randomized block design, comprising eleven treatments *i.e.* T_1 - RDF (N : P_2O_5 : K_2O @ 60 : 30 : 30 kg ha^{-1}), T_2 - RDF + S @ 40 kg ha^{-1}, T_3 - RDF + B @ 1 kg ha^{-1}, T_4 - RDF + Lime @ 0.2 LR, T_5 - RDF + Zn EDTA (foliar spray), T_6 - 75% RDF, T_7 - 75% RDF + FYM @ 5 t ha^{-1}, T_8 - 75% RDF + FYM @ 5 t ha^{-1} + S @ 40 kg ha^{-1}, T_9 - 75% RDF + FYM @ 5 t ha^{-1} + B @ 1 kg ha^{-1}, T_{10} - 75% RDF + FYM @ 5t ha^{-1} + Lime 0.2 LR and T_{11} - 75% RDF + FYM @ 5 t ha^{-1} + Zn EDTA (foliar

spray), respectively replicated thrice. The crop variety' Pusa Bahar 'was sown on 7 and 15 November and harvested on 20 and 29 February during 2010-11 and 2011-12 respectively. Nitrogen, phosphorous and potash were applied in the form of urea, di-ammoniun phosphate and muriate of potash. Phosphorous and potash were applied as basal and nitrogen was applied in equal two splits, *i.e.* as basal and rest at three weeks stage of the crop. Sulphur was applied as elemental sulphur, boron as borax, lime as paper mill sludge and zinc as Zn-EDTA. Five plants were selected from each net plot to record growth and yield parameters. The nutrient content (N, P, K, S, B, Ca ad Zn) were estimated from both seed and stover separately during both the years and their uptake were estimated by multiplying seed and stover yield with respective nutrient content. The total uptake was estimated by adding the values of each nutrient for seed and stover both and finally expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Effect on yield attributes

The data pertaining to various yield attributes studied *viz.,* number of siliquae $plant^{-1}$, seeds $siliqua^{-1}$, length of siliqua and 1000 seed weight as influenced by various treatments are presented in table.1.

Minimum number (120 $plant^{-1}$) of siliquae were recorded with 75 % RDF, which was 12 % less than that of RDF. Addition of FYM to 75% RDF increased the number by 20 % and 36 % more than RDF and 75 % RDF respectively. Maximum number of siliquae were produced per plant by addition of lime to 75 % RDF + FYM (226). Addition of either boron or zinc to RDF did not differ significantly from the effect of RDF and 75 % RDF +FYM. Application of sulphur with RDF and75 % RDF + FYM increased the siliquae number by 18 % to 24 %, whereas lime increased it by 38 % to 39 %.

Table 1: Effect of integrated nutrient management on yield attributes and yield (pooled).

Treatment	No. of siliqua $plant^{-1}$	Length of siliqua (cm)	No. of seeds $siliqua^{-1}$	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
	136	4.15	10.9	3.74	1055	2160
T_2	169	4.30	12.0	3.87	1162	2297
T_3	159	4.25	11.4	3.81	1107	2247
T_4	187	4.37	12.2	4.13	1270	2401
T_5	152	4.20	11.3	3.78	1091	2236
T_6	120	4.07	10.7	3.61	973	2146
T_7	163	4.22	11.9	3.86	1152	2449
T_8	192	4.38	12.6	4.01	1328	2654
T_9	169	4.33	12.1	3.90	1253	2545
T_{10}	226	4.42	13.8	4.35	1423	2759
T_{11}	167	4.25	11.6	3.85	1240	2509
SEm(±)	**6.72**	**0.04**	**0.32**	**0.03**	**16.87**	**29.92**
LSD(0.05)	**20.15**	**0.12**	**0.95**	**0.11**	**50.55**	**89.69**

Table 2: Effect of integrated nutrient management on nutrient uptake (pooled)

	Nutrient uptake (kg ha^{-1})						
Treatment	**N**	**P**	**K**	**S**	**B***	**Ca**	**Zn***
T_1	36.3	5.0	11.5	8.7	54	17.7	101
T_2	58.1	8.6	22.9	13.6	77	21.6	120
T_3	42.6	6.4	17.3	10.9	93	19.2	118
T_4	58.6	10.5	26.9	13.9	97	31.8	140
T_5	40.3	5.9	11.2	9.8	70	18.8	132
T_6	31.8	4.3	9.7	7.6	43	16.6	95
T_7	42.3	6.1	14.4	10.5	66	24.7	114
T_8	72.5	10.6	29.0	16.3	97	31.8	142
T_9	50.9	8.2	21.2	13.5	117	27.3	137
T_{10}	72.3	12.9	33.6	17.0	124	42.3	163
T_{11}	48.1	7.2	14.1	11.6	78	24.4	154
SEm(±)	**0.39**	**0.09**	**0.15**	**0.21**	**0.78**	**0.3**	**0.52**
LSD(0.05)	**1.17**	**0.27**	**0.44**	**0.63**	**2.34**	**0.9**	**1.57**

Longest siliqua (4.4 cm) were observed by application of lime with RDF or 75 % RDF + FYM followed by that of sulphur. It increased by 4.7 % more than RDF or 75 % RDF + FYM . Reduction of 25 % fertilizer from RDF did not affect the length significantly.

Maximum number of seeds siliqua^{-1} (13.8) was recorded with 75 % RDF + FYM + Lime, which was 10 % to 14 % more than 75 % RDF + FYM + S/B/Zn. Reduction of 25 % fertilizer from RDF did not affect seed number per siliqua significantly. However, it produced lowest number of seeds among the treatments (10.7siliqua^{-1}) but *at par* with T_{11}. Addition of FYM to 75 % RDF did not increase the seed number significantly. It was *at par* with that of addition of S/B/Zn to T_8.

Application of S/B/L/Zn increased test weight when applied with RDF (1 % to 10.4 %) or 75 % RDF + FYM (1 % to 12.7 %) except T_{11} .The effect of sulphur and lime was significant while that of boron and zinc was not, when applied with RDF or 75 % RDF + FYM.

Maximum siliquae plant^{-1} (226), longer siliqua (4.4 cm), number of seeds slilqua^{-1} (13.8) and test weight (4.35 g) was recorded in the treatment T_{10} *i.e.,* 75 % RDF + FYM (5 t ha^{-1} + lime (0.2 LR). Application of FYM @ 5 t ha^{-1} acted as a buffer in the experimental soil with pH 5.5 and its combined application with lime provided a favourable environment to supply both the macro and micro nutrients in adequate proportion.

Effect on seed and stover yield

The seed yield differed significantly due to addition of sulphur/ boron/ lime and zinc either with RDF or 75 % RDF + FYM @ 5 t ha^{-1}. Application of recommended dose of fertilizer produced the seed yield of 973 kg ha^{-1}. Reduction of 25 % RDF decreased the seed yield by 8.4 % and addition of 5 t FYM to 75 % RDF increased it by 18.4 % over 75 % RDF and 9.2 % over RDF. Addition of S, B, lime and zinc to RDF increased the seed yield by 10 %, 5 %, 20 % and 3 % respectively as compared to RDF alone. Integrated use of S, B, lime and zinc with 75 % RDF + FYM (5 t ha^{-1}), increased the seed yield by 15 %, 9 %, 24 % and 8 % respectively. Maximum seed yield (1423 kg ha^{-1}) was obtained with application of 75 % RDF + FYM (5 t ha^{-1}) + lime (0.2 LR) followed by 75 % RDF +FYM + Sulphur (1328 kg ha^{-1}) and RDF + Lime (1270 kg ha^{-1}).Improvement in seed yield might be due to improvement of soil pH due to lime, physicochemical properties of the soil due to FYM and instant availability of nutrients from inorganic fertilizer. Increased pod yield of groundnut by lime application have also been reported by Ghosh *et al*.(2015).

Similar trend was also observed in stover yield. It was maximum (2759 kg ha^{-1}) with application of 75 % RDF + FYM (5 t ha^{-1}) + lime (0.2 LR) followed by 75 % RDF + FYM + S (40 kg ha^{-1}). Addition of sulphur , B, lime and zinc to RDF increased the stover yield by 6 %, 4 %, 11 % and 4 % respectively and their integrated use with 75 % RDF + FYM 5 t ha^{-1} increased the stover yield by 23 %, 18 %, 28 % and 16 % respectively as compared to RDF.

The beneficial effect of combined application of FYM and lime in improving the physicochemical condition of the acid soil for achieving higher seed yield of mustard has been reported by Saha *et al*. (2010), Nayak (2007) and Badajena, 2003 .

Effect on nutrient uptake

Nutrient uptake differed significantly due to different treatments (Table 2) .Maximum amount of nitrogen (72.3 kg ha^{-1}), phosphorus (12.9 kg ha^{-1}) and potassium (33.6 kg ha^{-1}) was absorbed by the crop fertilized with 75 % RDF + FYM (5 t ha^{-1}) + lime (0.2 LR) due to highest biomass production. The combined application of inorganic fertilizers along with organic manure (FYM) and lime under acid soil condition control soil acidity, stimulate uptake of nturients due to enhanced microbial population and activity and better root growth under congenial soil physical condition created by addition of FYM. These results corroborated the earlier findings of Mishra and Das (2000).

Lime application has a positive influence on availability of sulphur. Highest uptake of sulphur (17 kg ha^{-1}) was also recorded in the treatment T_{10} (75 % RDF + FYM (5 t ha^{-1}) + lime (0.2LR)) which was *at par* with T_8 (75 % RDF + FYM 5 h ha^{-1} + S @ 40 kg ha^{-1}) due to application of S. These results are in accordance with those of Badajena (2003).

Liming of acid soil improves base saturation and availability of calcium and magnesium. Highest calcium uptake (42.3 kg ha^{-1}) in T_{10} (75 % RDF + FYM @ 5 t ha^{-1} + lime (0.2 LR) was due to application of lime that increased the availability of calcium in the root zone, hence its uptake. Sarkar (2013) reported that application of lime with NPK build up the organic carbon status, increased the content of Ca and Mg and reduced exchangeable Al^{+3} in soils

Maximum uptake of boron (124g ha^{-1}) was observed in the treatment applied with 75 % RDF + FYM 15 t ha^{-1}) + lime (0.2 LR). In acid soils where B is a limiting element, liming creates a favourable environment in that soil, stimulates the activities of the microbes,

consequently breaks down the B-diol complexes resulting in better B availability to plant (Bose *et al*., 2002).

Highest zinc uptake (163 g ha^{-1}) was also recorded in the treatment T_{10} *i.e.,* 75 % RDF + FYM + L. Greater accumulation and uptake of nutrients under this treatment could be ascribed to better availability and synergistic effect of applied nutrients.

From the above study it can be concluded that application of 75% RDF along with FYM @ 5t ha^{-1} and lime @ 0.2 LR produced higher yield of mustard and higher uptake of N, P, K, S, B, Ca and Zn as compared to recommended fertilizer alone and other nutrient management treatments.

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