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Influence of integrated nutrient management on growth, yield and quality of Indian mustard (*Brassica juncea* L.) in *tarai* region of northern India

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ABSTRACT

A field experiment was conducted during *Rabi* season, 2005-06 and 2006-07 at the Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar to study the effect of integrated nutrient management (INM) on growth, yield and quality of Indian mustard cultivar *Kranti*. Twelve treatments consisting of 100 and 75 % of the recommended dose of fertilizers (RDF) (120-40-20 kg N-P_2O_5-K_2O ha^{-1}) either alone or with successive addition of farmyard manure (FYM), sulphur, zinc, boron and *Azotobacter* were tested. Application of 100 % recommended dose of fertilizers along with farmyard manure, sulphur, zinc, boron and *Azotobacter* (seed treatment) resulted in maximum plant height, dry matter accumulation, total branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$, 1000 seed weight and higher seed yield. The variations in growth and yield between 100 and 75 % recommended dose of fertilizers with farmyard manure, sulphur, zinc, boron and *Azotobacter* were not significant. Significantly higher oil content was recorded at 75 % recommended dose of fertilizers with farmyard manure, sulphur, zinc, boron and *Azotobacter* than that of respective ingredients with 100 % recommended dose of fertilizers. Protein content was significantly higher in 100 % recommended dose of fertilizers + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + *Azotobacter* (seed treatment) compared to 75 % recommended dose of fertilizers. Nutrient concentration in terms of N, P, K, S, Zn and B content in seed and stover were significantly higher at higher 100 % recommended dose of fertilizers and increased significantly at both the fertility levels with each successive addition of farmyard manure, S, Zn, B and *Azotobacter*. Net returns and B : C ratio were recorded maximum in 100 % recommended dose of fertilizers + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + *Azotobacter* (seed treatment).

Key words: Growth, INM, Indian mustard (*Brassica juncea* L.), oil and protein content and yield.

The requirement of vegetable oils and fats will be much higher in coming years in view of ever increasing population. India would need 58 million tonnes of oilseeds by 2020 for maintaining minimum edible oil requirement of 12 kg $capita^{-1}$ $annum^{-1}$ (Mittal, 2008) from the present level of 8.2 kg (Anonymous, 2007). To produce an additional quantity of oilseed, the only option is to enhance productivity under the limited land resource condition. Among the oilseeds crop, rapeseed and mustard occupy rank next to soybean in acreage and production. The inadequate supply of inputs often leads to limit the yield potential of rapeseed and mustard (Anonymous, 2006).

Identification of the critical inputs to enhance the mustard production is need of hour. Apart from improved varieties and judicious irrigation, use of balanced fertilizers is critical for realizing higher yield. Indian soils are becoming deficient in N, P, K along with S, Zn, and B due to intensive cultivation and use of high analysis fertilizers (Srivastava *et al.* 2006). Under such situation organic manures can be exploited to boost the soil health condition vis-à-vis production of crops and to improve fertilizer use efficiency. However, the use of total organic or inorganic nutrient sources has some limitations (Kandpal, 2001). Balanced combination of FYM, bio-fertilizers and chemical fertilizers facilitate profitable and sustainable production (Singh and Sinsinwar, 2006). Hence, a field study was conducted to assess the response of Indian mustard (*Brassica juncea* L.) to integrated nutrient management.

MATERIALS AND METHODS

The experiment was carried out during *rabi* season of 2005-06 and 2006-07at the Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand situated at 29^0N latitude, 79.3^0E longitude and at an altitude of 243.24 meters. The soil of the experimental field was silty clay loam mollisol having having pH 7.5, organic carbon 0.90%, available nitrogen 230 kg N ha^{-1}, available phosphorus 19 kg P ha^{-1}, available potassium 302 kg K ha^{-1}, available sulphur 11 ppm, available zinc 0.47 ppm and available boron 0.62 ppm. The experiment consisted of twelve treatments *viz.*, T_1-100 % RDF, T_2 -100 % RDF + 2 t FYM ha^{-1}, T_3 -100 % RDF + 2 t FYM + 40 kg S ha^{-1}, T_4 - 100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 ha^{-1}, T_5 - 100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1}, T_6 -100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + *Azotobacter* (Seed treat.), T_7 -75 % RDF, T_8 -75 % RDF + 2 t FYM/ha, T_9-75 % RDF + 2 t FYM + 40 kg S ha^{-1}, T_{10} -75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 ha^{-1}, T_{11}- 75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} and T_{12} - 75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + *Azotobacter* (Seed treat.) laid out in randomized block design with three replications The inorganics were supplied through urea, diammonium phosphate, muriate of potash, gypsum, zinc sulphate and borax. The mustard variety '*Kranti*'

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was sown in rows 30 cm apart on 14^{th} and 10^{th} October, 2005 and 2006, respectively. Thinning was done 10 days after sowing to maintain plant to plant distance 15 cm. The FYM was applied in furrows 15 days before sowing as per the treatment. Full dose of phosphorus, potassium, sulphur, zinc sulphate, boron and half of nitrogen (as per treatment) were applied at the time of sowing. Remaining half of nitrogen was applied after first irrigation. The crop was harvested in the month of February during both the years. The oil content was estimated by non-destructive approach (Nuclear Magnetic Resonance method) using Newport Analyser-4000 (Satyarthi *et al.*, 2009). The processed plant samples were analyzed by Micro-kjeldahl method (Jackson, 1967) to determine nitrogen content. Wet digestion (di-acid) method (Jackson, 1973) was used for preparation of aliquot to determine P, K, S, Zn and B content in plant. However, boron free glassware was used for boron determination. These nutrients were analyzed as per procedure described by Singh *et al.* (1999). Since data followed the homogeneity test, pooling was done over the seasons and mean data are given. Data were analyzed in standard statistical programme developed by Department of Mathematics, Statistics and Computer Science, GBPUA&T, Pantnagar.

RESULTS AND DISCUSSION

Growth parameters

Plant height increased with the successive addition of FYM, sulphur, zinc, boron and *Azotobacter* with RDF and 75 % of RDF, though failed to result in significant differences at harvest stage (Table 1). Highest plant height was recorded with the integrated application of RDF alongwith FYM, sulphur zinc, boron and *Azotobacter* (Seed treatment). Dry matter accumulation was significantly influenced due to integrated nutrient management treatments. Maximum dry matter was recorded under 100 % RDF with all the supplementary ingredients being at par with that of 75 % RDF along with all the supplementary ingredients. Adequate supply of readily available nitrogen and other essential nutrients produced taller plants. Taller plants produced more dry matter because of more opportunity to production and accumulation of photosynthates. These results are in close conformity with the findings of Mandal and Sinha (2002) and Shukla *et al.* (2002).

Yield attributes and yield

The yield components, viz., branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1} and 1000-seed weight were significantly influenced due to integrated nutrient management treatments (Table 1). Addition of supplementary ingredients viz., FYM, sulphur, zinc, boron and *Azotobacter* at both the levels of NPK increased the number of branches. The maximum numbers of branches were recorded under T_{12}-100 % RDF + 2 t FYM + 40 kg S + 25 kg $ZnSO_4$+ 1 kg B ha^{-1} + *Azotobacter* (seed treatment). Crop receiving 75 % RDF exhibited minimum number of siliquae plant^{-1}, though remained at par with that of 100% RDF. Crop subjected to T_{12}-100 % RDF + 2 t FYM + 40 kg S + 25 kg $ZnSO_4$+ 1 kg B ha^{-1} + *Azotobacter* (seed treatment), however, exhibited maximum siliquae plant^{-1}. Seeds siliqua^{-1} increased with the successive addition of FYM, sulphur, zinc, boron and *Azotobacter* under 100 and 75 % RDF. The lowest number of seeds siliqua^{-1} was noted under 75 % RDF. The 1000-seed weight was also significantly higher in T_{12}-100 % RDF + 2 t FYM + 40 kg S + 25 kg $ZnSO_4$+ 1 kg B ha^{-1} + *Azotobacter* (seed treatment) over 100 % RDF. The similar trend was also observed for 1000-seed weight. The increase in these parameters may be ascribed to better growth and more photosynthate accumulation as a result of adequate nutrients available for growth

The crop fertilized with 75 % RDF produced lower seed yield, though *at par* with that of RDF during both the crop seasons (Table 1). Supplementing RDF with FYM, though improved seed yield but not to the level of statistical significance. Similar observations were made under 75 % RDF. However, addition of FYM and sulphur with RDF significantly improved seed yield over both RDF and 75 % RDF alone. Further, addition of zinc sulphate, boron and seed treatment with *Azotobacter* improved seed yield under both set of treatments. The highest seed yield was attained under RDF coupled with FYM, sulphur, zinc, boron and *Azotobacter,* though *at par* with that of 75 % RDF along with FYM, sulphur, zinc, boron and *Azotobacter*. The more number of branches under above treatment may be correlated with the more plant height and dry matter accumulation as a result of better nutrient supply to the crop resulting in profuse branching. Profused branching provided area to develop more number of siliquae in the same treatment. Increase in seeds per siliqua and 1000-seed weight could be ascribed to better growth and more photosynthate accumulation as a result of adequate nutrients availability to the crop. As yield is the resultant outcome of the effect of various growth factors and yield parameters its expression was observed with their integrated influence. 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 growth attributes and yield components and finally the yield. These results are in line with Rana *et al.* (2005) and Singh and Sinsinwar (2006).

Oil and protein content

The oil content in seed decreased with increasing NPK levels whereas, successive addition of FYM, sulphur, zinc, boron and *Azotobacter* increased oil content; being highest 75 % RDF along with FYM, sulphur, zinc, boron and *Azotobacter* (Table 1). Crop fertilized with FYM and sulphur with RDF and 75 %

Table 1: Growth, yield attributes, seed yield, oil and protein content and economics of mustard as influenced by integrated nutrient management (Pooled data of 2 years)

Treatments	Plant Height (cm)	Dry Matter (g plant^{-1})	Branches plant^{-1}	Siliquae plant^{-1}	Seeds siliqua^{-1}	1000 seed weight (g)	Seed yield (kg ha^{-1})	Oil content (%)	Protein content (%)	Net return (₹ ha^{-1})	Benefit cost ratio (B:C)
T_1	180.8	38.4	11.2	201.4	11.6	3.5	1430	38.6	20.42	15130	1.63
T_2	187.0	41.0	12.9	222.0	12.2	3.6	1548	38.9	20.96	16154	1.57
T_3	192.1	45.0	15.3	250.2	12.8	3.7	1694	39.2	21.52	18085	1.67
T_4	195.3	47.2	16.4	261.2	13.2	3.8	1739	39.5	21.82	18548	1.66
T_5	198.0	48.2	17.3	269.6	13.7	3.9	1772	39.7	21.98	18884	1.66
T_6	202.3	49.9	18.2	279.7	14.1	4.0	1809	40.0	22.12	19506	1.71
T_7	173.7	35.6	10.2	177.4	11.2	3.4	1303	39.2	20.08	13484	1.54
T_8	178.1	38.2	12.0	198.5	11.7	3.5	1416	39.5	20.63	14414	1.48
T_9	182.9	42.1	14.3	227.7	12.4	3.6	1570	39.9	21.28	16482	1.60
T_{10}	185.4	43.7	15.3	239.6	12.9	3.7	1622	40.1	21.39	17056	1.60
T_{11}	189.0	44.8	16.2	249.7	13.2	3.8	1657	40.4	21.60	17425	1.61
T_{12}	191.8	46.4	16.8	257.5	13.6	3.9	1694	40.7	21.69	18056	1.66
LSD(0.05)	NS	5.0	2.0	20.1	0.6	0.2	220	0.5	1.1	-	-

Table 2: N, P, K, Zn and B content of mustard as influenced by integrated nutrient management (Pooled data of 2 years)

Treatments	N (%)		P (%)		K (%)		S (%)		Zn (ppm)		B (ppm)	
	seed	stover	seed	stover	seed	stover	seed	stover	seed	stover	seed	stover
T_1	3.27	0.43	0.693	0.272	1.00	1.64	0.796	0.499	57.2	49.4	15.38	13.06
T_2	3.35	0.46	0.716	0.284	1.05	1.70	0.819	0.509	59.2	50.8	15.76	13.46
T_3	3.45	0.49	0.743	0.301	1.11	1.75	0.865	0.542	61.2	53.4	16.26	13.99
T_4	3.49	0.50	0.756	0.325	1.13	1.80	0.878	0.557	65.2	57.3	16.51	14.12
T_5	3.52	0.53	0.772	0.343	1.15	1.81	0.891	0.569	66.2	60.2	18.15	15.58
T_6	3.54	0.54	0.787	0.355	1.19	1.85	0.906	0.594	68.3	61.4	18.40	15.75
T_7	3.22	0.40	0.673	0.247	0.94	1.55	0.767	0.465	49.9	43.8	13.34	11.22
T_8	3.30	0.41	0.691	0.259	0.98	1.59	0.794	0.477	51.8	45.7	13.67	11.65
T_9	3.40	0.43	0.713	0.273	1.02	1.67	0.831	0.508	53.7	47.5	14.20	12.17
T_{10}	3.43	0.46	0.724	0.286	1.07	1.70	0.837	0.520	57.2	51.3	14.54	12.25
T_{11}	3.46	0.48	0.737	0.305	1.09	1.70	0.858	0.531	59.3	52.7	16.04	13.93
T_{12}	3.47	0.50	0.755	0.325	1.12	1.74	0.880	0.546	61.9	54.7	16.47	14.13
LSD(0.05)	0.20	0.04	0.062	0.031	0.09	0.11	0.062	0.042	5.3	5.3	1.28	1.09

Note: T_1-100 % RDF, T_2-100 % RDF + 2 t FYM ha^{-1}, T_3-100 % RDF + 2 t FYM + 40 kg S ha^{-1}, T_4-100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 ha^{-1}, T_5-100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1}, T_6-100 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + Azotobacter (Seed treat.), T_7-75 % RDF, T_8-75 % RDF + 2 t FYM/ha, T_9-75 % RDF + 2 t FYM + 40 kg S ha^{-1}, T_{10}-75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 ha^{-1}, T_{11}- 75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} and T_{12}- 75 % RDF + 2 t FYM + 40 kg S + 25 kg Zn SO_4 + 1 kg B ha^{-1} + Azotobacter (Seed treat.)

RDF recorded significantly higher oil content than that of RDF and 75 % RDF alone. However, lowest oil content was noted in RDF alone. The low oil content under RDF was due to more availability of nitrogen which increased the proportion of proteinous substance in the seed. Under high nitrogen supply a large proportion of photosynthates is diverted to protein formation leaving a potential deficiency of carbohydrates to be degraded to acetyl co-enzyme A for the synthesis of fatty acids. These results are in close conformity with the findings of Shukla and Kumar (1997). The increase in the oil content with supplementary ingredient is attributed to the increased availability of sulphur, zinc and boron.

Addition of supplementary ingredients viz. FYM, sulphur, zinc, boron and *Azotobacter* at both RDF and 75 % RDF progressively increased the protein content in seed; being maximum at RDF along with FYM, sulphur, zinc, boron and *Azotobacter*. Crop receiving 75 % RDF, exhibited minimum protein content, though *at par* with that of RDF alone. Variations in protein content were significant due to different treatments. Crop fertilized with RDF along with FYM, sulphur, zinc, boron and *Azotobacter* being *on par* with that of 75 % RDF with all the supplementary ingredients exhibited highest protein content. The higher protein content under above treatment was due to more nitrogen content under this treatment.

Nutrient content (%)

The data on per cent nutrients (N, P, K, S, Zn, B) content in seed and stover were significantly influenced by integrated nutrient management (Table 2). Successive addition of supplementary ingredients *viz.*, FYM, Sulphur, Zinc, Boron and *Azotobacter* (Seed Treatment) increased the per cent nutrients content in seed and stover at both RDF and 100% RDF. The maximum per cent of nutrients content in seed and stover was recorded in T_{12}-100 % RDF + 2 t FYM + 40 kg S + 25 kg $ZnSO_4$+ 1 kg B ha^{-1} + *Azotobacter* (seed treatment), whereas minimum was under 75% RDF. The higher nutrient content per cent in T_{12}-100 % RDF + 2 t FYM + 40 kg S + 25 kg $ZnSO_4$+ 1 kg B ha^{-1} + *Azotobacter* (seed treatment) may be because of better availability of nutrients at 100% recommended dose of fertilizers.

Economics

Highest net return and B: C ratio was noted under RDF coupled with all the supplementary ingredients owing to higher seed yield and comparatively lower cost under this treatment (Table 1). The lowest net return was noted in 75 % RDF alone whereas, a ration was lowest in 75 % RDF + FYM.

Thus, on the basis of above study it can be concluded that Indian mustard fertilized with 120 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1} along with FYM @ 2 t ha^{-1} (furrow applied), sulphur @ 40 kg ha^{-1}, zinc sulphate @ 25 kg ha^{-1}, boron @ 1 kg ha^{-1} and seed treatment with *Azotobacter* @ 10 g kg^{-1} seed sustained higher seed yield and net return.

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