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Short Communications

Effect of INM practices on productivity, profitability and quality of Indian mustard

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India is the third largest producer of rapeseed-mustard in the world after China and Canada and in India, it occupies 5.71 million ha area, with a production of 6.8 million tonnes registering the productivity 1184 kg/ha (Anonymous 2016). It is nutritionally very rich (20-25% protein and 37-49% oil) and is used as a condiment in the preparation of pickles, flavouring curries and vegetables as well as for cooking and frying purposes. Its oil is used in many industrial products, cake as cattle feed and manure and green leaves for vegetable and green fodder (Bhindani *et al*. 2020). It is grown under irrigated and rainfed conditions during winter and depending on availability of water and suitable cropping system. The national average productivity of rape seed-mustard is 1184 kg/ha which is lower than the world average productivity 2010 kg/ha (Anonymous 2016). The various reasons for low productivity are low solar radiation, high incidence of insect-pests and diseases, high infestation of weeds and poor soil management are the main causes, out of these, poor nutrient management is the major problem under tarai condition of Uttarakhand (Kumar *et al*. 2017a). However, it requires better nutrient management practices to express their full potential. In view of the above, the present study was undertaken to find out the effect of fertility levels on productivity, profitability and quality of mustard.

A field experiment was conducted during *rabi* 2015-16 at G B Pant University of Agriculture and Technology, Pantnagar, situated at 29ºN latitude, 79.29ºE longitude and 243.8 m amsl, Uttarakhand, India. The climate of Pantnagar is humid subtropical with hot summers, heavy rains in monsoon period and extreme cold in winters. The soil of experimental field was silty clay loam in texture, bulk density (1.54 Mg/m^3), *p*H 7.76, EC (0.24 dS/m), medium organic carbon (0.71%), low available N (203 kg/ha), medium in available P (18 kg/ha) and available K (223 kg/ha). The experiment comprised 10 treatment combination, viz. T1 (Control), T2 (100% PK), T3 (100% NPK), T4 (150% NPK), T5 (100% NPK + S), T6 (100% NPK + Zn @ 25 kg ZnSO4 /ha), T7 (100% NPK + B @ 1 kg B/ha), T8 (100% NPK + FYM @ 2.5 t/ha), T9 (100% NP) and T10 (100% NK) were laid out in Randomized Block Design with three replications. The fertilizer nutrients were supplied through Urea, SSP, muriate of potash, gypsum, zinc sulphate and boric acid used as the source of nitrogen, phosphorus, potassium, sulphur, zinc and boron, respectively. The nutrients were applied to the individual plots as per the treatment with different rates. Mustard, variety NDRE 4 was sown at 30 × 10 cm crop geometry during second fortnight of October with a seed rate of 5 kg/ha and harvested at second week of March. The crop was raised with recommended package of practices. The data collected of different parameters were subjected to appropriate statistical analysis under Randomized Block Design by following the procedure of ANOVA analysis of variance (SAS Software packages, SAS EG 4.3). Significance of difference between means was tested through 'F' test and the least significant difference (LSD) was worked out where variance ratio was found significant for treatment effect. The treatment effects were tested at 5% probability level for their significance.

The results revealed that 100% NPK + FYM @ 2.5 t/ha was recorded higher number of siliquae/plant (274) which was statistically at par with 100 % NPK + S @ 40 kg/ha, 100 % NPK + Zn @ 25 kg $ZnSO_4$/ha and 100 % NPK + B @ 1 kg B/ha but significantly higher than remaining treatments. Maximum number of seeds/siliqua (13.5) was noticed under 100 % NPK + FYM @ 2.5 t/ha and minimum number of seeds/siliqua (10.4) was found under control plot. Significant highest length of siliqua (4.1 cm) was under 100 % NPK + FYM @ 2.5 t/ha than that compared to all remaining treatments except 100 % NPK + Zn @ 25 kg $ZnSO_4$/ha. Maximum value of 1000 seed weight (3.8 g)

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Table 1 Yield attributes and yield of Indian mustard influenced by different fertility levels

Treatment	Number of siliquae/plant	Number of seeds/siliqua	Length of siliqua (cm)	1000-seed weight (gram)	Seed yield (q/ha)	Stover yield (q/ha)
Control	140	10.4	2.81	2.70	10.6	65.5
100% PK	198	11.2	3.03	3.01	12.9	79.7
100% NPK	240	11.9	3.50	3.41	18.5	114.2
150% NPK	228	11.7	3.42	3.42	18.1	111.6
100% NPK + S @ 40 kg/ha	268	12.9	3.81	3.74	19.4	119.4
100% NPK + Zn @ 25 kg $ZnSO_4$ /ha	260	12.7	3.70	3.63	19.2	118.1
100% NPK + B @ 1 kg B/ha	251	12.5	3.62	3.52	19.1	117.5
100% NPK + FYM @ 2.5 t/ha	274	13.5	4.14	3.81	22.2	136.5
100% NP	219	11.5	3.30	3.33	17.5	107.7
100% NK	202	11.3	3.13	3.12	17.2	105.6
SEm ±	10.4	0.7	0.11	0.09	0.82	4.70
LSD (P=0.05)	23.2	NS	0.30	0.26	2.01	12.1

was observed under 100% NPK + FYM @ 2.5 t/ha which was statistically at par with 100% NPK + S @ 40 kg/ha and 100% NPK + Zn @ 25 kg $ZnSO_4$/ha but significantly higher than other treatments (Table 1). Application of 100% NPK + FYM @ 2.5 t/ha was significantly enhanced seed and stover yield by 109 and 108 % than that compared to remaining treatments. The increased yield attributes and yield was probably due to more registered activities of meristematic tissues of plants at higher fertility levels as NPK plays a role in cell differentiation, more meristematic division and more translocation of food materials in plants, thereby resulting higher production of yield attributes and yield (Bhindani *et al.* 2020).

A critical examination of the data revealed that application of 100% NPK + S @ 40 kg/ha was registerd higher oil and protein content (41.2 and 19.9%) while lower values (40.3 and 19.2%) were recorded under control treatment (Table 2). Significant increased oil and protein yield by 109 and 108% under 100% NPK + FYM @ 2.5 t/ha than that compared to other treatments, respectively. The increase in oil content with sulphur fertilization may be attributed to its role in oil synthesis, as sulphur is a constituent of glutathione, a compound that plays a vital role in oil synthesis (Kumar *et al*. 2017a). The highest oil yield was recorded under 100 % NPK + FYM @ 2.5 t/ha because balanced amount of NPK were applied to the crop with FYM which improves physico-chemical and biological properties of soil and provide adequate amount of nutrients to the plants and produced more yield attributing characters, ultimately more seed yield. Oil yield is the function of oil content in seeds multiplied by seed yield per hectare (Kumar *et al.* 2017b). The increase in protein content might be due to higher nitrogen content in seeds as it is a mathematical value calculated from nitrogen content of seeds, as increasing

Table 2 Quality parameters and economics of Indian mustard influenced by different fertility levels

Treatment	Oil content (%)	Oil yield (q/ha)	Protein content (%)	Protein yield (q/ha)	Gross returns (× 10^3 ₹/ha)	Cost of cultivation (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	B: C ratio
Control	40.3	4.27	19.2	2.04	19.9	37.7	17.8	0.89
100% PK	40.5	5.21	19.3	2.50	22.3	45.8	23.5	1.05
100% NPK	40.7	7.54	19.6	3.65	23.8	65.6	41.9	1.76
150% NPK	40.7	7.37	19.8	3.61	25.7	64.2	38.4	1.49
100% NPK + S @ 40 kg/ha	41.2	7.98	19.8	3.85	24.6	68.7	44.0	1.78
100% NPK + Zn @ 25 kg $ZnSO_4$ /ha	40.9	7.84	19.7	3.79	25.3	68.0	42.7	1.68
100% NPK + B @ 1 kg B/ha	40.8	7.80	19.6	3.76	23.1	67.6	44.5	1.92
100% NPK + FYM @ 2.5 t/ha	41.1	9.11	19.8	4.42	27.5	78.5	51.0	1.85
100% NP	40.6	7.12	19.5	3.43	23.1	61.9	38.8	1.67
100% NK	40.6	6.97	19.5	3.35	21.8	60.8	38.9	1.78
SEm ±	0.94	0.33	0.35	0.19	0.73	-	1.41	0.06
LSD (P=0.05)	NS	0.80	NS	0.43	2.01	-	3.29	0.15

nitrogen level increases the proteinious substances in seeds (Singh *et al*. 2018).

The data on economic study was revealed that the 38% enhanced gross returns by application of 100% NPK + FYM @ 2.5 t/ha which was statistically at par with 150% NPK but significantly higher than remaining treatments, respectively. Maximum cost of cultivation ₹ 78.5 × 10^3/ha was recorded with the application of 100% NPK + FYM @ 2.5 t/ha and minimum cost of cultivation ₹ 17.8 × 10^3/ ha was observed under control treatment. Application of 100% NPK + FYM @ 2.5 t/ha was registered significantly higher net returns ₹ 51 × 10^3/ha than that compared to all remaining treatments, respectively. B: C ratio was increased by 115% with the application of 100% NPK + B @ 1 kg B/ha which was statistically at par with 100% NPK + S @ 40 kg/ha, 100% NPK + FYM @ 2.5 t/ha, 100% NPK + Zn @ 25 kg $ZnSO_4$/ha and 100% NK but significantly higher than other treatments, respectively. The results of present investigation indicated appreciable variation in net return due to different nutrient levels. It might be due to fact that 100% NPK + FYM @ 2.5 t/ha treatment got the maximum gross return. In general, net return and B: C ratio is a function of total cost of cultivation and gross return per ha. These results are in close conformity with those of Rathore *et al.* (2019).

SUMMARY

Based on the finding of the present study, it can be inferred that application of 100% NPK + FYM @ 2.5 t/ha was recorded significantly higher seed yield 22.2 q/ha, stover yield 136.5 q/ha, oil yield 9.11 q/ha, protein yield 4.42 q/ha and net returns ₹ 51 × 10^3/ha than that compared to control treatment. Maximum B: C ratio 1.92 was noticed under 100% NPK + B @ 1 kg B/ha which was statistically at par with 100 % NPK + S @ 40 kg/ha, 100 % NPK + FYM @ 2.5 t/ha, 100% NPK + Zn @ 25 kg $ZnSO_4$/ha and 100 % NK but significantly higher than other treatments, respectively. Hence, the farmers could economically benefited by using 100% NPK + FYM @ 2.5 t/ha in mustard crop under tarai region of Uttarakhand or similar agro-ecoregions.

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