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Effect of integrated nutrient management practices on productivity and profitability of Indian mustard (*Brassica juncea* L) grown under rainfed condition

Surender Kumar Sharma[1]* and Kuldeep Singh[2]

[1]*Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, 125004, Haryana, India*
[2]*Krishi Vigyan Kendra (CCS Haryana Agricultural University), Sadalpur, Hisar 125052, Haryana, India*
**Corresponding author: sksharma67@hau.ac.in*
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Abstract

Field experiments were carried out during 2019-20 and 2020-21 to find out the effect of integrated nutrient management practices on productivity and profitability of Indian mustard (*Brassica juncea* L.) grown under rainfed condition. Thirteen treatments having different combinations of NPK doses with and without FYM and a control (no fertilizer) were laid out in a complete randomized block design in triplicate. Results revealed that application of 30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) recorded the highest plant height, number of primary branches/plant, number of secondary branches/plant, number of siliquae/plant, seed yield (3079 and 3161 kg/ha) and stover yield (7706 and 7901 kg/ha) during both the years. Similarly, highest net returns (₹ 103912 and ₹ 117353/ha) and rainwater-use efficiency (48.5 and 99.1 kg/ha-mm) were also recorded with the treatment receiving 30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) during both the years. However, application of 60:30:15 kg NPK/ha resulted the highest benefit: cost ratio (4.20 and 4.62) during both the years.

Keywords: *Integrated nutrient management, Indian mustard, net returns, rainwater-use efficiency, yield*

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is a winter (*Rabi*) season crop which thrives best in light to heavy loam soils in semi-arid climates. Rapeseed-mustard group of crops are the second most important oilseed crops after soybean in India. India is the second largest grower (21.1 %) after Canada, and third largest producer (12.6 %) of rapeseed-mustard after Canada and China in the world (Choudhary *et al*., 2023). Being an oilseed crop, Indian mustard is a high energy requiring crop. But, due to cultivation in semi-arid climates and poor fertility soils, the production levels are still far behind the world level. Inadequate and imbalance fertilizer use and emergence of multiple nutrient deficiencies are the major factors responsible for low productivity of crop. The role of nitrogen in plants is considered as most important for the crop to activate many physiological activities and energy transformation. It also play an important role in plant nutrient uptake and helps in the better assimilation and partitioning of photosynthesis to the reproductive parts (Singh and Meena, 2004). Integrated nutrient management is crucial because it not only maintains high crop output over time but also enhances soil health and creates a safer environment (Singh *et al*., 2023). Integration of chemical fertilizers with organic manures has been found quite promising not only in sustaining the soil health and productivity but also in stabilizing the crop production in comparison to the use of each component separately. Farm yard manure rich in organic matter can be supplemented with NPK fertilizers. Although, it is expensive than chemical fertilizers on nutrient basis but other beneficial effect which it has on soil can compensate for the added cost. It not only provides most of the essential nutrients but also improves soil structure through binding effect on soil aggregates (Kumawat *et al*., 2018).

Balanced fertilization is necessary to increase productivity of Indian mustard. The optimum doses of nutrients were determined long back but thereafter, the fertility status, crop varieties and other inputs have undergone a considerable change, so there is a need to give fresh look to fertilizer requirement of Indian mustard in the light of introduction of new varieties under rainfed condition. The optimum supply of nitrogen, phosphorus and potash significantly influenced on growth and yield of Indian mustard. Therefore, yield of Indian mustard may increase with the application of nitrogenous, phosphatic and potassic fertilization. The present level of recommended N and P_2O_5 in Indian mustard is 40 and 20 kg/ha, respectively in Haryana which needs to be revised in the present context of decreasing soil fertility, nutrient factor productivity and climate change. Therefore, the present investigation was undertaken to study the response of integrated nutrient management on productivity and profitability of Indian mustard under rainfed condition.

Materials and Methods

Field experiments were conducted during *Rabi* seasons of 2019-20 and 2020-21 at Dryland Agriculture Research Farm of the Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana), India. The region has a semi-arid climate characterized by extremes of temperature in both summer and winter with average annual rainfall of about 425.5 mm mostly received in rainy season from July to September. The soil of the experimental field was sandy loam in texture having pH 7.8, low in organic carbon (0.18%), available nitrogen (111 kg/ha), medium in available phosphorus (11.8 kg/ha) and potassium (230 kg/ha). The experiment was laid out in a complete randomized block design with thirteen treatments and three replications. The thirteen treatments consists of T_1- Control (no fertilizer), T_2-40:20 kg NP/ha (recommended dose of fertilizer, RDF), T_3- 50:25 kg NP/ha, T_4- 60:30 kg NP/ha, T_5- 40:20:10 kg NPK/ha, T_6- 50:25:12.5 kg NPK/ha, T_7- 60:30:15 kg NPK/ha, T_8- 20:20 kg NP/ha (inorganic) + 20 kg N/ha through farm yard manure (FYM), T_9- 25:25 kg NP/ha (inorganic) + 25 kg N/ha (FYM), T_{10}-30:30 kg NP/ha (inorganic) + 30 kg N/ha (FYM), T_{11}- 20:20:10 kg NPK/ha (inorganic) + 20 kg N/ha (FYM), T_{12}-25:25:12.5 kg NPK/ha (inorganic) + 25 kg N/ha (FYM) and T_{13}- 30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM). The land was prepared thoroughly and well decomposed FYM as per treatments was uniformly broadcasted over the experimental area and thoroughly incorporated with soil at the time of final land preparation. Nitrogen content in FYM was taken in to consideration to against quantity of FYM. FYM contained 0.70% N, 0.22% P and 0.52% K. As per treatment, full dose of nitrogen as urea, phosphorus as single super phosphate and potassium as murate of potash were applied by broadcasting one day before sowing and incorporated into the soil. Crop was sown on 16th October 2019 and 23rd October 2020 and harvested on 24th March 2020 and 22nd March 2021 during first and second year, respectively. The seeds of Indian mustard var. 'RH 725' (136-143 days maturity) were sown at 45 cm (row to row) × 15 cm (plant to plant) spacing in the plots of size 6.0 m × 4.5 m. Intercultural operations and plant protection measures were taken as and when required. Rainwater-use efficiency (RWUE) was calculated by dividing the seed yield (kg/ha) to cumulative effective rainfall (mm) from sowing to harvesting. The total effective rainfall received during the crop growth period was 63.4 and 31.9 mm while during *rabi* season (Nov-Mar) it was 167.5 and 37.0 mm during 2019-20 and 2020-21 respectively compared to mean normal rainfall of 54.9 mm.

Observations on plant height and number of branches/plant were recorded manually on 5 random plants from each plot of each replication separately as well as yield and yield- attributing characters were recorded as per the standard method. The economics of different treatments was worked out in terms of cost of cultivation, net returns and benefit-cost ratio (B: C) on per hectare area basis to ascertain the economic viability of the treatments. All the results were analyzed statistically for drawing conclusion using online statistical analysis tools (OPSTAT).

Results and Discussion

Growth characters

Data pertaining to growth characters *viz.* plant height, number of primary and secondary branches per plant as influenced by integrated nutrient management practices are depicted in Table 1. All the integrated nutrient management treatments significantly influenced the plant height, number of primary and secondary branches/plant of mustard over control. However, the maximum plant height (199.4 and 202.4 cm) at harvest was registered with treatment T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) which was recorded significantly higher over the control during both the years. Significantly higher number of primary branches/plant (4.94 and 4.82) were observed with treatment T_{13} compared to control and remained at par with T_{10} and T_{12} during both the years. Treatment T_{13} being at par with T_6, T_7, T_{10} and T_{12} recorded significantly higher number of secondary branches/plant over control during both the years. Greater plant height, number of primary and secondary branches/plant might be due to receiving of adequate and balanced fertilization which led to better metabolic activities performed by the crop at optimum fertility levels. The results are corroborative with the findings of Basumotary *et al.* (2020) and Kaur and Kumar (2022).

Yield attributing characters

Data pertaining to yield attributing characters are depicted in Table 2. Results revealed that treatment T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) being on par with T_7, T_{10} and T_{12} resulted significantly higher number of siliquae/plant (461 and 463) over control during both the years. Yield attributing characters *viz*., siliqua length, number of seeds/siliqua and 1000 seed weight were not influenced significantly by different integrated nutrient management treatments. The adequate application of NPK especially nitrogen supply enables the crop to make rapid leaf growth to

Table 1: Effect of nutrient management practices on growth parameters of Indian mustard

Treatment*	Plant height (cm)		Primary branches/plant		Secondary branches/plant	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	182.8	180.3	4.15	4.10	13.6	14.1
T_2	191.9	192.4	4.28	4.21	15.0	15.6
T_3	193.7	194.7	4.31	4.23	15.5	15.9
T_4	195.0	196.2	4.38	4.28	15.9	16.5
T_5	192.2	193.1	4.43	4.31	15.6	16.2
T_6	194.9	195.8	4.49	4.38	16.1	16.6
T_7	196.5	198.1	4.73	4.61	16.6	17.1
T_8	195.4	196.2	4.64	4.58	15.2	15.8
T_9	197.8	198.4	4.71	4.60	15.8	16.3
T_{10}	198.2	200.1	4.88	4.77	16.4	16.9
T_{11}	196.2	198.6	4.84	4.70	15.6	16.2
T_{12}	198.1	200.3	4.89	4.75	16.0	16.7
T_{13}	199.4	202.4	4.94	4.82	16.7	17.3
SEm±	2.7	2.8	0.03	0.02	0.2	0.3
CD (P=0.05)	7.8	8.2	0.08	0.07	0.7	0.8

*Treatment details are given under materials and methods section.

Table 2: Effect of nutrient management practices on yield attributes of Indian mustard

Treatment*	Siliquae/plant		Siliqua length (cm)		Seeds/siliqua		1000-seed weight (g)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	353	356	5.5	5.6	12.4	13.2	4.93	4.95
T_2	395	398	5.7	5.8	12.9	13.7	4.98	5.01
T_3	415	417	5.8	5.9	13.0	13.9	5.01	5.08
T_4	435	436	5.9	6.2	13.1	14.0	5.03	5.09
T_5	402	405	5.8	5.9	13.0	13.8	5.03	5.05
T_6	420	421	5.9	6.1	13.2	14.0	5.06	5.08
T_7	445	447	5.9	6.2	13.2	14.2	5.10	5.12
T_8	413	416	5.8	6.0	13.3	14.0	5.08	5.14
T_9	431	433	5.9	6.1	13.4	14.1	5.10	5.16
T_{10}	447	449	5.9	6.2	13.5	14.3	5.12	5.20
T_{11}	429	431	5.9	6.1	13.7	14.3	5.11	5.18
T_{12}	447	449	6.0	6.2	13.8	14.5	5.14	5.22
T_{13}	461	463	6.0	6.2	13.9	14.7	5.18	5.25
SEm±	8.6	9.0	0.04	0.05	0.10	0.12	.03	0.03
CD (P=0.05)	25.1	26.3	NS	NS	NS	NS	NS	NS

*Treatment details are given under materials and methods section.

intercept more solar radiation to produce more filled siliquae. Samant and Panigrahi (2018) and Maurya *et al.* (2020) also recorded higher number of siliquae/plant in mustard with the integrated nutrient management practices.

Seed and stover yield

Application of nutrient management treatments resulted in significantly higher seed and stover yield over control in both the years (Table 3). T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) recorded significantly highest seed yield (3079 and 3161 kg/ha) of mustard over control during both the years and remained at par with T_7-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM), T_{12}-25:25:12.5 kg NPK/ha (inorganic) + 25 kg N/ha (FYM), T_{10}-30:30 kg NP/ha (inorganic) + 30 kg N/ha (FY M) and T_9-25:25 kg NP/ha (inorganic) + 25 kg N/ha (FYM). Increase in seed yield due to successive increase in the levels of NPK may be mainly due to increase in yield attributing character i.e. higher number of siliquae/plant. Similarly, the highest stover yield of 7706 and 7901 kg/ha during two consecutive years were recorded with T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) which was at par with T_7-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM), T_{12}-25:25:12.5 kg NPK/ha (inorganic) + 25 kg N/ha (FYM), T_{10}-30:30 kg NP/ha (inorganic) + 30 kg N/ha (FY M) and T_9-25:25 kg NP/ha (inorganic) + 25 kg N/ha (FYM), T_4-60:30 kg NP/ha and T_6-50:25:12.5 kg NPK/ha. Increase in stover yield at higher levels of NPK might be due to increase in plant height, number of primary and secondary branches/plant. Higher seed and stover yield with increased levels of NPK/ha was also reported by Verma *et.al.* (2022) and Singh and Sinsinwar (2006).

Table 3: Effect of nutrient management practices on yield and rainwater-use efficiency (RWUE) of Indian mustard

Treatment*	Seed yield (kg/ha)		Stover yield (kg/ha)		RWUE (kg/ha-mm)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	2230	2313	5797	5981	35.2	72.5
T_2	2664	2756	6953	7115	42.0	86.4
T_3	2740	2819	7179	7362	43.2	88.4
T_4	2840	2937	7396	7560	44.8	92.1
T_5	2750	2828	7063	7241	43.4	88.7
T_6	2816	2905	7353	7514	44.4	91.1
T_7	2908	2992	7498	7668	45.8	93.8
T_8	2839	2907	7196	7362	44.7	91.1
T_9	2910	2991	7448	7641	45.9	93.8
T_{10}	3023	3104	7791	7986	47.7	97.3
T_{11}	2892	2962	7255	7442	45.6	92.9
T_{12}	2964	3052	7563	7750	46.7	95.7
T_{13}	3079	3161	7706	7901	48.5	99.1
SEm±	62	60	147	133	-	-
CD (P=0.05)	181	174	428	388	-	-

*Treatment details are given under materials and methods section.

Table 4: Effect of treatments on economics of Indian mustard

Treatmet*	Cost of cultivation (₹/ha)		Gross return (₹/ha)		Net return (₹/ha)		B:C ratio	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	28400	28400	99928	110545	71528	82145	3.52	3.89
T_2	29775	29775	119132	131712	89357	101937	4.00	4.42
T_3	30119	30119	122495	134765	92376	104646	4.07	4.47
T_4	30462	30462	126920	140351	98272	109889	4.16	4.61
T_5	30090	30090	122938	135123	92847	105033	4.09	4.49
T_6	30513	30513	125858	138839	95345	108326	4.12	4.55
T_7	30936	30936	129929	142962	98993	112026	4.20	4.62
T_8	31541	31541	126876	138857	95335	107316	4.02	4.40
T_9	32325	32325	130018	142902	97692	110577	4.02	4.42
T_{10}	33110	33110	135018	148329	101907	115219	4.08	4.48
T_{11}	31856	31856	129221	141454	97365	109598	4.06	4.44
T_{12}	32720	32720	132407	145793	99687	113073	4.05	4.46
T_{13}	33584	33584	137496	150937	103912	117353	4.09	4.49

*Treatment details are given under materials and methods section.

Rainwater-use efficiency

The rainwater-use efficiency (RWUE) was highest (48.5 and 99.1 kg/ha-mm) in the treatment T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM), followed by the treatment T_{10}-30:30 kg NP/ha (inorganic) + 30 kg N/ha (FYM) during both the years (Table 3). This indicated the better use of rainwater under this treatment than rest of treatments. Sharma and Thakral (2023) also reported higher rainwater-use efficiency in Indian mustard by foliar spray of water-soluble complex fertilizer with $ZnSO_4$ under rainfed situation of Haryana.

Economics

Data pertaining to economics of two year study are depicted in Table 4. Among the different integrated nutrient management treatments, the cost of cultivation varied from ₹ 28400 to ₹ 33584/ha with a maximum with treatment T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM). The net returns ranged from ₹ 71528 to ₹ 117353/ha with the variation of benefit: cost ratio of 3.52 to 4.62. The maximum net returns (₹ 103912 and ₹ 117353/ha) were recorded with treatment T_{13}-30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha (FYM) during both the years closely followed by treatment T_{10}-30:30 kg NP/ha (inorganic) + 30 kg N/ha (FYM). However, treatment T_7-60:30:15 kg NPK/ha gave the highest B:C ratio (4.20 and 4.62) during both the years. Singh *et al.* (2014) also reported similar results.

Conclusion

The study revealed that application of 30:30:15 kg NPK/ha (inorganic) + 30 kg N/ha through farm yard manure can be practiced for maximizing productivity, profitability and rainwater-use efficiency of Indian mustard under rainfed condition of sandy-loam soils in arid/semi-arid regions.

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