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Yield, quality and economics of Indian mustard (*Brassica juncea*) under different nutrient supply in clay loam soils of Rajasthan

BS Meena, BK Patidar, LK Meena, SN Meena and KC Meena

Abstract
A field experiment was conducted at Agricultural Research Station, Kota during the *rabi* seasons of 2017-18, 2018-19 and 2019-20 to find out suitable nutrient management practices for Indian mustard sown on clay loam soil after harvest of urdbean. The treatments consisted of 12 nutrient management practices *viz.*,T_1:control,T_2:100% $P_{40}K_{30}$ kg/ha,T_3:100% $N_{80}P_{40}K_{30}$ kg/ha,T_4:150% $N_{120}P_{60}K_{45}$ kg/ha, T_5:100% $N_{80}P_{40}K_{30}$+S_{40} kg/ha,T_6:100% $N_{80}P_{40}K_{30}$+Zn_5 kg/ha, T_7:100% $N_{80}P_{40}K_{30}$+ B_1 kg/ha,T_8:100% $N_{80}P_{40}K_{30}$+ farm yard manure (FYM) 2.5 t/ha, T_9:100% $N_{80}P_{40}$ kg/ha,T_{10}: 100% $N_{80}K_{30}$ kg/ha,100% $N_{80}P_{40}K_{30}$+S_{40}+Zn_5+B_1 kg/ha+ FYM 2.5 t/ha,T_{12}:125% $N_{100}P_{50}$ $K_{37.5}$ kg/ha. Application of 100% RDF($N_{80}P_{40}K_{30}$+S_{40}+Zn_5+B_1kg/ha) along with FYM 2.5 t/ha had significance influenced on branches/plant(16.36), siliquae /plant (230.77),seeds/siliqua (16.20), 1000-seed weight (5.32 g),seed weight/plant(15.00 g),seed yield(2517 kg/ha),oil content (39.30%), protein content(21.08%) and gross return(₹107774/ha) over control,100% $P_{40}K_{30}$ kg/ha,100% N_{80} K_{30} kg/ha and 100% $N_{80}P_{40}$ kg/ha and at par with rest of treatments. While the highest net return (₹82723/ha) and harvest index (32.47%) recorded under application of 125% RDF ($N_{100}P_{50}K_{37.5}$ kg/ha) which was significantly higher than control, 100% $P_{40}K_{30}$ kg/ha, 100% $N_{80}P_{40}K_{30}$ kg/ha, 100% $N_{80}P_{40}K_{30}$+ B_1 kg/ha, 100% $N_{80}K_{30}$ kg/ha and 100% $N_{80}P_{40}$ kg/ha and at par with rest of nutrient management treatments. The highest benefit cost ratio of 3.34 recorded under the same treatment, but it was significantly superior over control, 100% P_{40} K_{30} kg/ha, 100% $N_{80}P_{40}$ kg/ha and 100% RDF ($N_{80}P_{40}K_{30}$+S_{40}+Zn_5+B_1 kg+FYM 2.5 t/ha and at par with rest of treatments. Thus, the results showed that mustard fertilized with 100% RDF ($N_{80}P_{40}K_{30}$+S_{40}+Zn_5+B_1 kg/ha) along with FYM 2.5 t/ha was found beneficial for obtaining higher seed yield and net returns in irrigated areas of south-eastern Rajasthan.

Keywords: FYM, micronutrient, management, mustard and return

Introduction
Rapeseed-mustard is grown over 5.96 million ha area with a production of 8.32 million tonnes at an average productivity of 1397 kg/ha (GOI, 2017-18) [3]. It is the most important rabi season oilseed crop of Rajasthan which is grown on 2.18 mha with annual production of 3.40 mt at an average productivity of 1558 kg/ha (Anonymous, 2019-20) [1]. The development of modern agricultural technologies, intensification of cropping system and changed cropping pattern without balanced fertilization has also led to depletion of major as well as micro nutrients from the soil (Prasad, 2006) [8]. Presently in south-eastern Rajasthan Indian mustard (*Brassica juncea*) is being grown on clay loam soil under irrigated conditions after harvest of urdbean without considering nutrient management which is essential for harvesting good yield. Imbalanced use of chemical fertilizers especially NPK and without application of S, Zn, B and organic manure not only lowers productivity but also adversely affects soil health by continuous mining of major nutrients, S, Zn and B which is essential nutrient for oilseed crops (Singh and Wanjari, 2012) [12]. Nitrogen deficiency may decrease yield while, excess N availability reduces the oil quality. In addition to major nutrients, smaller quantities of secondary and micronutrients such as sulphur, zinc and boron do enhance the yield as well as quality of mustard. Under the present situation application of nutrient elements especially NPKSZnB and also smaller quantity of organic manure every year is essential for increasing mustard yield and maintaining crop production and soil fertility at higher level in irrigated condition. Further, combined application of major and secondary nutrients along with FYM resulted in higher yield and quality of mustard (Meena and Meena, 2015) [6]. Sulphur requirement of oilseed crops is generally higher than those of cereal crops (Hegde and Sudhakar Babu, 2009) [5] but its application as a fertilizer is generally overlooked resulting in widespread deficiency of this element. Sulphur and Zn plays vital roles in growth, development and quality of oil seed crops.

Several studies have also established the synergistic and interactive response of S nutrition with N and P application on enzymetic activities, protein synthesis and nodulation activities (Sheoran *et al*. 2013) [10]. Since very little information on this aspect is available for mustard being grown in clay loam soils of Rajasthan, the present study was undertaken to evaluate the effect of different nutrient supply on yield, quality and economics of Indian mustard.

Materials and Methods

A field experiment was conducted at Agricultural Research Station, Kota during the *rabi* seasons of 2017-18, 2018-19 and 2019-20 to study the effect of different nutrient supply on yield, quality and economics of Indian mustard grown on *Vertisol* soil after harvest of urdbean in irrigated areas of south-east Rajasthan. The experimental soil was clay loam in texture with a pH of 7.88, medium in organic carbon (0.52%), available nitrogen (280 kg/ha), phosphorus (40.3 kg/ha) and high in potassium (400 kg/ha), zinc (0.92 mg/kg soil) and low in sulphur (8.90 kg/ha) contents. The experiment comprised of 12 treatment combinations,*viz.*,T_1: control,T_2:100% $P_{40}K_{30}$ kg/ha,T_3:100% $N_{80}P_{40}K_{30}$ kg/ha,T_4:150% $N_{120}P_{60}K_{45}$ kg/ha,T_5:100% $N_{80}P_{40}K_{30}$+S_{40} kg/ha,T_6:100% $N_{80}P_{40}K_{30}$+Zn_5 kg/ha,T_7:100% $N_{80}P_{40}K_{30}$+B_1 kg/ha,T_8:100% $N_{80}P_{40}K_{30}$+FYM 2.5 t/ha,T_9:100% $N_{80}P_{40}$ kg/ha,T_{10}:100% $N_{80}K_{30}$ kg/ha,100% $N_{80}P_{40}K_{30}$ +S_{40}+Zn_5+B_1 kg + FYM 2.5 t/ha,T_{12}:125% $N_{100}P_{50}K_{37.5}$ kg/ha were laid out in randomized block design with three replications. The nutrients especially NPKSZn and B were supplied through urea, dia-ammonium phosphate, muriate of potash, bentonite sulphur pellet, zinc sulphate and borax fertilizers, respectively. Full dose of P_2O_5 K_2O sulphur, zinc, boron and half N were applied as basal at planting and half N top-dressed at 40 days after planting of the crop as per treatments. The farm yard manure (FYM) was incorporated in soil at last ploughing as per treatment. 5 kg/ha seed of variety 'DRMRIJ 31' was used, planted at crop geometry of 30 x10 cm in respective years. The gross plot size for each treatment was 6 m x 3.6 m and net plot size was 5 m x 2.7 m. All the recommended agronomic practices were done throughout the crop season. The average annual rainfalls received during cropping period of three years were 965 mm. The crop was harvested manually at physiological maturity stage as per treatments respectively years. Initial and post harvest soil samples after 3 years were collected from 0-15 cm depth, dried processed and analyzed for oxidizable organic carbon, N, P, K, S and Zn using standard procedures. Growth, yield attributes, seed yield, quality parameter and available nutrient in soil were workout as per standard statistical procedure and using formulae. The economics was worked out based on pooled yield data and considering price of input and output of the prevailed market. The data were statistically analyzed and the results of pooled analysis are presented.

Results and Discussion

Growth and yield attributes

All nutrient management treatments brought about significant improvement in branches/ plant, siliquae/plant and seeds/siliqua over control (Table 1). Application of 100% RDF (N_{80} P_{40} K_{30} + S_{40}+ Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha had significance influenced on branches/plant (16.36), siliquae/plant (230.77), seeds/siliqua (16.20), 1000-seed weight (5.32 g) and seed weight / plant (15.00 g) over control, 100% P_{40} K_{30} kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha and at par with rest of treatments. However, the differences recorded in growth and yield attributes were statistically at par with each other, but significantly superior over control. Significantly improvement in yield attributes were observed with the supply of balanced nutrients of N, P, K, S, Zn and B along with FYM in smaller quantity every year which improved fertility status of soil and created congenial environment in soil which increased the nutrient availability and thereby increased the uptake of nutrients by crop. This could be due to continuous and balanced supply of NPK along with S, Zn, B and FYM thus increasing the absorption of plant nutrients. However, addition of Zn and B nutrient along with NPK did not show any significant response in yield attributes over all the other treatments except control, 100% P_{40} K_{30} kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha. The results are in agreement with the finding of Chaudhary *et al*., (2016) [2] and Girase *et al*., (2016) [4]. The combined effect of plant nutrients played very significant role due to their synergistic effect and enhanced the partitioning of photosynthetic in vegetative and reproductive parts goes simultaneously in the later growth phases. The results confirm the findings of Meena *et al.*, (2018) [7].

Table 1: Yield attributes and quality of Indian mustard as influenced by different plant nutrient supply treatments (Pooled data of 3 years)

Treatment	Branches / plant	Siliquae / plant	Seeds / siliqua	1000-seed weight (g)	Seed weight /plant (g)	Oil content (%)	Protein content (%)
T1: Control	10.86	121.69	13.95	4.29	11.71	38.30	20.40
T2: 100% $P_{40}K_{30}$ kg/ha	13.64	143.47	14.57	4.64	12.91	38.50	20.60
T3: 100% $N_{80}P_{40}K_{30}$ kg/ha	14.80	204.61	15.93	5.13	14.72	39.00	20.90
T4: 150% N_{120} $P_{60}K_{45}$ kg/ha	15.86	220.35	16.06	5.17	14.85	38.97	21.08
T5: 100% $N_{80}P_{40}K_{30}$ + S_{40} kg/ha	15.60	225.39	16.05	5.23	14.88	39.20	20.96
T6: 100% $N_{80}P_{40}$ K_{30} + Zn_5 kg/ha	15.47	214.32	15.96	5.15	14.80	38.95	20.90
T7: 100% $N_{80}P_{40}K_{30}$ + B_1 kg/ha	15.43	213.45	15.85	5.14	14.76	38.92	20.85
T8: 100% $N_{80}P_{40}K_{30}$ + FYM 2.5 t /ha	15.66	216.22	16.02	5.21	14.93	39.15	21.05
T9: 100% $N_{80}P_{40}$ kg/ha	13.86	152.38	14.62	4.76	13.12	38.75	20.72
T10: 100% $N_{80}K_{30}$ kg/ha	13.75	150.22	14.61	4.72	13.07	38.60	20.75
T11:100% $N_{80}P_{40}K_{30}$ + S_{40}+Zn_5+B_1 kg/ha + FYM 2.5 t/ha	16.36	230.77	16.20	5.32	15.00	39.30	21.08
T12:125% $N_{100}P_{50}K_{37.5}$ kg/ha	15.69	221.30	16.05	5.18	14.83	39.10	21.00
SEm+	0.63	7.97	0.40	0.15	0.40	0.12	0.09
CD (P=0.05)	1.79	22.46	1.12	0.43	1.13	0.35	0.25

Yield and quality

A linear and significant improvement in seed yield and quality parameters, *viz*. oil content and protein content recorded with increase in nutrient management levels up to 125% RDF (N_{100} P_{50} $K_{37.5}$ kg/ha). The maximum seed and stover yields (2517 and 5247 kg/ ha) was obtained under the

application of 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha which was significantly higher over control, 100% P_{40} K_{30} kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha and at par with rest of the nutrient management treatments (Table 2). While the highest harvest index (32.47%) recorded under application of 125% RDF (N_{100} P_{50} $K_{37.5}$ kg/ha) which was significantly higher than control, 100% P_{40} K_{30} kg/ha,100% N_{80} P_{40} K_{30} kg/ha, 100% $N_{80}P_{40}K_{30}$+ B_1 kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha and at par with rest of treatments. Further addition of supplementary macro, micronutrients and manure with recommended dose of fertilizer i.e. NPK improved the seed yield significantly over control and imbalance use of fertilizer. The increase in seed yield might be attributed to higher number of yield attributes, *viz*. branches/plant, siliquae/plant, seeds/siliqua and 1000-seed weight. This could be due to continuous and balanced supply of NPK along with S, Zn, B and FYM and thus increasing the absorption of plant nutrients. Our results confirm the finding of Singh and Meena (2004) [11], Chaudhary *et al*., (2016) [2] and Girase *et al*., (2016) [4]. Application of 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha brought significant improvement in oil content (39.30%) and protein content (21.08%) over control, 100% P_{40} K_{30} kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha and on par with rest of nutrient management treatments. Further increment in nutrient management from 125% RDF to 150% RDF reflected oil content in seed. Thus seed yield and quality parameters were also higher under the said nutrient management treatment. The positive effect of balanced nutrients supply of N P K S Zn B along with FYM on seed and quality yield has also been reported by Tetarwal *et al*., (2013) [13] and Meena and Meena (2015) [6].

Table 2: Yield and economics of Indian mustard as influenced by different plant nutrient supply treatments (Pooled data of 3 years)

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T1: Control	1553	3346	31.70	20250	66990	46740	2.31
T2: 100% $P_{40}K_{30}$ kg/ha	1891	3986	32.07	22938	81340	58402	2.55
T3: 100% $N_{80}P_{40}K_{30}$ kg/ha	2351	4946	32.21	23994	100800	76806	3.20
T4: 150% N_{120} $P_{60}K_{45}$ kg/ha	2516	5258	32.37	25578	107707	82129	3.21
T5: 100% $N_{80}P_{40}K_{30}$ + S_{40} kg/ha	2443	5106	32.36	25594	104666	79072	3.09
T6: 100% $N_{80}P_{40}$ K_{30} + Zn_5 kg/ha	2359	4948	32.28	25011	101139	76128	3.04
T7: 100% $N_{80}P_{40}K_{30}$ + B_1 kg/ha	2401	5047	32.24	25744	102899	77155	3.00
T8: 100% $N_{80}P_{40}K_{30}$ + FYM 2.5 t /ha	2473	5188	32.28	25994	105949	79955	3.08
T9: 100% $N_{80}P_{40}$ kg/ha	2137	4587	31.94	23418	91765	68347	2.92
T10: 100% $N_{80}K_{30}$ kg/ha	2064	4436	31.87	21882	88693	66811	3.05
T11:100% $N_{80}P_{40}K_{30}$ + S_{40}+Zn_5+B_1 kg/ha + FYM 2.5 t/ha	2517	5247	32.42	30361	107774	77413	2.55
T12:125% $N_{100}P_{50}K_{37.5}$ kg/ha	2512	5224	32.47	24786	107509	82723	3.34
SEm+	104	220	0.07	-	4430	4381	0.17
CD (P=0.05)	294	621	0.22	-	12490	12352	0.47

Economics

The highest gross return (₹107774/ha) at application of 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha and net return (₹82723/ha) at application of 125% RDF (N_{100} P_{50} $K_{37.5}$ kg/ha) fetched which was significantly higher over control, 100% P_{40} K_{30} kg/ha, 100% N_{80} K_{30} kg/ha and 100% N_{80} P_{40} kg/ha and at par with rest of the nutrient management treatments (Table 2).While the highest benefit cost ratio of 3.34 recorded under the application of 125% RDF (N_{100} P_{50} $K_{37.5}$ kg/ha) which was significantly superior than control, 100% P_{40} K_{30} kg/ha, 100% N_{80} P_{40} kg/ha and 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha due to higher cost of FYM and at par with rest of treatments, indicating the response of FYM along with fertilizers was found positive in soil but negative trending in B:C ratio analysis. However, the rate of increase in net return was very less by application of 150% RDF (N_{120} P_{60} K_{45} kg/ha), indicating the non-responsiveness and the non suitability of this treatment for increasing mustard production. Maximum crop production cost (₹30,361 /ha) recorded in 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg + FYM 2.5 t/ha owing to higher cumulative cost of fertilizer and FYM and lower added of nutrients, whereas minimum production cost and net return recorded in control.

Thus, it can be concluded that mustard grown on *Vertisol* soil after harvest of urdbean, fertilized with 100% RDF (N_{80} P_{40} K_{30} + S_{40} + Zn_5 + B_1 kg/ha) along with FYM 2.5 t/ha or 125% RDF (N_{100} P_{50} $K_{37.5}$ kg/ha) was found beneficial for obtaining higher seed yield, oil content and net returns in irrigated areas of south-eastern Rajasthan.

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