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Integrated nutrient management of mustard (*Brassica juncea* L.) alluvial soil of Uttar Pradesh

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Abstract
A field experiment was carried out in the pot culture of Soil Science and Agricultural Chemistry, C S Azad University of Agriculture & Technology during 2017-18. The experiment consisted 9 treatments *viz.* T_1: Control, T_2: 100% N (RDF), T_3: 75% NPK (RDF), T_4: 75% NPK + FYM T_5: 75% NPK + FYM + PSB + S, T_6: 100% NPK, T_7: 100% NPK + FYM, T_8: 100% NPK + PSB + FYM and T_9: 100% NPK + FYM + PSB + S assigned in randomized block design replicated thrice during *rabi* season of 2017-18. The soil of the experimental plot was sandy loam in texture, medium in fertility and slightly alkaline in reaction. The weather during the experimental period was by and large normal and devoid of any extreme conditions. The results indicated that application of T_9: 100% NPK + FYM + PSB + S resulted in significantly maximum plant height, number of functional leaves, number of branches plant^{-1}, girth of plant, days to 50% flowering and maturity, root development, Oil (%), Oil yield and ultimately higher seed yield and straw yield as compared to other corresponding tested treatments. The treatment also excelled in harvest index, net return and benefit: cost ratio under control.

Keywords: Root development, Oil yield, Seed yield, and B:C Ratio

Introduction
Mustard is one of the most popular edible oilseed and oil in meals, have an important role to relieving mineral nutrition and caloric nutrition of human being and animals. Oil seeds play a vital role in Indian agricultural economy, occupying sizeable; share (14%) of the country's gross cropped area and contributing about 10% value of agricultural products. Among different oil seed crops, rapeseed and mustard ranks second after groundnut and contribute nearly 33% of the total oilseed production in the country. In India, mustard occupied an area of 5.04 m ha with a production of 3.0 mt having the productivity of 1000 kg ha^{-1} Uttar Pradesh ranks second after Rajasthan in area and production of rapeseed and mustard accounting 0.909 m ha area and 0.897 m t production. The productivity of rapeseed and mustard in U.P. is 897 kg ha^{-1} against the productivity of 1488 kg ha^{-1} of Haryana (Anonymous, 2018) [1]. The major reasons for low yields in U.P. may be attributed to poor nutrient management and plant protection measures. Indian soils have generally been reported to be low in nitrogen, phosphorus and sulphur. Because of multiple cropping and introduction of high yielding varieties, the deficiency of these nutrients in soil is becoming wider.

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 fertilizer 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) [4]. Keeping in view of declining productivity, it is apparent that there is need to generate more information on integrated nutrient management for oilseeds especially mustard for sustainable productivity. Hence, present investigation was undertaken to evaluate the effect of INM in integration of FYM and biofertilizer on growth and yield under a given set of management practices on mustard in central alluvial tract of Uttar Pradesh.

Materials and Methods

The experiment was conducted during *rabi* season of 2017-18 in pot culture of Soil Science and Agricultural Chemistry of C S Azad University of Agriculture & Technology, Kanpur in alluvial soil. Soil of the experimental plot was sandy loam in texture and slightly calcareous having organic carbon 0.32%, total nitrogen 0.03%, available P_2O_5 16.3 ha^{-1}, pH 7.7, electrical conductivity 0.36 dSm^{-1}, permanent wilting point 6.3%, field capacity 18.4%, maximum water holding capacity 29.6%, Bulk density 1.46 Mgm^{-3}, particle density 2.56 Mgm^{-3} and porosity 42.9%. The experiment was conducted in a randomized block design with three replications and nine treatments *viz.* T_1: Control, T_2: 100% N (RDF), T_3: 75% NPK (RDF), T_4: 75% NPK + FYM T_5: 75% NPK + FYM + PSB + S, T_6: 100% NPK, T_7: 100% NPK + FYM, T_8: 100% NPK + PSB + FYM and T_9: 100% NPK + FYM + PSB + S. Mustard cv Varuna was sown in rows 45 cm apart using 5 kg seed ha^{-1}. Full dose of P and K while half dose of N was applied as basal dose at the time of sowing where rest of N was given in two split doses during experimentation. Available moisture at sowing time upto 100 cm soil profile was 276.4 mm. Whereas amount of rainfall received during the crop period was nil against the average annual rainfall of about 800 mm. Recommended package of practices were applied in different treatments. Soil moisture was monitored gravimetrically using the sample collected from 0-25, 25-50, 50-75 and 75-100 cm soil depths at regular monthly intervals to quantify the soil moisture content and growth parameters by randomly selecting three plants for each plots till the harvest.

The data collected on growth, yield attributes and yields were statistically analyzed **(**Fisher and Yates, 1958) [2]. Recommended package of practices and fertilizers doses were applied in different treatments. The harvest index was worked out with the help of following formula:

$$\text{Harvest Index}(\%) = \frac{\text{Seed yield}(q\ ha^{-1})}{\text{Biological yield}(q\ ha^{-1})} \times 100$$

The oil content of the oven dried seeds was estimated by extracting oil using petroleum ether (60-80 ^oC) as solvent and Soxhlet apparatus as given by Sadasivum and Manickam, (1992) [6]. The oil yield (kg ha^{-1}) was calculated using following formula:

Oil yield (kg ha^{-1}) = Seed oil content (%) x Seed yield (kg ha^{-1})

For economic evaluation the cost of cultivation, gross returns, net returns, and B:C ratio were computed using standard procedure based on minimum support price of Indian mustard. Root studies were made at harvest by selecting two plants at random from each plot. The roots were freed with a fine jet of water spray so that the delicate rootlets were not broken.

Results and Discussion

The Plant stand, Plant height and number of functional leaves were significantly affected due to different levels of INM application. Increasing levels of fertilizer application up to 100% NPK + FYM + PSB + S. Significantly increased the number of functional leaves. Further, it was considerably enhanced due to addition of FYM and again with PSB in treatment of T_9 which showed the highest values. It is well known fact that adequate fertilization to crop is known to improve various physiological and metabolic processes in the system. Phosphorus plays an important role as a structural component of the cell constituents and metabolic active compound. Increase N and P provide congenial nutritional environment to the crop plants. Such improvements under increased metabolic process in plants resulted in greater meristematic activities and applied growth thereby improving growth and development ultimately contributing towards improved photosynthesis of the plants Gupta *et al.,* (2011) [3].

Days to 50% flowering as well as 50% maturity of the plants. The beneficial effect of FYM on these parameters might be due to its contribution in supplying additional plant nutrients and its capacity to improving solubility in the presence of PSB of native soil nutrients. Adequate availability of these nutrients in mustard improved growth and vigour of the crop with efficient and greater partitioning of metabolites and greater translocation of synthesized food material to the reproductive organs would have delayed the flowering and maturity. The application of increasing levels of fertility significantly increased root depth as well as dry weight of roots over the period of study. Supply of nitrogen and phosphorus to soil have accelerated various physiological processes in plants favoring increased root development possibly the result of effective uptake and utilization of other nutrients absorbed through its extensive root system developed due to PSB application Verma *et al.,* (2017) [9].

Number of branches $plant^{-1}$ and girth of plants will significantly increased to maximum in the treatment of T_9 with application of 100% NPK + FYM + PSB + S in soil followed by T_8 and lowest under control. This could be attributed to amending of soil with organic manure in conjunction with mineral fertilizer and PSB which helped in growth and development of plants. The use of FYM solubilised, transformed P forms in to comparatively more soluble forms. Further, the addition of FYM over other treatments showed superiority over others in improving the attribute characters. Moreover, balanced nutrition under favorable environment of FYM and PSB to crop plants would have helped in producing new tissues and development of leading ultimately to increased branching and girth of plant. Thus, the treatment of T_9 excelled over control in the present investigation. The yield attributing characters of mustard crop such as number of siliqua $plant^{-1}$, number of seeds per siliqua, 1000-seed weight were affected significantly due to different levels of INM application. Yield attributing characters were found in increasing trend with increasing doses of INM application Rahul Ranjan *et al.* (2018) [5].

The seed yield differences due to fertilizer were found to be statistically significant over control. Seed yield $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$ and 1000-seed weight. These characters were highest in T_9 with application of 100% NPK + FYM + PSB + S in soil and lowest under control. All these characters might have resulted in appreciably higher seed yield per plant which might be held responsible for seed yield per hectare. It has been established that the efficiency of inorganic fertilizer can be greatly increased through its integration with organic manures, thereby reflecting in harvest index too Verma *et al.* (2017) [9].

The gross, net returns and benefit: cost ratio were affected by nutrient management treatments. Treatment of 100% NPK + FYM + PSB + S in soil resulted in highest net returns of *Rs.* 33204 with B:C ratio of 1.98 whereas these parameters were lowest under control. Higher productivity may be attributed to the positive effect of FYM supplemented with PSB in presence of chemical fertilizer Verma and Yadav, (2018) [7].

Table 1: Effect on Initial and Final Plant stand, Plant Height, Number of functional leaves plant^{-1} and Number of branches plant^{-1} of mustard crop under different treatments.

Treatments	Plant population (000 ha^{-1})		Plant Height (cm)				Number of functional leaves plant^{-1}				Number of branches plant^{-1}					
											Primary			*Secondary*		
	Initial	Final	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	60 DAS	90 DAS	At Maturity	60 DAS	90 DAS	At Maturity
T_1	112.10	111.74	21.9	67.4	93.2	109.3	7.90	9.87	15.67	8.49	5.78	7.47	13.69	9.69	14.67	15.83
T_2	115.46	114.74	22.2	68.3	94.1	110.4	9.98	10.70	17.53	11.23	6.56	8.78	14.76	11.45	16.36	17.89
T_3	117.76	116.26	22.5	69.8	95.3	112.1	10.78	14.36	17.32	13.79	6.98	9.07	16.05	12.56	18.76	18.90
T_4	118.25	117.06	23.2	71.2	96.2	116.3	12.76	16.36	19.08	15.00	9.45	10.46	18.05	15.24	20.65	20.14
T_5	122.56	119.34	26.8	74.0	98.0	119.0	14.71	19.85	21.47	18.55	13.97	17.00	21.78	19.56	23.56	24.78
T_6	118.00	117.00	23.0	70.3	96.0	114.3	11.78	15.35	18.65	14.76	7.89	9.60	17.38	14.37	19.46	19.04
T_7	119.34	117.35	24.5	72.7	97.1	117.3	13.47	17.34	20.87	16.87	10.98	14.37	19.05	17.89	21.07	21.34
T_8	120.87	118.07	25.9	73.6	97.7	118.7	14.04	18.78	21.45	17.98	12.47	16.45	20.57	18.57	22.76	23.67
T_9	123.56	120.89	27.4	74.7	98.9	120.0	15.18	19.03	22.78	19.36	14.23	17.98	22.56	20.56	24.12	25.23
SE (d)	2.24	2.05	1.34	1.22	1.79	1.99	0.68	0.84	0.95	0.87	0.47	0.60	0.71	0.61	0.81	0.90
CD (P=0.05)	N.S.	N.S	2.63	2.49	3.98	4.76	1.41	1.79	1.89	1.78	0.87	1.21	1.42	1.29	1.76	1.89

T_1 : Control, T_2 : 100% N (RDN), T_3 : 75% NPK (RDF), T_4 : 75% NPK + FYM, T_5 : 75% NPK + FYM + PSB + S, T_6 : 100% N P K, T_7 : 100% NPK + FYM, T_8 : 100% NPK + PSB + FYM and T_9 : 100% NPK + FYM + PSB + S.

Table 2: Effect on yield attributes of mustard crop under different treatments

Treatments	Days to 50% flowering	Days to 50% Maturity	Girth of plant^{-1} (cm)				Root depth (cm)	No. of Roots plant^{-1}	Dry weight of Roots (g)	No. of siliquae plant^{-1}	No. of seeds siliquae^{-1}	Weight of siliquae^{-1} (g)	Length of siliquae (cm)	1000-seed weight
			30 DAS	60 DAS	90 DAS	At Harvest								
T_1	44.78	56.45	5.4	7.7	9.0	10.2	58.9	12.47	23.29	94.20	12.87	13.69	4.3	4.12
T_2	45.32	58.93	5.8	7.9	9.2	11.0	61.4	13.98	24.28	97.48	14.29	16.39	4.9	5.32
T_3	46.46	61.48	6.0	8.0	9.5	11.3	63.2	15.27	25.69	99.40	15.19	16.90	5.4	5.62
T_4	48.97	64.27	6.8	8.5	11.0	12.6	67.5	17.36	27.38	111.48	17.97	18.40	5.9	6.00
T_5	52.12	68.37	8.0	9.1	14.5	15.4	70.0	19.36	30.57	116.12	19.39	21.00	6.4	6.97
T_6	47.90	63.56	6.3	8.3	10.9	11.7	65.2	16.46	26.17	110.59	16.39	17.39	5.7	5.86
T_7	49.34	65.71	7.0	8.8	11.3	13.5	68.0	18.24	28.97	113.49	18.79	19.39	6.0	6.43
T_8	51.24	67.38	7.3	9.0	13.7	14.3	68.3	19.00	29.38	114.28	19.00	20.39	6.2	6.64
T_9	53.67	69.49	8.5	9.2	15.0	16.0	71.0	20.45	32.47	117.00	20.49	21.47	6.8	7.00
SE (d)	0.41	0.56	0.61	0.54	0.63	0.73	0.47	0.51	0.78	0.51	0.40	0.63	0.08	0.13
CD (P=0.05)	0.87	1.08	1.23	1.04	1.29	1.30	0.91	1.12	1.49	1.05	0.87	1.19	0.19	0.29

T_1 : Control, T_2 : 100% N (RDN), T_3 : 75% NPK (RDF), T_4 : 75% NPK + FYM, T_5 : 75% NPK + FYM + PSB + S, T_6 : 100% N P K, T_7 : 100% NPK + FYM, T_8 : 100% NPK + PSB + FYM and T_9 : 100% NPK + FYM + PSB + S.

Table 3: Effect on Seed yield, Stover yield, Harvest index, Oil, Oil yield and economics of mustard crop under different treatment

Treatments	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})		Harvest index (%)	Oil (%)	Oil Yield (q ha^{-1})	Total cost (Rs ha^{-1})	Gross Return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
		Stick	Straw							
T_1	16.09	45.29	19.58	24.80	37.12	597.26	29958	47821	17863	1.59
T_2	16.78	45.79	20.00	25.50	37.56	630.25	32099	52123	20024	1.62
T_3	18.76	47.34	20.65	28.00	38.76	727.13	33344	56028	22684	1.68
T_4	19.29	49.38	21.66	27.15	40.38	778.93	33317	59968	26651	1.79
T_5	21.48	51.34	23.28	28.78	43.09	925.57	33278	64090	30812	1.92
T_6	19.08	48.00	20.56	27.82	39.67	756.90	32839	56571	23732	1.72
T_7	20.87	50.56	22.13	28.71	41.09	857.54	32808	60846	28038	1.85
T_8	21.15	51.64	22.87	28.38	42.23	893.16	33054	61802	28748	1.86
T_9	22.02	51.70	23.45	29.30	44.23	973.94	33799	67003	33204	1.98
SE (d)	0.72	0.63	0.44	0.09	0.46	2.13	-	-	-	-
CD (P=0.05)	1.52	1.23	0.91	0.19	0.93	4.31	-	-	-	-

T_1 : Control, T_2 : 100% N (RDN), T_3 : 75% NPK (RDF), T_4 : 75% NPK + FYM, T_5 : 75% NPK + FYM + PSB + S, T_6 : 100% N P K, T_7 : 100% NPK + FYM, **T_8 :** 100% NPK + PSB + FYM and **T_9 :** 100% NPK + FYM + PSB + S.

Conclusion

From the foregoing discussion it can be concluded that application of 100% NPK + FYM + PSB + S incorporated in the soil have fetched highest net return of Rs *Rs.* 33204 with B: C ratio of 1.98 would be quite remunerative for higher productivity along with seed yield in light textured alluvial soils of Uttar Pradesh.

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