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Effect of Integrated Nutrient Management on Growth, Yield and Economics of Indian Mustard *Brassica juncea* (L.)

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ABSTRACT : A field experiment was carried out under medium black calcareous soil during *rabi* seasons of 2020- 21 and 2021-22 at the Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar, Gujarat, India, with the combination of different organic and inorganic sources of nitrogen to evaluate their effect on the growth, yield and economics of Indian mustard. The results of experiment indicated that overall growth of the crop *viz*., plant height, number of branches/plant and dry matter accumulation at 60, 90 DAS and at harvest, Physiological parameters *viz*., CGR, RGR and NAR at different growth stages, yield attributes and yield *viz*., number of siliquae/plant, length of siliquae, number of seed per siliquae, seed, stover and biological yields were significantly higher with the application of 75% RDF + FYM @ 5.0 t ha^{-1} in mustard as compared to rest of integrated nutrient management treatment combinations. However, application of 75% RDF + FYM @ 5.0 t ha^{-1} also recorded higher gross returns (₹147564 ha^{-1}) and net returns (₹100657ha^{-1}) although higher B: C ratio (2.73) was obtained under 100% RDF in comparison to other treatments.

Keywords: Integrated nutrient management, FYM, Plant height, Number of branches, Dry matter, seed yield, straw yield.

INTRODUCTION

Oilseeds are the second largest agricultural commodities in India after cereals. Among the different oilseed crops grown in the country, Rapeseed-Mustard accounts for one-third of total oil production in India and it ranks second after groundnut (Shekhawat *et al*., 2012). Indian mustard (*Brassica juncea* L.) is the most popular one among different species of rapeseed and mustard grown in India. Mustard is an important oilseed crop belonging to family cruciferae.

In India, rapeseed-mustard is the main oilseed crop growing in *rabi* season occupying more than 80 percent of the area under oilseeds crop. Indian mustard is predominantly cultivated in the states of Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Punjab and Bihar. Its cultivation is also being extended to non-traditional areas of southern states like Karnataka, Andhra Pradesh and Tamil Nadu.

Mustard grown on an area of 8.06 million hectares with total production of 11.75 million tones and productivity of 1458 kg ha^{-1} (Agricultural Statistics at a Glance, 2022) in India. In Gujarat, it is mostly cultivated under irrigated condition on different type of soil in Northern parts and Saurashtra region of the state. In Gujarat, Banaskantha, Patan, Mahesana, Kutch, Sabarkantha and Gandhinagar are the pivotal mustard growing districts. The cultivated area in Gujarat is 0.27 million hectares with production of 0.55 million tones and productivity of 1999 kg ha^{-1}.

Mustard is a potential crop in winter (*rabi*) season due to its wider adaptability and suitability to exploit residual moisture. In India, intensive agriculture using exhaustive high yielding varieties of crops has led to heavy withdrawal of nutrients from the soil during past few years and fertilizer consumption remained much below in comparison to removal. This gap between nutrient removal and supply cannot be bridged by fertilizer alone. The imbalance and inadequate supply of fertilizers accompanied by restricted use of organic manures not only leads to limit the yield potential but soils also get deficient in the nutrients which deteriorate the soil health with decline in crop response. Cropping sequence with mustard without proper nutrient management leading to fast depletion of soil fertility and crop productivity. The rising prices and lack of availability of inorganic fertilizers at right time to the farmers due to poor transport facility necessitates some alternative ways of nutrients supply. Further, as the mineral fertilizers alone cannot meet the requirement of crop stand in cropping systems because of high cost and also environment related risks involved in its application and usage integrated use of organic and inorganic is desired to attain the sustainability of a system (Yadav *et al*., 2010).

Integration of organic manure like vermicompost, farmyard manure, poultry manure etc. with fertilizers, not only supplies macronutrients but also meet the requirement of micronutrients. It is a good source of organic matter and plays a vital role in improving soil fertility. Integrated use of nutrient is very essential approach which is not only sustains high crop production over the years but also improves soil health and ensures safer environment (Pathak and Pal 2016).

Application of vermicompost and farm yard manure improves soil health by improving nutrient availability, water holding capacity (WHC), soil physical properties and microbial activity. Vermicompost is rich in humus forming microbes and nitrogen fixers and drying of the vermicompost does not deteriorate the microbial population. Integration of vermicompost with fertilizers, not only supply macronutrients but also meet the requirement of micronutrients, besides improving soil health. The use of humic substances is increasing day by day in agriculture. Plants grown on soils which contain adequate amount of humin, humic acid (HA) and fulvic acid (FA) are subjected to less stress, healthier, produce higher yields and the nutritional quality of harvested foods and feeds are superior. The role of humic acid is well known in controlling, soil-borne diseases and improving soil health and nutrient uptake by plants, mineral availability, fruit quality, etc (Mauromicale *et al.,* 2011).

MATERIALS AND METHODS

The present investigation entitled "Effect of integrated nutrient management on growth, yield and economics of Indian mustard {*Brassica juncea* (L.)"was carried out for two consecutive years during the *rabi* seasons of 2020-21 and 2021-22 at the Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar, Gujarat, which is geographically situated at the latitude of 22.3°N, longitude of 70.0°E and at an altitude of 7.77 m above mean sea level. It lies under North Saurashtra zone-VI of Gujarat state. It enjoys a typically subtropical climate characterized by moderately cold and moist winter, moderately hot and dry summer and warm and moderately humid monsoon. The rainy season commences in the second fortnight of June and ends by September with an average rainfall of 722.5 mm (average of last 10 years). July and August are the months of heavy rainfall. Winter sets in the month of November and continues till the month of February. January is the coldest month of winter. Summer season commences during the second fortnight of February and ends by middle of June. April and May are the hottest months of summer.

The experiment was carried out in Randomized Block Design with three replication. The treatments comprised were T_1 - Control, T_2 - 100% RDF, T_3 - 75% RDF + FYM @ 5.0 t ha^{-1}, T_4 - 75% RDF + vermicompost @ 1.5 t ha^{-1}, T_5 -75% RDF + humic acid @ 5.0 kg ha^{-1}, T_6 - 50% RDF + FYM @ 10.0 t ha^{-1}, T_7 -50% RDF + vermicompost @ 3.0 t ha^{-1} and T_8 - 50% RDF + humic acid @ 10.0 kg ha^{-1}. The soil of the experimental plot was clayey in texture, low in organic carbon (0.45%), slightly alkaline in reaction with pH and EC with low in available nitrogen (228 kg/ha), medium in available phosphorus (31.2 kg/ha), medium in available potash (298 kg/ha), higher in available sulphur (32.5 mg/kg)), medium in available iron (7.67 mg/kg), higher in available zinc (0.80 mg/kg) and higher in available manganese (12.80 mg/kg). The required quantities of 75% RDF (37.5 kg N ha^{-1}) and (37.5 kg P_2O_5 ha^{-1}) was applied to urea and DAP fertilizer while organic fertilizers farm yard manure, vermicompost and humic acid were applied in respective plots as per the treatments and incorporated into soil 15 days before sowing of the crop. The periodical plant protection measures for mustard crop were followed to save the crop from pests and diseases. The mustard crop was harvested manually. Different growth and yield components were recorded periodically. Economics were worked out based on prices of output and input in the crop season. The data Where subjected to standard analysis of variance technique (Gomez and Gomez 1984). The mean treatment were compared at $P< 0.05$ level of significance.

RESULTS AND DISCUSSION

A. Growth parameters

Results showed that, growth parameters was significantly affected by different combined (Table 1-2). According the study application of 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) significantly increased plant height at 60, 90 DAS and harvest. which was remained at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4) and 100% RDF (T_2) compared with rest of treatment combinations. Number of branches were significantly increased with 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) at 60, 90 DAS and harvest and remained at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4), 100% RDF (T_2) and 75% RDF + humic acid@ 5.0 kg ha^{-1} (T_2) compared with rest of treatment combinations. While dry matter accumulation per plant was also significantly increased with 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) in mustard. The growth parameters was not positively affected at 30 DAS by different treatments. This improvement in growth attributes could be assigned to better soil environment with nutrient management system. The beneficial effects might have been derived due to combined application of organic and inorganic manure which satisfied the immediate requirement of nutrients and also provided favorable soil environment for better plant growth. Favorable soil conditions have led to significant improvements in plant growth, primarily attributed to the presence of nitrogen. Nitrogen plays a crucial role in cell division, cell elongation, and chlorophyll production. Its involvement in DNA and protein synthesis ensures proper cell replication and structure, while its contribution to chlorophyll enhances photosynthesis. This collective influence results in enhanced growth parameters, including increased biomass, expanded leaf area, and overall improved plant vigor. The result obtained from the present experiment are in near conformity with the finding of Tripathi *et al.* (2011); Maurya *et al.* (2020); Indira *et al.* (2021) ; Kaur and Kumar (2022).

B. Physiological parameters

The pooled data in (Table 2-3) showed all the treatments were significantly affected to plant Physiological parameters. In mustard significantly influenced the crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) of mustard with 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) which was statistically at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4) at 30-60 DAS, 60 -90 DAS and 90 DAS - harvest but relative growth rate (RGR) was non-significant at 90 DAS - harvest in mustard. Here, the reason might be that in case of combined use of organic and inorganic fertilizers provided slow, consistent and better availability of nutrients resulted in higher dry matter accumulation and also increased leaf area index. When LAI is large to intercept 95% of sunlight then plant get optimum crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) of mustard Similar reports were also made by Mandal and Sinha (2004); Mondal *et al.* (2015).

Yield attributes. Among the various INM treatments investigated (Table 4) application of 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) produced significantly higher number of siliquae/plant, length of siliquae and number of seeds/siliquae. This remained at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4) but there was not any positive impact on test weight in mustard. This indicates that supplementing the inorganic fertilizer with organic manures improve physical, chemical and biological properties of soil, which in turn depends upon optimum growth of photosynthetic organs, translocation of nutrients and photosynthesis to developing plant and finally larger frame to accommodate more number of yield attributes. The results lend support to the earlier findings of by Tripathi *et al.* (2011); De and Sinha (2012); Pati and Mahapatra (2015); Bijarnia *et al.* (2017); Kumar *et al.* (2018); Singh *et al.* (2018); Verma *et al.* (2021).

Seed, stover and biological yield. The results related to Seed, stover and biological yield showed significant differences between different treatment combinations (Table 5). Application of 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) was significantly increased seed (2612 kg ha^{-1}), stover (5204 kg ha^{-1}) and biological yield (7816 kg ha^{-1}), which was statistically at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4) and 100% RDF (T_2) except biological yield. The cultivation of mustard responds favorably to this combined application of organic and inorganic fertilizer which exhibiting higher root growth. This robust root system facilitates optimal absorption of moisture and nutrients from the soil, contributing to superior dry matter production. The consequential translocation of photosynthates from leaves to the seed-bearing siliquae further ensures the development of high-quality seeds. The seed size must have risen because to additional carbohydrates, synthesis process, etc. under integrated nutrition supply. Due to synergy relation between organic and inorganic fertilizers has proven pivotal in achieving higher seed yield. These findings are in accordance with the results reported by Mandal and Sinhala (2004); Tripathi *et al.* (2011); De and Sinha (2012); Pati and Mahapatra (2015); Bijarnia *et al.* (2017); Kumar *et al.* (2018); Singh *et al.* (2018); Varma *et al.* (2021); Tyagi *et al.* (2022).

Quality parameters . Various treatments of integrated nutrient management in previous chapter (Table 6) imposed in mustard indicated that there was not any positive effect of any treatment on oil content in mustard but oil yield of mustard was significantly higher with the application of 75% RDF + FYM @ 5.0 t ha^{-1} (T_3) and remained statistically at par with 75% RDF + vermicompost @ 1.5 t ha^{-1} (T_4) and 100% RDF (T_2). Oil yield of mustard is increased due to synergetic effect of seed yield. Similar study by Maurya *et al.* (2020) ; Dubey *et al.* (2021) was also reported.

Economics. According to Table 7 application of RDF along with FYM 5.0 t ha^{-1} (T_3) recorded the maximum gross return of ₹1,47,538ha^{-1} and net returns of ₹1,00,631ha^{-1} for mustard. This was followed by treatmentT_4 (75% RDF + 1.5 t ha^{-1} of vermicompost) and T_2 (100% RDF). The benefit-cost ratio of 2.72 was recorded under T_2 (100% RDF), followed by T_3. This might be due to higher yield of crop with this treatment. Similar results were also reported by Tripathi *et al.* (2011); Singh *et al.* (2018); Maurya *et al.* (2020); Annapoorna and Chandranath (2021); Varma *et al.* (2021).

Table 1: Effect of integrated nutrient management on plant height and number of branches per plant of mustard.

Treatments	Plant height (cm)				Number of branches per plant		
	30 DAS	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1 : Control	16.60	140.15	158.01	162.09	7.30	9.43	10.23
T_2 : 100% RDF	18.37	161.69	179.05	184.16	9.27	11.90	12.58
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	19.53	171.72	183.67	191.04	9.87	12.37	13.09
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	18.50	163.49	182.76	189.35	9.17	12.33	13.00
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	18.20	154.99	171.71	180.89	8.83	11.77	12.23
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	18.60	150.52	158.75	164.38	8.53	10.77	11.30
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	17.47	153.59	159.58	166.78	8.67	11.17	11.86
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	17.97	145.62	162.72	165.55	8.40	10.40	11.20
SEm±	0.81	3.95	4.57	4.58	0.26	0.32	0.30
CD (P=0.05)	NS	11.43	13.22	13.28	0.75	0.94	0.87
CV (%)	10.87	6.23	6.60	6.40	7.26	7.06	6.18

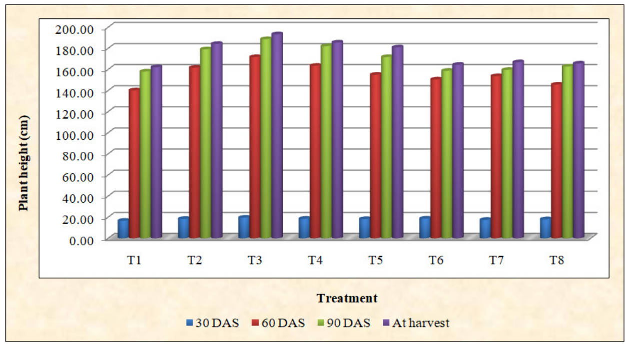

Fig. 1. Effect of integrated nutrient management on plant height at 30 DAS, 60 DAS, 90 DAS and harvest of mustard.

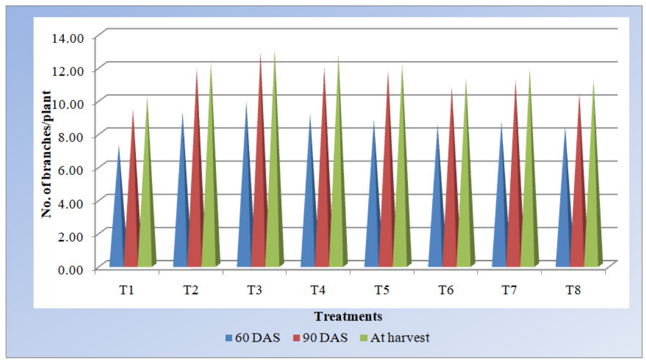

Fig. 2. Effect of integrated nutrient management on number of branches per plant at 60 DAS, 90 DAS and harvest of Mustard.

Table 2 : Effect of integrated nutrient management on dry matter accumulation per plant and crop growth rate of mustard.

Treatments	Dry matter accumulation per plant (g)				Crop growth rate (g/m^2/day)			
	30 DAS	60 DAS	90 DAS	At harvest	0-30 DAS	30-60 DAS	60-90 DAS	90-At harvest
T_1 : Control	10.47	31.43	69.85	75.68	7.32	14.61	26.82	5.67
T_2 : 100% RDF	10.75	39.12	96.92	104.56	7.66	20.16	41.13	7.58
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	10.94	43.38	118.63	126.95	7.86	23.30	53.39	8.34
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	10.68	41.62	109.00	117.05	7.57	21.94	47.69	7.96
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	10.63	36.12	85.16	91.83	7.50	18.03	34.67	6.57
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	10.51	34.01	79.36	86.13	7.44	16.66	32.06	6.67
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	10.58	32.80	82.08	89.15	7.36	15.59	34.29	6.78
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	10.46	32.85	78.39	84.90	7.35	15.76	32.09	6.37
SEm ±	0.33	1.39	2.72	2.72	0.28	1.06	1.69	0.34
CD (P=0.05)	NS	4.02	7.87	7.87	NS	3.07	4.90	0.97
CV (%)	7.50	9.34	7.40	6.86	9.09	14.22	10.97	11.79

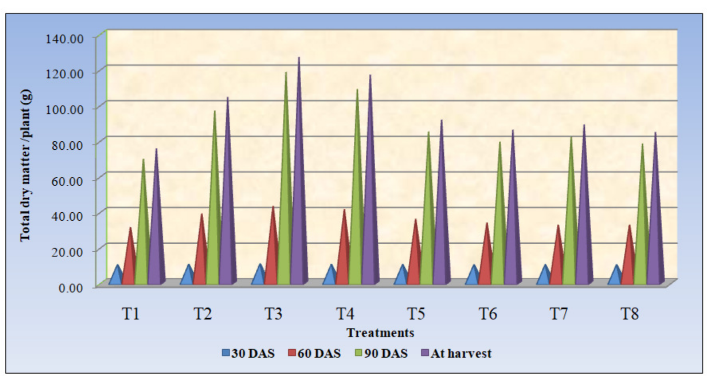

Fig. 3. Effect of integrated nutrient management on dry matter accumulation per plant at 30 DAS, 60 DAS, 90 DAS and harvest of mustard.

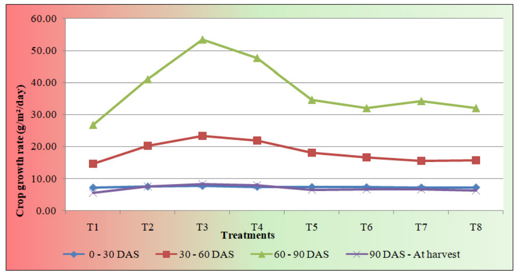

Fig. 4. Effect of integrated nutrient management on crop growth rate at 0-30 DAS, 30-60 DAS, 60 -90 DAS and 90 DAS -harvest of mustard.

Table 3 : Effect of integrated nutrient management on relative growth rate and net assimilation rate of mustard.

Treatments	Relative growth rate (g/g/day)			Net assimilation rate (g/m^2/day)		
	30-60 DAS	60-90 DAS	90-At harvest	30-60 DAS	60-90 DAS	90-At harvest
T_1 : Control	0.037	0.027	0.0022	2.442	2.927	0.314
T_2 : 100% RDF	0.043	0.030	0.0025	3.123	3.786	0.535
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	0.046	0.033	0.0027	3.472	3.932	0.564
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	0.045	0.032	0.0027	3.296	3.693	0.532
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	0.041	0.029	0.0025	2.818	3.218	0.518
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	0.039	0.028	0.0028	2.652	2.830	0.490
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	0.038	0.031	0.0026	2.469	3.054	0.548
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	0.038	0.029	0.0027	2.582	2.978	0.510
SEm±	0.001	0.001	0.0002	0.160	0.174	0.031
CD (P=0.05)	0.004	0.003	NS	0.462	0.503	0.089
CV (%)	8.03	7.85	15.09	13.68	12.88	14.97

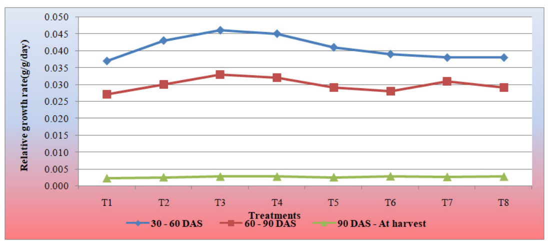

Fig. 5. Effect of integrated nutrient management on relative growth rate at 30 - 60 DAS, 60 - 90 DAS and 90 DAS – harvest of mustard.

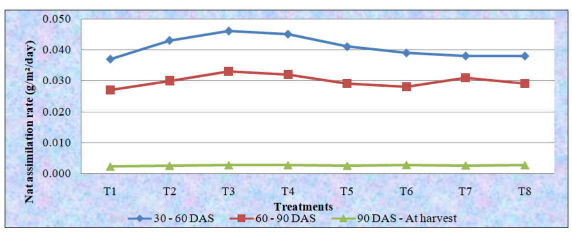

Fig. 6. Effect of integrated nutrient management on net assimilation rate at 30-60 DAS, 60 - 90 DAS and 90 DAS - harvest of mustard.

Table 4 : Effect of integrated nutrient management on number of siliquae per plant, length of siliquae, number of seed per siliquae and test weight of mustard.

Treatments	Number of siliquae/plant	Length of siliquae (cm)	Number of seeds/siliquae	Test weight (g)
T_1 : Control	353.86	4.09	11.25	4.45
T_2 : 100% RDF	521.37	4.69	12.56	4.74
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	566.77	4.93	13.20	4.79
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	531.57	4.76	12.77	4.77
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	424.70	4.74	12.19	4.73
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	377.80	4.38	11.63	4.62
T_7 : 50% RDF + vermicompost @ 3.0 t ha^{-1}	404.63	4.51	11.68	4.67
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	372.27	4.34	11.61	4.65
SEm±	16.31	0.11	0.27	0.14
CD (P=0.05)	47.23	0.32	0.79	NS
CV (%)	8.99	5.87	5.51	7.15

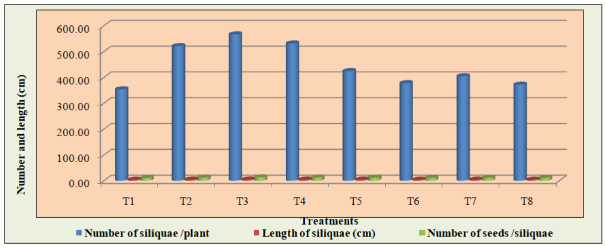

Fig. 7. Effect of integrated nutrient management on number of siliquae/plant, length of siliquae and number of seed/ siliquae of mustard.

Table 5 : Effect of integrated nutrient management on seed, stover and biological yield of mustard.

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
T_1 : Control	1790	3418	5208
T_2 : 100% RDF	2390	4820	7210
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	2612	5204	7816
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	2515	4937	7452
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	2101	4245	6346
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	2031	3815	5846
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	2056	4043	6099
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	1976	3779	5754
SEm±	77.8	148.5	186.5
CD (P=0.05)	225.1	430.3	540.3
CV (%)	8.72	8.50	7.07

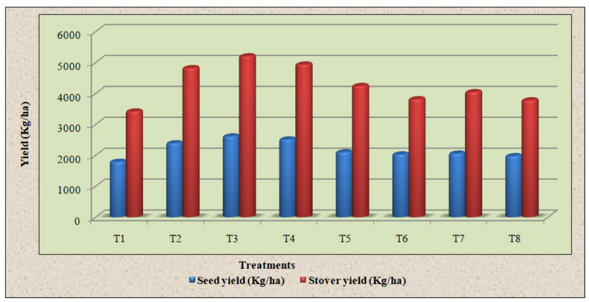

Fig. 8. Effect of integrated nutrient management on seed and stover yield of mustard.

Table 6 : Effect of integrated nutrient management on oil content and oil yield of mustard.

Treatments	Oil content (%)	Oil yield (kg/ha)
T_1 : Control	34.79	623.34
T_2 : 100% RDF	37.96	907.02
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	39.32	1027.46
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	38.59	971.45
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	37.50	790.10
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	37.27	757.98
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	36.69	753.58
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	36.46	720.79
SEm±	0.90	34.83
CD (P=0.05)	NS	100.87
CV (%)	5.92	10.42

Table 7 : Effect of integrated nutrient management on economics of mustard.

Treatments	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_1 : Control	100785	67755	2.05
T_2 : 100% RDF	135089	98807	2.73
T_3: 75% RDF + FYM @ 5.0 t ha^{-1}	147564	100657	2.15
T_4 : 75% RDF + vermicompost @ 1.5 t ha^{-1}	141912	96148	2.10
T_5: 75% RDF + humic acid @ 5.0 kg ha^{-1}	118793	80265	2.08
T_6: 50% RDF + FYM @ 10.0 t ha^{-1}	114258	56732	0.99
T_7 : 50% RDF +vermicompost @ 3.0 t ha^{-1}	116052	60814	1.10
T_8 : 50% RDF + humic acid @10.0 kg ha^{-1}	111272	70506	1.73

CONCLUSIONS

On the basis of two years experimental results, it can be concluded that application of 75% RDF (37.50-37.50-00 N-P_2O_5-K_2O kg/ha) + FYM @ 5.0 t ha^{-1} significantly increased mustard seed yield and improved nutrient uptake compared to rest of treatment combinations. This treatment also boosted soil nutrient availability after harvest crop. Economically, it resulted in higher gross returns (₹147,564 per hectare) and net returns (₹100,657 per hectare)) although higher B: C ratio (2.73) was obtained under 100% RDF . Overall, the combination of 75% RDF + FYM proved most effective in enhancing both crop productivity and profitability in mustard cultivation.

FUTURE SCOPE

Integration of other sources of nutrients that were not tried in this investigation *viz.*, green manures, edible and non-edible oil cakes, enriched FYM, biochar, etc. can be proposed to try individually or in combination with inorganic fertilizer.

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