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Effect of Different Nutrients and its Integration on Growth, Yield and Quality of Double Zero Indian Mustard (*Brassica juncea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, to assess the effect of different nutrients and their integration on growth, yield and quality of Indian mustard (*Brassica juncea* L.). Indian mustard cultivar Pusa Mustard 31(PDZM -31) was grown during winter (*rabi*) season of 2020-21. The treatments comprised of Control (T_1), 100% N (T_2), 100% NP (T_3), 100% NPK (T_4), 125%NPK (T_5), 100% NPK+ S@40kg ha^{-1} (T_6), 100%NPK+ Zn @5kg ha^{-1} (T_7), 100%NPK + B @1kg ha^{-1} (T_8), 75% NPK+ Vermicompost @ 2t ha^{-1} (T_9), 75%NPK+ Farm Yard Manure @ 6t ha^{-1} (T_{10}), 75%NPK + VC @ 2t ha^{-1}+ Azotobacter (T_{11}) and 75% NPK + FYM @ 6t ha^{-1} + Azotobacter (T_{12}). Results revealed that treatment T_{11} (75% NPK + VC@2t ha^{-1} + Azotobacter) and T_{12} (75% NPK + FYM@6t ha^{-1} + Azotobacter) exhibited significant influence on the growth, yield and quality of mustard as compared to the application of 100% NPK alone. Significant improvement in growth parameters *viz.* plant height, leaf area index, dry matter accumulation as well as crop growth rate, relative growth rate and yield was recorded with the application of T_{11} and T_{12}. Maximum oil content (40.67%) was obtained in T_6 (100% NPK+ S@ 40kg ha^{-1}) and maximum oil yield (796.76 kg ha^{-1}) was obtained in

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T_{12}, it remained at par with T_5, T_6, T_{10} and T_{11}. Maximum protein content (21.75%) was found in T_{12} which was on par with T_5, T_9, T_{10} & T_{12}. The maximum protein yield (492.88 kg ha^{-1}) was obtained in treatment T_{12} which was statistically on par with T_{11}, T_5 and T_6 respectively. T_{11} and T_{12} exhibited significant influence on the growth and yield of mustard as compared to other treatments respectivity. Integration of inorganic and organic sources of nutrients improved the growth parameters, yield and quality parameters of Indian mustard, whereas the use of chemical fertilizer alone showed a pronounced decline of these parameters.

Keywords: Growth; integration; yield; quality; oil content; protein content.

1. INTRODUCTION

Indian mustard (*Brassica juncea* L.) is commonly known as *raya* or *laha*. It is an important oilseed crop in the world. It plays an important role in meeting edible oil demand of the country. Indian mustard is chiefly cultivated in Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, and Gujarat. Its cultivation is also being extended to non-traditional areas of cultivation in southern states like Karnataka, Tamil Nadu and Andhra Pradesh.

Among the nine oilseed crops the contribution of Rapeseed and Mustard is around 26%. In India, Rapeseed and Mustard is grown on an area of 6.9 million hectares with production of 7.2 metric million tonnes and productivity of 1.0375 mt/ha [1].India is ranked third after Canada and China sharing about 11.0% of the global rapeseed-mustard production (72.41 mt) and 24.7% and 29.4% in terms of area and production, respectively, of oilseeds in India during 2018-19. Of the projected demand of 82-101 mt of oilseeds by 2030, contribution of rapeseed-mustard is projected at 16.4-20.5 mt, considering its share of 20-25% in production. Near doubling the production of rapeseed-mustard from its current production of 9.26 mt within 10 years is a daunting challenge necessitating multi- pronged strategy [2].

The efficiency of fertilizer nitrogen is only 40-50%, phosphorous 15-20% and Sulphur 10-12% in Indian soils and this could be enhanced by efficient use of inputs [3]. The nutrient requirement of Indian mustard, in general is high and inadequate nutrient use often leads to low productivity of the major nutrient elements, which is insufficient in most of the Indian soils, plays appreciably an important role in *Brassica juncea* [4]. Added to this is the use of high yielding varieties of mustard which has led to increased depletion of nutrients from the soil. The imbalance between nutrient availability, supply and removal cannot be overcome by application of fertilizer alone. This can be achieved through balanced and integrative use of different nutrients.

All the major nutrient *viz.*, nitrogen, phosphorus, sulphur and boron play an important role in increasing the yield and quality of mustard. The nitrogen supply of oilseed rape is of central importance to ensure high yields. As oleiferous brassicas are heavy users of N, and available N is the most limiting source in many areas of the world [5], therefore, mineral N fertilization is a crucial factor in oilseed rape production [6]. Phosphorus fertilization is a major input in crop production [7]. It participates in metabolic activities as a constituent of nucleoprotein and nucleotides and also plays a key role in the formation of energy rich bond like adenosine diphosphate (ADP) and adenosine triphosphate (ATP). Favourable response of mustard to applied P was reported by [8] and [9]. Sulphur fertilization has also been shown to increase the oil content in seeds of rapeseed-mustard [10]. Sulphur is the key component of balanced nutrient application for higher yields and superior quality produce of mustard. Sulphur plays a vital role in the synthesis of amino acids, chlorophyll and certain vitamins in mustard plant [11]. Sulphur plays a crucial role in providing nutrition to oilseed crops, more importantly the crops of Cruciferae family [12].

Zinc is important for stability of the cytoplasmic ribosome, cell division, dehydrogenase, proteinase, peptidase enzymes and helps in the synthesis of the protein and carotene [13,14]. Boron plays a prominent role in diverse range of the plants functions including cell wall formation, stability, maintenance of structural and functional integrity of the biological membranes, movement of the sugar products in the plants from source to sink [15].

Farmyard manure with good amount of organic matter can be applied along with N, P & K fertilizers. Although, FYM is costlier than the other chemical fertilizers on nutrient basis, the other beneficial effects it has on soil, can balance the increase in added cost. FYM supplies the essential plant nutrients and also improves the soil structure, nutrient use efficiency, microbial action and ensures better availability of nutrients in soil. Soil quality improved with the application of organic manures like FYM, leaf compost and Vermicompost [16].

The purpose of the current study was to investigate the response of Indian Mustard (*Brassica juncea* L.) for their growth, yield and quality parameters under different nutrient management practices.

2. MATERIALS AND METHODS

The experiment was carried out at Crop Research Centre, Sardar Vallabhbhai Patel Universityof Agriculture and Technology, Meerut (U.P.) to study the influence of different nutrient management practices on productivity and profitability of Double Zero Indian Mustard in Randomized Block Design with 12 treatments (Table 1), replicated three times. The treatments comprised of Control (T_1), 100% N (T_2), 100% NP (T_3), 100% NPK (T_4), 125%NPK (T_5), 100% NPK+ S@40kg ha^{-1} (T_6), 100%NPK+ Zn @5kg ha^{-1} (T_7), 100%NPK + B @1kg ha^{-1} (T_8), 75% NPK+ Vermicompost @ 2t ha^{-1} (T_9), 75%NPK+ Farm Yard Manure @ 6t ha^{-1} (T_{10}), 75%NPK + VC @ 2t ha^{-1}+ Azotobacter (T_{11}) and 75% NPK + FYM @ 6t ha^{-1} + Azotobacter (T_{12}). Results revealed that treatment T_{11} (75% NPK + VC@2t ha^{-1} + Azotobacter) and T_{12} (75% NPK + FYM@6t ha^{-1} + Azotobacter) respectively. The maximum and minimum temperatures recorded were 35.21 °C and 4.89 °C during the crop growth period. Maximum temperature ranged from 18.13 °C to 34.01 °C during maturity phase of the crop. Relative humidity varied from 26.57% to 94.86% during crop growth period. The area receives mean annual rainfall of 845mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (220.7 kg ha^{-1}) and organic carbon (0.48%), medium in available phosphorous (13.8 kg ha^{-1}) and potassium (247.2 kg ha^{-1}) and slightly alkaline (pH 7.8) in reaction with electrical conductivity of 0.22 dS m^{-1}. The gross and net plot size were 6m X 4.5m and 4.8m X 2.7m respectively. The crop variety Pusa Mustard 31(PDZM-31) was sown on 19 October 2020 and harvested on 20 March 2021.The seed rate was 5 kg ha^{-1}. Seeding was done in the row to row spacing of 45 cm and plant to plant spacing of 15cm. The recommended dose of nitrogen (120kg ha^{-1}) was applied in two equal split, the half as basal and the remaining half was top dressed 2 times at the time of first and second irrigation. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Murate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (60kg ha^{-1}) through DAP. Vermicompost (2t ha^{-1}) and FYM (6t ha^{-1}) were applied in the field as per treatments at the time of sowing. The sulphur (40 kg ha^{-1}) was applied through Gypsum in the field at sowing time. Boron was applied as basal dose through borax (1 kg ha^{-1}) at the time of sowing. Zinc (5 kg ha^{-1}) was applied at the time of sowing in the form of Zinc sulphate. The seed was treated with Azotobacter @200g / 10 kg seed which was appliedas per treatments before the sowing. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 15 cm. Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. The observations recorded included Growth parameters [Plant height (cm), No. of primary and secondary branches, Plant dry weight (g plant^{-1})], Leaf area index (LAI), Crop growth rate (g m^{-2} day^{-1}), Relative growth rate (g g^{-1} day^{-1}), yield (Seed and stover yield), Oil content (%), Oil yield (kg ha^{-1}), Protein content (%) and Protein yield (kg ha^{-1}). Soxhlet's extraction method was used to determine the oil content. Oil yield (kg ha^{-1}) was obtained by multiplying oil content with seed yield divided by 100. Protein content (%) was calculated by multiplying % N content with factor of 6.25. Protein yield was obtained by multiplying protein content (%) with seed yield divided by 100. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at *P<0.05* level of pro bability using t-test and calculating CD values.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Data regarding Growth parameters *viz*., Plant height (cm), No. of primary and secondary branches and Plant dry weight (g plant^{-1}) is mentioned in Table 1 and depicted in Fig. 1a, 1b and 1c.

Table 1. Influence of different nutrients on Growth parameters of Indian mustard at harvest

Treatments		Plant height (cm)	Primary branches	Secondary branches	Plant dry weight (g plant^{-1})
T_1	Control	173.6	5.6	10.8	37.3
T_2	100% N	180.0	5.8	11.3	47.9
T_3	100% NP	183.7	5.8	11.1	53.2
T_4	100% NPK	184.2	5.9	11.5	55.7
T_5	125%NPK	191.2	5.9	11.6	66.5
T_6	100% NPK+ S@ 40kg ha^{-1}	195.5	6.3	12.5	66.2
T_7	100%NPK+ Zn@ 5kg ha^{-1}	181.9	6.0	12.1	60.9
T_8	100%NPK + B@ 1kg ha^{-1}	184.9	6.1	12.2	57.2
T_9	75% NPK+ VC@ 2t ha^{-1}	195.1	6.2	12.4	61.7
T_{10}	75%NPK+FYM@ 6t ha^{-1}	196.5	6.2	12.4	62.1
T_{11}	75%NPK + VC@ 2t ha^{-1}+ Azotobacter	204.1	6.3	12.4	64.5
T_{12}	75% NPK + FYM@ 6t ha^{-1} + Azotobacter	201.7	6.4	12.7	64.7
SEm ±		3.1	0.08	0.1	1.6
CD (P=0.05)		9.1	0.25	0.4	4.7

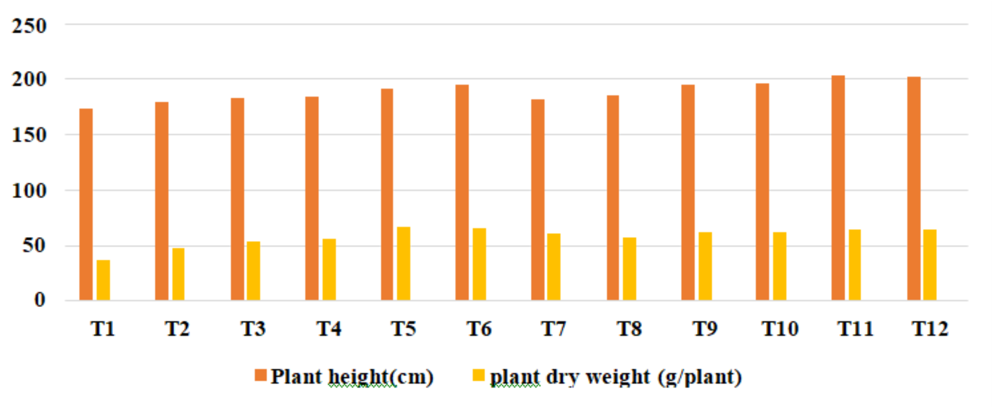

Fig. 1a. Inflence of different nutrient management practices on Growth parameters of Indian mustard at harvest stage

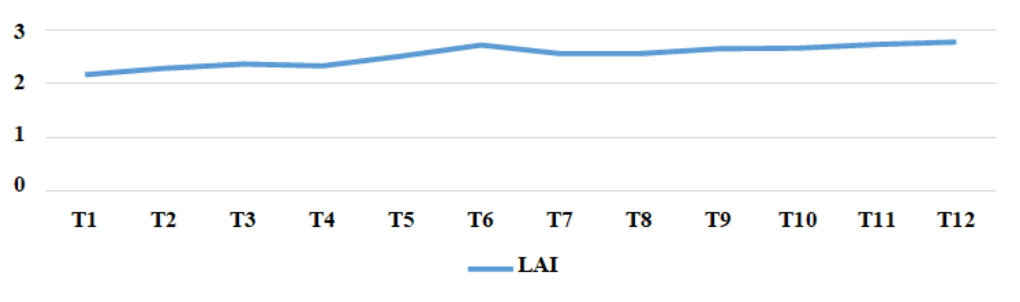

Fig. 1b. Leaf area index of Indian mustard at 90 DAS - harvest

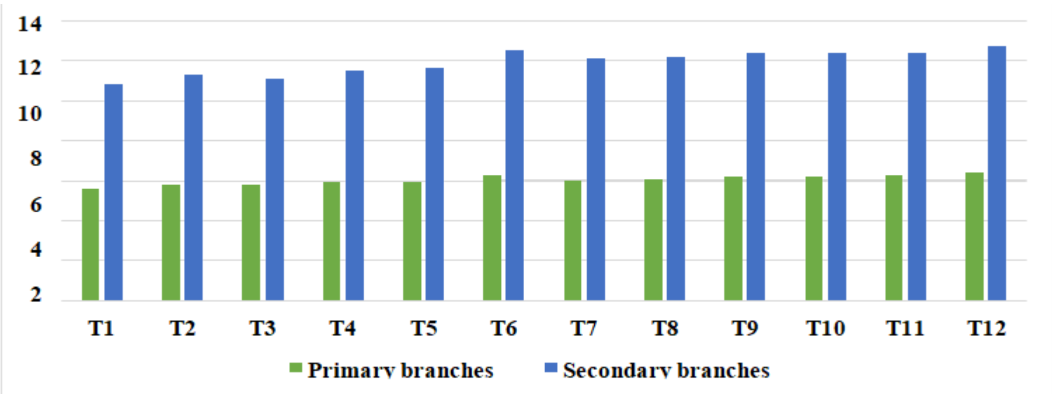

Fig. 1c. Influence of different nutrient management practices in Indian mustard on No of Primary & Secondary branches

At harvest, application of T_{11} (75% NPK + VC@ 2t ha^{-1} + Azotobacter) exhibited significantly taller plant 204.1cm which was on par with T_6 (100% NPK+ S@ 40kg ha^{-1}), T_9 (75% NPK+ VC@ 2t ha^{-1}), T_{10} (75%NPK+FYM@ 6t ha^{-1}) and T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) whereas, the lowest plant height was recorded under control. On an average an increase in height of 9.5% and 16.2 % was obtained in T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) over T_4 (100% NPK) and T_1 (Control) respectively.

Highest value of primary branches plant^{-1} and secondary branches plant^{-1} were recorded in T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) and was statistically on par with T_6, T_8, T_9, T_{10}, T_{11} and T_6, T_9, T_{10} and T_{11} respectively at harvest stage. In case of plant dry weight, treatment T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) exhibited highest plant dry weight and was on par with T_9, T_{10} and T_{11} at Harvest stage.

The favourable effect on dry matter production might be due to higher Leaf area index and more number of branches associated with high photosynthetic accumulation and their translocation which together accounted for higher dry matter production. 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 essential macronutrients, micronutrients, organic manure and biofertilizers which satisfied the immediate requirement of nutrients and also provided favourable soil environment for better plant growth. The results obtained from the present experiment are in near conformity with the findings of Tripathi *et al.* [4], Dubey *et al.* [17], Kansotia *et al.* [18], Singh *et al.* [19] and Kumar *et al.* [20].

3.2 Crop Growth Rate, Relative Growth Rate and Leaf Area Index

The Crop Growth Rate was non- significant, however the maximum CGR (3.4 g m^{-2} day^{-1}) was obtained in T_7 and minimum in Control. The highest RGR (0.011 g g^{-1} day^{-1}) was recorded in T_{12} which was significantly higher than rest of the treatments. The lowest relative growth rate (0.006 g g^{-1} day^{-1}) was recorded in T_1. T_{12} exhibited significantly higher leaf area index (2.78) respectively, which was on par with T_6, T_7, T_8, T_9, T_{10} and T_{11}.

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 essential macronutrients, micronutrients, organic manure and biofertilizers which satisfied the immediate requirement of nutrients and also provided favourable soil environment for better plant growth. The results obtained from the present experiment are in near conformity with the findings of Tripathi *et al.* [4], Singh *et al.* [19] and Kumar *et al.* [20].

3.3 Yield and Quality Parameters of Indian Mustard

Data (Table 3 & Table 4) regarding the influence of different nutrients on yield and quality parameters of Indian mustard is depicted in Figs. 2 & 3.

Among the various nutrient levels, the treatment T_{12} exhibited significantly higher seed yield (22.66 q ha^{-1}) which was statistically on par to T_5, T_6 and T_{11}. Treatment T_1 with no application of any fertilizer recorded lowest grain yield of 8.89 q ha^{-1}. About 20.7%, 20.1%, 19.2% and 16.9% increase in seed yield was recorded by T_{12}, T_{11}, T_5 and T_6 respectively over treatment T_4.

Table 2. Influence of different nutrients on CGR, RGR and LAI of Indian mustard

Treatments		CGR ($g/m^2/day$)	RGR (g/g/day)	LAI
90 DAS to Harvest				
T_1	Control	1.9	0.006	2.17
T_2	100% N	3.8	0.007	2.29
T_3	100% NP	4.0	0.008	2.37
T_4	100% NPK	2.9	0.008	2.33
T_5	125%NPK	3.3	0.008	2.52
T_6	100% NPK+ S@ 40kg ha^{-1}	3.4	0.007	2.72
T_7	100%NPK+ Zn@ 5kg ha^{-1}	4.2	0.007	2.56
T_8	100%NPK + B@ 1kg ha^{-1}	2.9	0.008	2.56
T9	75% NPK+ VC@ 2t ha^{-1}	3.0	0.008	2.66
T10	75%NPK+FYM@ 6t ha^{-1}	2.8	0.007	2.67
T11	75%NPK + VC@ 2t ha^{-1}+Azotobacter	2.7	0.008	2.73
T12	75% NPK + FYM@ 6t ha^{-1} + Azotobacter	2.8	0.011	2.78
SEm ±		*0.5*	*0.001*	*0.07*
C D (P=0.05)		*NS*	*0.004*	*0.22*

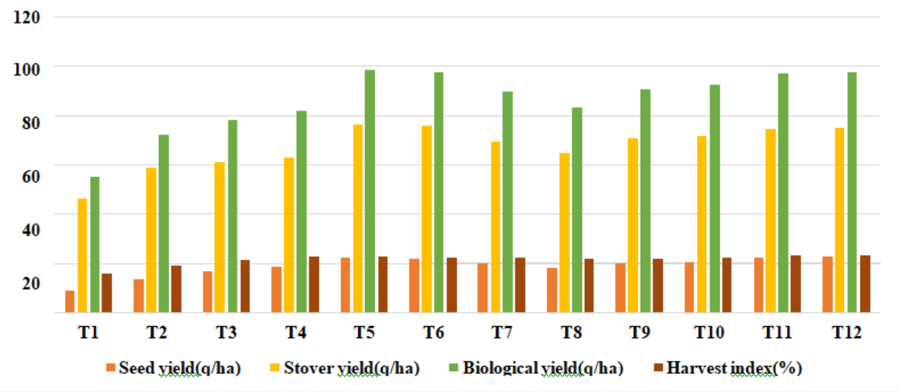

Fig. 2. Influence of different nutrients on yield of Indian mustard

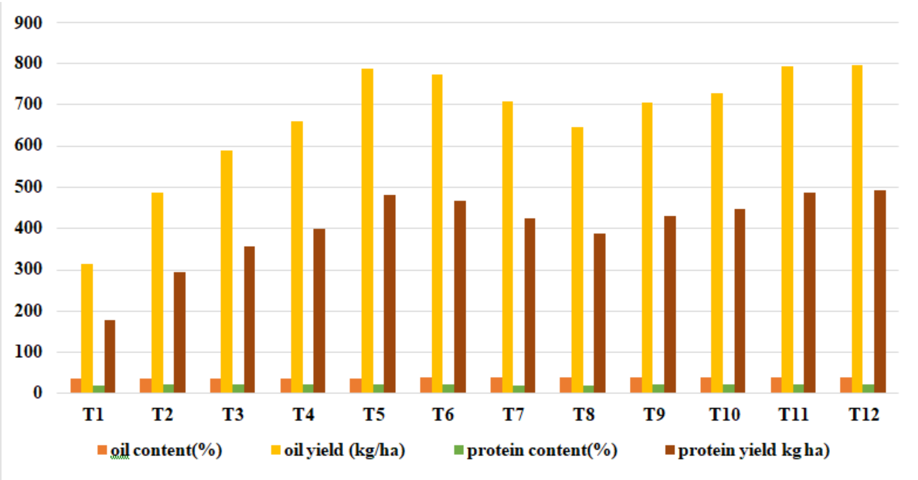

Fig. 3. Influence of different nutrient management practices on quality parameters of Indian Mustard

Maximum stover yield and biological yield was recorded in T_5 (125% NPK) followed by T_6, T_9, T_{10}, T_{11}, T_{12} and T_6, T_{10}, T_{11} and T_{12} which were at par with each other respectively. In all cases, the minimum values of yield (Seed, stover and biological yield) were obtained in T_1 (Control).

The maximum seed yield was recorded due to integrated application of FYM, chemical fertilizers and biofertilizers. This might be due to slow release of nutrient from FYM leading to reduced loss of nitrogen and efficient use of Macro and micronutrients. The production of growth promoting and antifungal substances by Azotobacter and nitrogen fixation was possibly the reason for higher yields. These findings are in conformity with the results Singh *et al.* [19], Kumar *et al.* [20]. Singh and Singh [21], Sharma *et al.* [22], Dhruw *et al*. [23] and Shivendu *et al.* [24]. (21, 22, 19, 23, 20 and 24).

T6 (100% NPK+ S@ 40kg ha^{-1}) recorded maximum oil content (40.67%) which was significantly higher than oil content of other treatments. However, the lowest oil content (35.16 %) was found in treatment T_1 (Control). It is evident from the data (Table 4) that, though the maximum oil yield (796.76 kg ha^{-1}) was obtained in T_{12} it remained at par with T_5, T_6, T_{10} and T_{11}. Whereas, the lowest oil yield (312.77 kg ha^{-1}) was produced in T_1. Hence, there was significant difference in oil yield produced by various treatments.

Maximum protein content (21.75%) was obtained in treatment T_{12} which was on par with treatment T_5, T_9, T_{10} & T_{12}. Lowest protein content (19.93%) was obtained in treatment T_1. Significantly higher protein yield (492.88 kg ha^{-1}) was obtained in treatment T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) which was statistically on par with T_{11}, T_5, T_6. The lowest

Table 3. Influence of different nutrients on Yield of Indian mustard

Treatments		Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
T_1	Control	8.89	46.33	55.22	16.08
T_2	100% N	13.79	58.70	72.49	19.05
T_3	100% NP	16.75	61.45	78.20	21.43
T_4	100% NPK	18.77	63.25	82.02	22.89
T_5	125%NPK	22.38	76.41	98.80	22.66
T_6	100% NPK+ S@ 40kg ha^{-1}	21.96	75.90	97.86	22.45
T_7	100%NPK+ Zn@ 5kg ha^{-1}	20.17	69.68	89.86	22.48
T_8	100%NPK + B@ 1kg ha^{-1}	18.37	64.87	83.25	22.06
T_9	75% NPK+ VC@ 2t ha^{-1}	20.07	70.80	90.87	22.08
T10	75%NPK+FYM@ 6t ha^{-1}	20.67	71.88	92.56	22.33
T11	75%NPK + VC@ 2t ha^{-1}+Azotobacter	22.54	74.70	97.25	23.19
T12	75% NPK + FYM@ 6t ha^{-1} + Azotobacter	22.66	75.08	97.74	23.21
SEm ±		0.48	1.83	1.96	0.58
C D (P=0.05)		1.41	5.39	5.74	1.72

Table 4. Influence of different nutrients on Quality parameters of Indian mustard

Treatments		Oil content (%)	Oil Yield (kg ha^{-1})	Protein content (%)	Protein Yield (kg ha^{-1})
T_1	Control	35.16	312.78	19.93	177.27
T_2	100% N	35.66	485.19	21.25	293.16
T_3	100% NP	35.33	589.03	21.31	357.00
T_4	100% NPK	36.54	660.00	21.29	399.68
T_5	125%NPK	35.68	787.22	21.47	480.78
T_6	100% NPK+ S@ 40kg ha^{-1}	40.67	772.23	21.22	466.13
T_7	100%NPK+ Zn@ 5kg ha^{-1}	38.34	709.47	21.10	425.80
T_8	100%NPK + B@ 1kg ha^{-1}	38.42	646.14	21.16	388.97
T_9	75% NPK+ VC@ 2t ha^{-1}	39.15	705.91	21.50	431.67
T_{10}	75%NPK+FYM@ 6t ha^{-1}	39.39	726.98	21.60	446.54
T_{11}	75%NPK + VC@ 2t ha^{-1}+ Azotobacter	39.46	792.82	21.62	487.62
T_{12}	75% NPK + FYM@ 6t ha^{-1} + Azotobacter	39.69	796.76	21.75	492.88
SEm ±		*0.2*	*16.8*	*0.1*	*10.7*
C D (P=0.05)		*0.7*	*49.3*	*0.3*	*31.5*

protein yield (177.27 kg ha^{-1}) was recorded in T_1 which was significantly lower than the rest of the other treatments. Increase in oil content may be ascribed to the enhanced protein synthesis (acetyl-CoA carboxylase) and increased oil accumulation in the developing seeds [11] by the S application. Such an increase of oil content is in accordance with the findings of Kumar and Trivedi, [25] and Das and Ghosh [26].

The increase in protein content with S application has also reported by Kartikeyan and Shukla [27] and Patel *et al*. [28]. Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein and oil [29]. Probably higher dose of fertilizers fortified with vermicompost helped in efficient translocation of nitrogen from vegetative parts to the developing seeds as well as synthesis of protein [30].

4. CONCLUSION

Among the various nutrient management practices, treatment T_{11} (75% NPK + VC@ 2t ha^{-1} + Azotobacter) and T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) exhibited significant influence on the growth and yield of mustard as compared to the application of 100% NPK alone. An increment in growth attributes, yield and quality parameters was recorded with the application of 75% NPK + VC@ 2t ha^{-1} + Azotobacter (T_{11}) and 75% NPK + FYM@ 6t ha^{-1} + Azotobacter (T_{12}) respectively. Therefore, application of application of 75% NPK + VC@ 2t ha^{-1} + Azotobacter (T_{11}) and 75% NPK + FYM@ 6t ha^{-1} + Azotobacter (T_{12}) found to be beneficial for enhancing growth and productivity of Indian mustard.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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