Original Research Article

Effect of different nutrient management practices on Productivity and Profitability of Double Zero Indian Mustard (*Brassica juncea* L.)

ABSTRACT

A field experiment was conducted at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, with a view to compare the production potential under different nutrient management practices and also to find out the economic viability of this cultivar for soil quality. 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+ VC@ 2t ha^{-1} (T_9), 75%NPK+FYM@ 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 yield attributes and yields of mustard as compared to the application of 100% NPK alone. The maximum gross return was obtained in T_{12} followed by $T_{11.}$ The highest net return was obtained in T_5 followed by T_{12}, T_6 and T_{11}, while minimum gross return and net return was obtained in T_1. Application of 75% NPK + FYM@6t ha^{-1} + Azotobacter (T_{12}) and 75%NPK + VC@ 2t ha^{-1}+ Azotobacter (T_{11}) recorded higher gross return and net return but the B:C ratio was lower due to higher cost of vermicompost. Higher values of B: C ratio (4.23) was obtained in T_6 and T_5 respectively.

Keywords: Indian mustard, nutrient management practices, production potential, profitability

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 various cultivated oilseed crops the contribution of Rapeseed and Mustard is around 26%. Rapeseed and Mustard is grown on an area of 6.9 million hectares, 7.2 M Mt of production and 1.0375 Mt ha^{-1} productivity in India **(Anonymous 2019).** 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. The area production and productivity of Rapeseed and Mustard in Uttar Pradesh is 0.9mha, 0.95mt and 1055 kg ha^{-1} respectively. The estimated demand of oilseeds by 2030 is 82-101 mt and contribution of rapeseed-mustard is projected to be 16.4-20.5 mt, accounting its share of 20-25% in production **(Chauhan *et al* 2020).**

Indian mustard requires optimum weather conditions for its good growth and development. Since it is mostly grown after the harvest of rice and late recession of moisture from rice fields in Uttar Pradesh, the sowing of mustard crop gets delayed and the growth and vigour of mustard is not good as timely sown crop. It is important to increase the productivity of Indian mustard, which still has a greater scope to exploit the yield potential of existing cultivars with agronomic management.

Among the various agronomic factors that are known to enhance crop production, fertilizer and nutrient management play a significant role. 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 **(Hegde and Sudhakara Basu, 2004)**. 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 *Brassicajuncea*.

Knowledge of the concentration of the dosage of plant nutrients in a crop and the amount of nutrients removed by a particular crop from the soil may be a useful guide for the recommendation of a sound nutrient management Programme. For sustainable crop production, integrative effect of organic, inorganic and bio-fertilizers is important. Biofertilizers and organic manures play a significant role in sustaining soil health. Nitrogen, phosphorous and potassium as major nutrients and ~~S~~sulphur, boron among the secondary nutrients play an important role in influencing the yield and quality of mustard. Moreover balanced fertilization is an important aspect of crop production technology.

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Material and Methods

The experiment was carried out at Crop Research Centre, Sardar Vallabhbhai Patel University of 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 maximum and minimum temperatures recorded were 35.21 ^{0} C and 4.89 ^{0} C during the crop growth period. Maximum temperature ranged from 18.13 ^{0} C to 34.01 ^{0} 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, thehalf 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 and was thoroughly mixed at the time of sowing. The sulphur was applied through Gypsum in the field as per treatments. Boron was applied through borax at the time of sowing. Zinc 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 applied as 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. At the harvest, seeds per siliqua, 1000 seed weight, seed yield and stover yield were calculated. Economics of treatments were computed on the basis of prevailing market price of inputs and outputs under each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in performing different operation was also included. 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 probability using t-test and calculating CD values.

Result and Discussion

Influence of different nutrients on yield attributes of Indian mustard

Yield attributes *viz.*, Number of siliqua plant^{-1}, Siliqua length (cm), Number of seeds per siliqua and weight of 1000 seeds of Indian mustard were affected significantly by various treatments involving different nutrient management practices (Table 1 and fig 1a &1b).

Table 1: Influence of different nutrients on yield attributes of Indian mustard.

Treatments		No. of siliqua plant^{-1}	Siliqua length (cm)	Number of seeds siliqua^{-1}	1000 seed weight(g)
T_1	Control	148.0	4.17	12.4	3.46
T_2	100% N	207.0	4.22	12.9	3.53
T_3	100% NP	240.7	4.29	13.3	3.55
T_4	100% NPK	257.3	4.32	13.3	3.64
T_5	125%NPK	251.3	4.37	14.4	3.63
T_6	100% NPK+ S@ 40kg ha^{-1}	259.2	4.34	15.6	3.67
T_7	100%NPK+ Zn@ 5kg ha^{-1}	255.0	4.33	14.2	3.62
T_8	100%NPK + B@ 1kg ha^{-1}	235.7	4.43	14.6	3.61
T_9	75% NPK+ VC@ 2.5t ha^{-1}	256.0	4.50	15.5	3.74
T_{10}	75%NPK+FYM@ 6t ha^{-1}	257.0	4.51	15.5	3.75
T_{11}	75%NPK + VC@ 2t ha^{-1}+Azotobacter	259.3	4.53	16.0	3.77
T_{12}	75% NPK + FYM@6t ha^{-1} + Azotobacter	254.7	4.54	16.1	3.78
SEm ±		***7.7***	***0.03***	***0.19***	***0.03***
C D (P=0.05)		***22.7***	***0.09***	***0.55***	***0.08***

From the given data (Table 1) it can be inferred that the maximum number of siliqua plant^{-1} (259) were produced in the treatment T_{11} (75%NPK + VC@ 2t ha^{-1}+ Azotobacter) which was found to be on par with T_4 (100%NPK), T_6 (100% NPK+ S@40kg ha^{-1}), T_7

Comment [T3]: the variables numbers in table 1 should be followed by a letter notation that indicates a significant or non-significant difference according to the results of the significant difference test

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(100%NPK+ Zn@5kg 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). However, the lowest number of siliqua $plant^{-1}$ (148) were recorded in treatment T_1 (Control) which was significantly lower than rest of the other treatments. In mustard sink lies in siliqua and seeds. Therefore, under optimum supply of recommended dose of fertilizers, greater translocation of photosynthesis occurs from source (leaves) to sink site (siliqua and seeds), resulting into increased number of siliquae. The results were in accordance with those reported by **Bhat *et al.* (2006), Kumar *et al.* (2014) and Sharma *et al.* (2016).**

Significantly higher siliqua length (3.54) was recorded in treatment T_{12} (75% NPK + FYM@ 6t ha^{-1} + Azotobacter) which was statistically found to be on par with, T_9 (75% NPK+ VC@ 2t ha^{-1}), T_{10} (75%NPK+FYM@ 6t ha^{-1}) and T_{11} (75%NPK + VC@ 2t ha^{-1}+ Azotobacter).Treatment T_1 (Control) recorded the lowest siliqua length (4.17cm) and next in order was treatment T_2 (100% N). It might be due to increased and prolonged availability of nutrients from integrated use of FYM, major nutrients and biofertilizers, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by **Singh and Siniswar (2006), Patel *et al* (2009) and Kumar *et al* (2014).**

It is evident from the data that the significantly higher number of seeds $siliqua^{-1}$ (16.1) were produced in treatment T_{12} (75% NPK + FYM@6t ha^{-1} + Azotobacter) which remained on par with, T_9 (75% NPK+ VC@ 2t ha^{-1}), T_{10} (75%NPK+FYM@ 6t ha^{-1}) and T_{11} (75%NPK + VC@ 2t ha^{-1}+ Azotobacter). Treatment T_1 recorded lowest number of seeds $siliqua^{-1}$ (12.4) followed by T_2 (100% N). Adequate nutrients availability to the crop as a result of increment in photosynthesis as well as growth led to increase in the no of seeds $siliqua^{-1}$. These findings were almost similar to the results reported by **Hussain *et al* (2008), Tripathi *et al* (2011) and Dubey *et al* (2013).**

Maximum test weight (3.78g) was recorded in T_{12} (75% NPK + FYM@6t ha^{-1} + Azotobacter) which was on par to T_9 (75% NPK+ VC@ 2t ha^{-1}), T_{10} (75%NPK+FYM@ 6t ha^{-1}) and T_{11} (75%NPK + VC@ 2t ha^{-1}+ Azotobacter), whereas the lowest test weight (3.46) was recorded in T_1 (Control). The integrated application of FYM, macro and micro nutrients and biofertilizers might increase availability of plant nutrients which result into better nourishment of plants and the formation of bold seeds, ultimately increased weight of seeds. The results were similar to the findings reported by **Dubey *et al* (2013), Kumar *et al.* (2014) and Sharma *et al.* (2016).**

Influence of different nutrient management practices on Productivity

Data with regard to the effect of different nutrient management practices on seed yield, stover yield, biological yield and harvest index of mustard crop are mentioned in Table 2 and depicted in fig 2.

Table 2: Influence of different nutrients on Yield of Indian mustard

Comment [T5]: the variables numbers in table 1 should be followed by a letter notation that indicates a significant or non-significant difference according to the results of the significant difference test

Treatments		Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	HI (%)
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
T_{10}	75%NPK+FYM@ 6t ha^{-1}	20.67	71.88	92.56	22.33
T_{11}	75%NPK + VC@ 2t ha^{-1}+Azotobacter	22.54	74.70	97.25	23.19
T_{12}	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***

Among the various nutrient levels, the treatment T_{12} (75% NPK +FYM@ 6t ha^{-1} + Azotobacter) exhibited significantly higher seed yield (22.66 q ha^{-1}) which was statistically on par to T_5 (125% NPK), T_6 (100% NPK+ S@ 40kg ha^{-1}) and T_{11} (75%NPK + VC@ 2t ha^{-1}+ Azotobacter), .Treatment T_1 (Control) 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} (75% NPK +FYM@ 6t ha^{-1} + Azotobacter), T_{11} (75% NPK + VC@ 2t ha^{-1} + Azotobacter), T_5 (125% NPK) and T_6 (100% NPK + S@ 40kg ha^{-1}) respectively over treatment T_4 (100% NPK), also T_9 (75% NPK+ VC@ 2t ha^{-1}) and T_{10} (NPK+FYM 6t ha^{-1}) recorded increase in seed yield of 6.9% and 10.1% respectively over T_4 (100 % NPK)

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respectively. Treatment T_2 (100% N) and T_3 (100 % NP) showed an increment in seed yield of 55.1% and 88.4% respectively over T_1 (Control). Addition of Sulphur (T_6) and Zinc (T_7) to RDF (100% NPK) recorded an increase of 16.9 % and 7.4% seed yield respectively over T_4 (100% NPK). It can also be seen from the data (Table 2) that by the addition of Biofertilizer treatment T_{11} ((75% NPK + VC@2t ha^{-1} + Azotobacter) showed 12.3% seed yield increment over T_9 (75% NPK+ VC@ 2t ha^{-1}). Similarly T_{12} (75% NPK +FYM@6t ha^{-1} + Azotobacter) recorded 9.6 % increase in seed yield over T_{10} ((NPK+FYM 6t ha^{-1}). 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.

In the same way, stover yield of mustard (Table 2) was significantly influenced by different nutrient management treatments. Results revealed that the differences in stover yield were found significant due to different treatments. Though significantly higher stover yield 76.41q ha^{-1} was recorded under T_5, it was statistically on par with $T_{6,}$ T_{10}, T_{11} and T_{12}. The lowest stover yield (46.33 q ha^{-1}) was recorded in T_1 (control). Similar trend was observed in Biological yield, whereas maximum harvest index (23.21 %) was recorded in T_{12} which was on par with $T_{4,}$ $T_{5,}$ $T_{6,}$ T_7, T_8, T_9, T_{10} and T_{11}. The increase in straw yield was mainly due to increased growth attributing characters like plant height and number of primary and secondary branches plant-1. The use of organic manure like FYM and biofertilizers in conjunction with macro and micronutrients had profound effect on vegetative growth due to improved nutrients availability in the soil for longer time with progressive decompositions of FYM. These findings are in conformity with the results of **Singh and Singh (2014), Sharma *et al.* (2016)**, **Singh *et al.* (2017), Dhruw *et al*. (2017), Kumar *et al*. (2018) and Shivendu *et al.* (2019).**

Economics

From Table 3 it can be seen that among the various nutrient levels, the cost of cultivation (Rs. ha^{-1}) varied from 26,299 to 39,542 Rs. ha^{-1}. The highest cost of cultivation was registered with the application of 75%NPK + VC@ 2t ha^{-1}+ Azotobacter (T_{11}) followed by 75% NPK+ VC@ 2t ha^{-1} (T_9), 75% NPK + FYM@6t ha^{-1} + Azotobacter (T_{12}) while the application of no fertilizer (Control) registered the lowest cost of cultivation. Maximum gross returns (175479 Rs. ha^{-1}) was obtained by the application of 75% NPK + FYM@ 6t ha^{-1} + Azotobacter (T_{12}) followed by 75%NPK + VC@ 2t ha^{-1}+ Azotobacter (T_{11}), 125% NPK (T_5) and 100% NPK+ S@ 40kg ha^{-1} (T_6).

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Table 3: Influence of different nutrient combinations on Economic analysis of Indian mustard

Treatments		Cost of cultivation (Rs. Ha^{-1})	Gross income (Rs. Ha^{-1})	Net income (Rs. Ha^{-1})	B:C Ratio
T_1	Control	26,299	73906	47607	1.81
T_2	100% N	27,833	110693	82859	2.97
T_3	100% NP	30,186	131498	101311	3.35
T_4	100% NPK	31,312	145673	114360	3.65
T_5	125%NPK	33,230	173988	140758	4.23
T_6	100% NPK+ S@ 40kg ha^{-1}	32,662	171000	138338	4.23
T_7	100%NPK+ Zn@ 5kg ha^{-1}	38006	157051	119045	3.13
T_8	100%NPK + B@ 1kg ha^{-1}	34,162	143458	109296	3.19
T_9	75% NPK+ VC@ 2t ha^{-1}	39312	156713	117400	2.98
T_{10}	75%NPK+FYM@ 6t ha^{-1}	37312	161087	123774	3.31
T_{11}	75%NPK + VC@ 2t ha^{-1}+ Azotobacter	39542	174555	135013	3.41
T_{12}	75% NPK + FYM@ 6t ha^{-1} + Azotobacter	37542	175479	137937	3.62

The lowest Gross return of 73906 Rs. ha^{-1} was obtained in treatment T_1 (Control). Maximum net return of 140758 Rs ha^{-1} was recorded by the application of 125% NPK (T_5) followed by 75% NPK + FYM@ 6t ha^{-1} + Azotobacter (T_{12}), 100% NPK+ S@ 40kg ha^{-1} (T_6) and 75%NPK + VC@ 2t ha^{-1} + Azotobacter (T_{11}). However, the maximum Benefit cost ratio of 4.23 was obtained by the application of 100% NPK+ S@ 40kg ha^{-1} (T_6) & 125% NPK (T_5) followed by T_4, T_{11} and T_{12}. The higher net returns and BCR was mainly due to increase in seed yield. Similar results recorded by **Nath *et al*. (2018), Rohit *et al.* (2019) and Satyanarayana *et al*. (2020).**

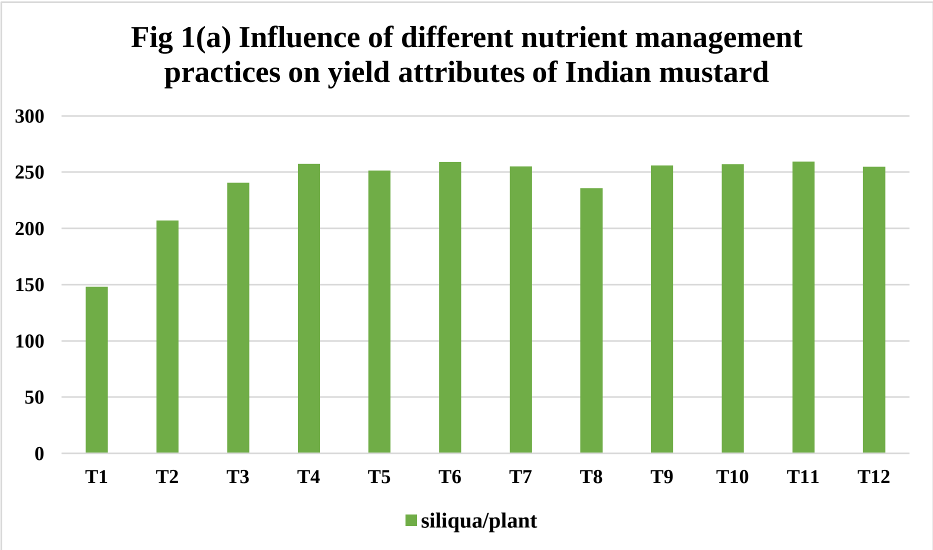
Fig 1(a) Influence of different nutrient management practices on yield attributes of Indian mustard
300
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200
150
100
50
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T1
T2
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T4
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T7
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T12
siliqua/plant

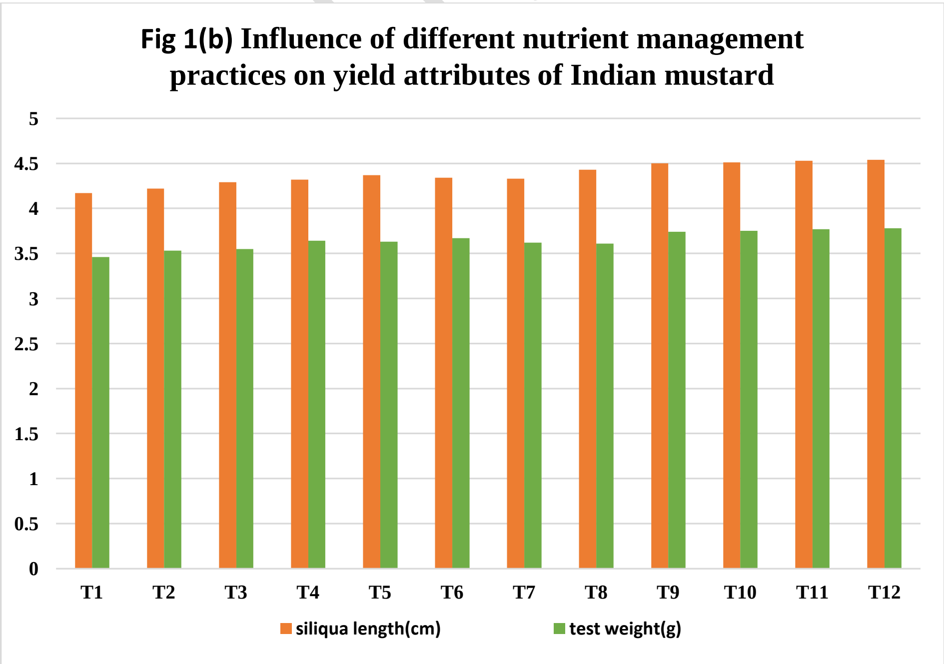
Fig 1(b) Influence of different nutrient management practices on yield attributes of Indian mustard
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
T1
T2
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T5
T6
T7
T8
T9
T10
T11
T12
siliqua length(cm)
test weight(g)

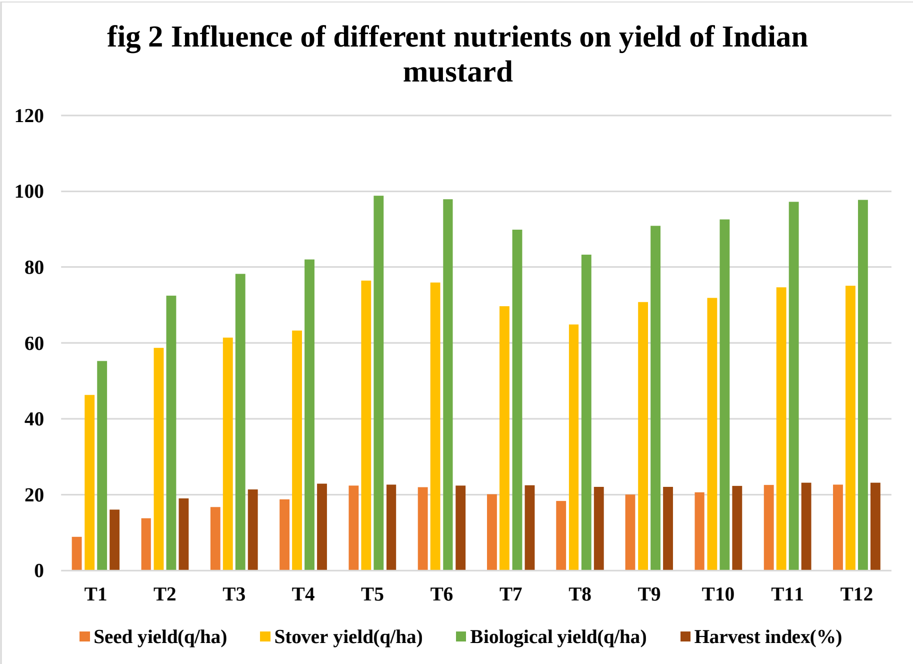
fig 2 Influence of different nutrients on yield of Indian mustard
120
100
80
60
40
20
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T3
T4
T5
T6
T7
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T9
T10
T11
T12
Seed yield(q/ha)
Stover yield(q/ha)
Biological yield(q/ha)
Harvest index(%)

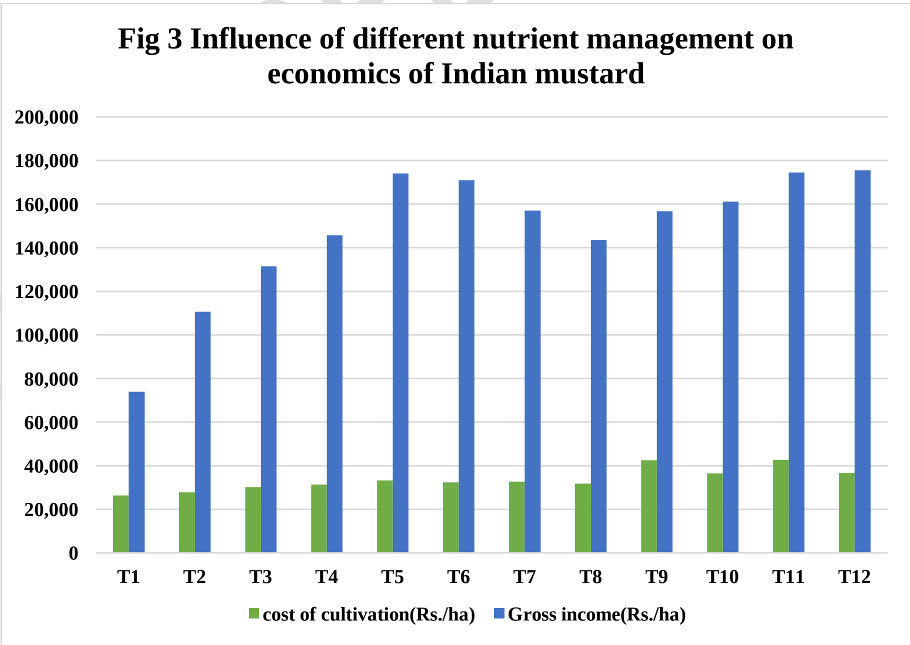
Fig 3 Influence of different nutrient management on economics of Indian mustard
200,000
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140,000
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40,000
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T1
T2
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T4
T5
T6
T7
T8
T9
T10
T11
T12
cost of cultivation(Rs./ha)
Gross income(Rs./ha)

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Comment [T8]: All references had cited in document, but it's better used reference manager i.e mendeley, or others

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