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Effect of major, secondary and micro nutrients on growth, yield and economics of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was carried out under sandy loam soil during *rabi* season of 2022- 23 at the Agricultural Research Farm, Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar, (India) with the combination comprising different levels of major, secondary and micro nutrients 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 and physiological parameter RGR at different growth stages, yield attributes and yield *viz*., number of siliquae/plant, length of siliquae, number of seed per siliquae, seed, straw and biological yields were significantly higher with the application of 150%ha-^{1} in mustard as compared to rest of major, secondary and micro nutrients treatments combinations. However, application of 150% ha-^{1} also recorded higher net returns (Rs.89581 ha-^{1}) B: C ratio (1.69). Although higher net returns in secondary and micro nutrients combination with the application of 40 kg S + 5 kg Zn + 1 kg Bha^{-1}, enriched with 500 kg FYM ha^{-1} was recorded highest net returns (Rs. 68919 ha^{-1}) and the treatment 20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} enriched with 500 kg FYM ha^{-1} recorded the highest B: C ratio (1.41).

Keywords: Major, secondary & micro nutrients, FYM, plant height, number of branches, dry matter accumulation, seed and straw yield

Introduction
In India oilseeds constitute an important group of crops next only to cereals. Scientists of our nation and world have worked tirelessly, in the modern era of agriculture, significant progress has been made towards achieving food grain self-sufficiency, but the same results have not yet been achieved in the case of oilseeds and pulses. The time has come to update and re-examine the technologies in order to increase the output of edible oils. The supply position of food fats is very alarming and there is an acute shortage of edible oils in the country. Massive quantities of oils and oil seeds are being imported every year to cope-up with the domestic needs to maintain even the barest minimum level of intake.

Brassica juncea L. is known by various common names like Indian mustard, brown mustard and oriental mustard. It is also known as rai, raya, and laha in Hindi in various parts of India. Indian mustard is believed to have originated from *Brassica rapa* and *Brassica nigra* in middle east and India. It belongs to family *Cruciferae* (*Brassicacea*e), having chromosome number 2n=36 and self-pollinated and self-compatible in nature. Indian mustard can be differentiated from rapeseed because of its high plant height, a greater number of branches, tapering roots and color of seed is brown to dark brown. High and low temperature at vegetative and reproductive growth stage respectively is considered good for yield and oil quantity and quality.

There are many factors which affect the production and productivity of India mustard among all this nutrient management is one the major factor which largely affects the production. About 70 per cent of the total area under rapeseed and mustard comes under rainfed area and the soil of this area is hungry and thirsty and having low fertility status which ultimately affect the yield of

the crop. There are abundant scope to increase the yield of Indian mustard through optimum fertilizer dose that is why Proper combination of fertilizer with inclusion of secondary and micro nutrient must be required to increase the production and productivity of Indian mustard to meet the increasing demand oil seed in the country.

Materials and Methods

The present experiment entitled "Effect of major and micro nutrients level on growth, yield and economics of Indian Mustard (*Brassica juncea* L.) was carried out *Rabi* season of 2022-23 at the Agriculture Research Farm, Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. Which is geographically situated at the south and west coast of the River Burhi Gandhak and between latitude 25.39°N and 85.40°E longitude and approximately 52.18-meter above mean sea level this area falls under Bihar's Agro-climatic zone-1.

The experiment was carried out in split plot design having major nutrient treatment in main plot and secondary and micro nutrients treatments in sub plot. The treatments comprised were main plot treatment: (Major nutrient levels) F_1: Control, F_2:100% NPK, F_3:125% NPK, F_4:150% NPK with (Recommended dose of fertilizer (RDF): - 80 N:40 P_2O_5:40 K_2O kg ha^{-1}) and Sub plot:(secondary and micro nutrients levels) M_1:20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} M_2:40 kg S + 5 kg Zn + 1 kg Bha^{-1} M_3:20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} enriched with 500 kg FYM ha^{-1} M_4:40 kg S + 5 kg Zn + 1kg Bha^{-1} enriched with 500 kg FYMha^{-1} .The soil of the experimental plot was sandy loam texture, low in organic carbon (0.41%), alkaline in reaction with pH and EC is normal with low in available nitrogen (164.21 kg ha^{-1}), medium in available phosphorus (18.32 kg ha^{-1}), medium in available potash (127.40 kg ha^{-1}), low in available zinc (0.43 mg kg-1).The required quantities of RDF (80N:40 P_2O_5:40 K_2O kg ha^{-1}) was applied to urea, DAP and MOP fertilizer while organic fertilizers farm yard manure 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 (ANOVA) technique Fisher's (1938) had been used to determine of magnitude & nature, treatment this 'F' test shows the suitable impacts.

Results and Discussion

Growth Parameter

Results showed that, growth parameters were significantly affected by different combined (Table 1). According the study with the application of major nutrients level @ 150% NPK (F_4) significantly increased plant height at 30, 60 & 90 DAS and harvest. which was remained at par with 125% NPK (F_3) compared with rest of treatment combinations and application of secondary and micro nutrient @ of 40 kg S + 5 kg Zn + 1kg B ha^{-1}enriched with 500 kg FYM ha^{-1}recorded highest plant height at all growth stages except at 30 DAS. Application of major nutrient significantly impact the number of branches $plant^{-1}$and higher number of branches was recorded under 150% NPK (F_4) which was significantly superior over control and 100% NPK (F_2) this might be due to enhanced availability of nutrient that overall plant growth and development and The number of branches non-significantly impacted by different secondary and micronutrients levels however highest number of branches $plant^{-1}$was recorded in of 40 kg S + 5 kg Zn + 1kg B ha^{-1}enriched with 500 kg FYM ha^{-1} (M_4). A level of major nutrient highest dry matter accumulation was recorded under 150% NPK (F_4) which is significantly superior to control and 100% NPK (F_2). While dry matter accumulation in secondary and micronutrient levels per plant was also significantly increased with the application of 40 kg S + 5 kg Zn + 1 kg B ha^{-1} enriched with 500 kg FYM ha^{-1} (M_4) which significantly higher over 20 kg S +2.5 kg Zn + 0.5kg B ha^{-1} (M_1) and 40 kg S + 5 kg Zn + 1kg B ha^{-1} (M_2). The application of nitrogen, phosphorus, and potassium to mustard plants provides them with essential nutrients that support various physiological processes, including cell division, protein synthesis, energy transfer, and water regulation. These processes collectively contribute to increased plant height and overall growth.

The application of sulphur (S), zinc (Zn), boron (B) and FYM can also positively impact the height and overall growth of mustard. These micronutrients play specific roles in various physiological processes that contribute to plant height obtained by the application of secondary and micronutrient growth. Sulphur is an essential component of amino acids and protein. Proteins are vital for cell division, growth, and overall plant development. Zinc is a crucial micronutrient that plays a role in various enzymatic activities within plants. It's essential for processes such as DNA and RNA synthesis, auxin hormone regulation, and overall plant metabolism. Adequate zinc levels promote root development, nutrient uptake, and overall plant growth, Boron is essential for cell wall formation, sugar transport, and hormone regulation within plants. It is involved in the synthesis of pectin a major component of cell walls, which influences cell elongation and expansion Farm Yard Manure (FYM) can positively impact the plant height of mustard and overall plant growth due to its contributions to soil fertility, nutrient availability, and soil structure. The results obtained from the present experiment are in near conformity with the finding of Jat *et al.* (2017) [3]: Sharma *et al.* (2020) [13]: Kumar *et al.* (2018) [5]: Choudhary *et al.* (2022) [1]: Patel *et al.* (2022) [9]: Yadav *et al.* (2021) [18]: Yadav *et al.* (2014) [19].

Physiological Parameter-Relative growth rate (RWR)

The pooled data in (Table-1) showed relative growth rate are influence of various major nutrients on relative growth rate was non-significant at all stages of growth except at harvest, where the effect of major nutrient is significant on relative growth rate at harvest stage maximum relative growth rate was obtained under 150% NPK, which was significantly superior. Sufficient supply of nutrients as a result of higher nutrient application than the control. The increased relative growth rate could be attributed to an increase in cell multiplication, cell elongation, and cell expansion during the crop season. This could be result increased photosynthetic output and translocation, ultimately improving plant growth. These findings are consistent with those of Devi *et al.* (2022) [2]. Different secondary and micronutrients had non-significant effect on relative growth rate.

Yield attributes

Among the various treatments investigated (Table-1) Major nutrient levels with the application of 150% NPK produced significantly higher number of siliquae/plant, length of silique and number of seeds/siliquae. This remained at par with 125% NPK and 100% NPK. Highest 1000 Seed weight was recorded in 125% NPK which was at par 150% NPK and significantly

superior over 100% NPK and control. In secondary and micronutrient level the highest number of siliquae/plant, length of siliquae and number of seeds/siliquae was recorded under 40 kg S + 5 kg Zn + 1kg B ha^{-1}enriched with 500 kg FYM ha^{-1}but there was not any positive impact on test weight 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 Tyagi *et al*. (2022) [17]: Sharma *et al.* (2020) [13]: Singh *et al.* (2022) [14].

Seed, straw, biological yield and Harvest- index (%)

The results related to Seed, straw and biological yield showed significant differences between different treatment combinations (Table 2). The Major nutrient levels have a remarkable impact on the grain yield. Application of 150% NPK was significantly increased seed (2306 kg ha-1), straw (9595 kg ha^{-1}) and biological yield (11901 kg ha^{-1}), which statistically similar to the 125% NPK and significantly superior over 100% NPK and control. Application of Secondary and micro nutrients were creating significant impact on grain yield. The maximum grain yield (1956 kg ha^{-1}) was obtained by the application of 40 kg S + 5 kg Zn + 1kg B ha^{-1} enriched with 500 kg FYM ha^{-1}which statistically similar to the 20 kg S + 2.5 kg Zn + .5 kg B ha^{-1} enriched with 500 kg FYM ha^{-1} and lowest value of grain yield (1709 kg ha^{-1}) obtained under 20 kg S + 2.5 kg Zn + .5 kg B ha^{-1}. Effect of secondary and micro nutrient levels was recorded non-significant although maximum straw yield (8355 kg ha^{-1}) was obtained by the application of 40 kg S + 5 kg Zn + 1kg B ha^{-1} enriched with 500 kg FYM ha^{-1} and lowest value of straw yield (7332 kg ha$^{-1)}$ obtained under 20 kg S + 2.5 kg Zn + .5 kg B ha^{-1} and maximum biological yield (10311 kg ha^{-1}) was obtained by the application of 40 kg S + 5 kg Zn + 1kg B ha^{-1} enriched with 500 kg FYM ha^{-1}and lowest value of biological yield obtained under 20 kg S + 2.5 kg Zn + .5 kg B ha^{-1}. In the present investigation on various major nutrients, secondary and micronutrient enriched with FYM showed no significant impact on harvesting index. Biological yield in Indian mustard due to their pivotal roles in crucial physiological processes. These findings are in accordance with the results reported by Singh *et al.* (2022) [15]: Kumar *et al.* (2022) [4]: Sinha *et al*. (2005) [16]: Sharma *et al*. (2020) [13]: Raghuvanshi *et al.* (2018) [10]: Tyagi *et al.* (2022) [17]: Rajput *et al.* (2018) [11].

Quality parameters

Various treatments of major, secondary and micro nutrient level in previous chapter (Table-2) imposed in mustard indicated that there was not any positive effect of any treatment on oil content in mustard. The oil content of Indian mustard varies significantly with level of Secondary and micro nutrients. Application of 40 kg S + 5 kg Zn + 1kg B ha-^{1} enriched with 500 kg FYM ha-^{1} recorded higher oil content over other treatment which is statistically at par with of 40 kg S + 5 kg Zn + 1kg B ha-^{1}. The major nutrient maximum oil yield (913 kg ha^{-1}) was recorded in the treatment applying 150% NPK which significantly higher over rest of the treatments except 125% NPK and Secondary and Micro nutrients was found non-significant on number of oil yield. Oil yield of mustard is increased due to synergetic effect of seed yield. Similar study by Nath *et al.* (2018) [8]: Lakhan *et al*. (2017) [6] was also reported.

Economics

According to (Table-3) In major nutrient the application of 150% NPK gave significantly maximum gross return, net return and B: C ratio which was statistically at par with 125% NPK and significantly superior over rest treatment. This may be due to application of more doses of N, P and K showed mark improvement in seed and straw yield and thus gaining more profit in the form of gross return, net return and B:C ratio. This result is supported by the Saini *et al.* (2023) [12].In secondary and micro nutrients application of 40 kg S + 5 kg Zn + 1kg B ha^{-1} enriched with 500 kg FYM ha^{-1}gave significantly higher gross return and net return. Which was statistically at par with 20 kg S +2.5 kg Zn + 0.5kg B ha^{-1} enriched with 500 kg FYM ha^{-1}but B:C ratio was higher in treatment applying 20 kg S +2.5 kg Zn + 0.5kg B ha^{-1} enriched with 500 kg FYM ha^{-1}which was statistically at par with 40 kg S + 5 kg Zn + 1kg B ha^{-1}enriched with 500kg FYM ha^{-1}.This may be due to combined application of Secondary and micro nutrients enriched with FYM to get maximum seed yield and straw yield. These results are in accordance with the results obtained in by Mahor *et al*. (2022) [7]: Saini *et al.* (2023) [12].

Table 1: Effect of different nutrient levels on growth and yield attributes of Indian mustard.

Treatments	Plant height (cm)	Number of branches plant^{-1}	Dry matter accumulation (g plant^{-1})	Relative growth rate (g g^{-1} day^{-1})	No. of siliqua plant^{-1}	Length of siliqua (cm)	No. of grains siliqua^{-1}	1000-seed weight (g)
Main plot treatment: Major nutrient levels								
F_1- Control	149.3	5.00	20.18	0.024	105	2.84	9.86	3.88
F_2- 100% NPK	164.2	6.05	27.00	0.022	129	3.28	11.52	4.86
F_3- 125% NPK	175.6	7.03	31.51	0.023	148	3.36	11.64	4.95
F_4-150% NPK	181.9	8.01	34.86	0.039	151	3.69	12.05	4.94
S.Em(±)	4.1	0.128	0.73	0.015	3.8	0.10	0.2	0.1
CD (p=0.05)	14.1	0.44	2.53	0.002	13.0	0.34	0.7	0.3
Sub plot treatment: Secondary and micro nutrient levels								
M_1-20 kg S + 2.5 kg Zn + 0.5 kg B ha^{-1}	158.4	6.50	25.71	0.023	125	3.06	10.77	4.60
M_2- 40 kg S + 5 kg Zn + 1 kg Bha^{-1}	168.1	6.51	27.55	0.027	131	3.20	11.04	4.63
M_3-20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} enriched with 500 kg FYM ha^{-1}	170.8	6.52	29.24	0.028	137	3.41	11.32	4.68
M_4-40 kg S + 5 kg Zn + 1kg Bha^{-1} enriched with 500 kg FYMha^{-1}	173.8	6.54	31.05	0.029	141	3.49	11.94	4.72
S.Em(±)	3.8	0.164	0.89	0.014	3.8	0.11	0.3	0.2
CD (p=0.05)	11.1	NS	2.60	NS	13.0	0.32	0.8	NS

Table 2: Yield, Oil content and oil yield of Indian mustard as influenced by different nutrient levels.

Treatments	Grain yield (Kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (Kg ha^{-1})
Main plot treatment: Major nutrient levels						
F_1- Control	1174	5424	6598	17.97	37.49	440
F_2- 100% NPK	1789	7524	9313	19.35	38.77	695
F_3- 125% NPK	2120	8876	10996	19.28	38.97	826
F_4-150% NPK	2306	9595	11901	19.39	39.52	913
S.Em(±)	53.95	216	210	0.64	0.59	28.24
CD (p=0.05)	186	747	727	NS	NS	97.75
Sub plot treatment: Secondary and micro nutrient levels						
M_1-20 kg S + 2.5 kg Zn + 0.5 kg B ha^{-1}	1709	7332	9041	18.86	37.37	639
M_2- 40 kg S + 5 kg Zn + 1 kg Bha^{-1}	1817	7602	9420	19.23	39.90	729
M_3-20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} enriched with 500 kg FYM ha^{-1}	1907	8130	10037	18.98	37.25	713
M_4-40 kg S + 5 kg Zn + 1kg Bha^{-1} enriched with 500 kg FYMha^{-1}	1956	8355	10311	18.91	40.25	792
S.Em(±)	35	240	247	0.59	0.90	20.56
CD (p=0.05)	102	699	719	NS	2.64	60.02
Interaction	237	NS	NS	NS		

Table 3: Effect of different nutrients levels on economics of Indian mustard.

Treatments	Total Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Main plot treatment: Major nutrient levels				
F_1- Control	42416	72932	30422	0.72
F_2- 100% NPK	49508	109249	59647	1.20
F_3- 125% NPK	50887	128712	78356	1.54
F_4-150% NPK	52205	140511	89581	1.69
S.Em(±)	-	2655.0	2654.0	0.054
CD (p=0.05)	-	9187.3	9187.3	0.187
Sub plot treatment: Secondary and micro nutrient levels				
M_1-20 kg S + 2.5 kg Zn + 0.5 kg B ha^{-1}	46779	104464	57841	1.21
M_2- 40 kg S + 5 kg Zn + 1 kg Bha^{-1}	49729	110968	61020	1.20
M_3-20 kg S + 2.5 kg Zn + 0.5 kg Bha^{-1} enriched with 500 kg FYM ha^{-1}	47779	116480	68857	1.41
M_4-40 kg S + 5 kg Zn + 1kg Bha^{-1} enriched with 500 kg FYMha^{-1}	50729	119492	68919	1.33
S.Em(±)	-	1939.2	1939.2	0.039
CD (p=0.05)	-	5660.1	5660.1	0.114

Conclusion

Based on findings results, it can be concluded that application of major nutrients @ 150% NPK 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 net returns (88581₹ ha^{-1}) although higher B: C ratio (1.69) which was statistically at par with 125% NPK. Among the secondary and micro nutrient levels higher net return (68919 ₹ ha^{-1}) were recorded under 40 kg S+5 kg Zn+1 kg B ha^{-1} enriched with 500 kg which was statistically at par with 20 kg S+2.5 kg Zn+0.5 kg B ha^{-1} enriched with 500 kg FYM ha^{-1} and B:C ratios (1.41) were achieved under 20 kg S+2.5 kg Zn+0.5 kg B ha^{-1} enriched with 500 kg which was statistically at par with 40 kg S+5 kg Zn+1 kg B ha^{-1} enriched with 500 kg FYM ha^{-1}.

Future Scope:

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

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