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Profitability and productivity of Indian mustard affected by micro and secondary nutrient application in calcareous soil

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Abstract

A field experiment was conducted to enhance micro and secondary nutrient availability into calcareous soils and their effect on mustard crop yield attributes. Treatment comprised with FYM level (control, @5 t ha^{-1} and @10 t ha^{-1}) and five treatment of sources of nutrient (control, 2.5 kg Zn + 1 kg B + 5 Kg Fe + 10 kg S ha^{-1}, 5 kg Zn + 2 kg B + 10 kg Fe + 20 S kg ha^{-1}, 2.5 kg Zn + 1 kg B + 5 Kg Fe +10 kg S enriched FYM @ 500 kg ha^{-1} and 5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1}). Experiment results showed that application of FYM @ 10 t ha^{-1} along with 5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1} significantly (p=0.05) improved yield attributes, seed yield (29.64 q ha^{-1}), stover yield (76.25q ha^{-1}) and oil content (43.11%). Application of micronutrient enriched FYM improve the availability of nutrient and their uptake to mustard results in higher productivity and quality of crop in calcareous soils. Highest benefit cost ratio (3.22) was obtained under the treatment of M_4 (2.5 kg Zn + 1 kg B + 5 kg Fe + 10 g S enriched FYM @ 500 kg ha^{-1}). Thus, micro and secondary nutrients concentration may be enhanced in soil through application of enriched compost compared to alone use.

Keywords: *Benefit cost ratio, enriched FYM, micronutrients, mustard, saline soil, secondary nutrients*

Introduction

In dry and semi-arid regions where Indian mustard is cultivated, salinity of soil and water resources is a severe issue, and micronutrients are typically unavailable due to its conversion into an unavailable form under high salty water irrigation. Mustard, in general is very sensitive to sulfur (S) and micronutrient deficiency, especially zinc (Zn) and boron (B). However, Zn, iron (Fe), manganese (Mn) and copper (Cu) are found mostly deficit in arid and semi-arid region due to high base soil reaction results in its unavailability to crop plant in saline/sodic soils (Bharti *et al.,* 2017). Micronutrient deficiency is becoming more serious problem in mustard growing areas due to continuous application of high saline water irrigation. In India only about one-third of the fertilizer requirements of oilseed crops are actually applied leading to continuous mining of nutrients from the soil by oilseeds (Sudhakara Babu and Hegde, 2011).

Sulfur, Zn, B and Fe are important plant nutrients for optimum yield of rapeseed-mustard crops. Increasing the S availability in S deficient soils improved the crop yield and oil content in mustard crop. Similar pattern, increasing levels of micronutrient in soil improved the yield and yield attributes of mustard. Micronutrient chelates, though more effective in maintaining their availability in soil solution, but their use on large scale under field condition is prohibitive due to high cost. Application of organic sources as yield improving soil amendments, which mediate the plant nutrient dynamics and improve microbial population and diversity (Meena *et al.*, 2016; Singh *et al.*, 2019). However, shortage of farm yard manures (FYM) on large scale has become a major problem in present time. Thus micronutrient-enriched FYM may be an important strategy for reducing deficiency in arid and semi-arid region under saline water irrigation and also helps in reducing load of chemical fertilizers and also brings down the pH of the soil and helps in reclaiming alkaline soils. It was reported that Zn and Fe enriched FYM improved average mustard seed yield by 20 per cent over control whereas it was 11 per cent over straight Zn and Fe application (Meena *et al.*, 2008). Thus, Zn and Fe enriched FYM enhanced uptake of N, S and micronutrients by mustard, and improved oil and protein content of mustard seed (Meena *et al.*, 2008). The role of organic material in enhancing of nutrient availability and promoting reclamation of saline/sodic soils through improvement of soil physico-chemical properties, biological process is well known (Meena *et al*., 2021). In this background, a field experiment was conducted to see the effect of micro and secondary nutrients enriched FYM in calcareous soil on profitability and productivity of mustard.

Materials and Methods

The experiment was conducted at research farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur located at 77°3' E longitude, 27°15' N latitude and at an altitude of 178.37 meter above mean sea level. The region falls under Agro climatic Zone III a (semi-arid Eastern plain) with sub-tropical and semi-arid climate. The soil samples were collected, processed and analysed for physico-chemical properties of experiment soils with standard procedures (Singh *et al*., 2005). The soil pH and EC of the experimental area were 8.3 and 1.30 dS m^{-1}, respectively. The soil before the experiment was poor in organic carbon (0.24 %) and available N (126.3 kg ha^{-1}) while moderate in 0.5 *N* $NaHCO_3$ extractable P (17.2 kg ha^{-1}) and 1 *N* NH_4OAc exchangeable K (149.26 kg ha^{-1}). The bulk density was 1.52 mg per m^3. It is apparent from the data presented in Table 1 revealed that the soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen, phosphorus and medium in available potash.

The treatments comprising FYM (control (F_0), FYM @ 5 t ha^{-1} (F_1), FYM @ 10 t ha^{-1} (F_2) and five micro nutrient source combinations with enriched FYM (control-M_1, 2.5 kg Zn + 1 kg B + 5 Kg Fe + 10 kg S ha^{-1} (M_2), 5 kg Zn + 2 kg B + 10 kg Fe + 20 S kg ha^{-1} (M_3), 2.5 kg Zn + 1 kg B + 5 Kg Fe + 10 kg S enriched FYM @ 500 kg ha^{-1} (M_4), 5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1} (M_5)) were laid out treatment in split plot design (SPD) with 3 replications. In this experiment musturd variety DRMRIJ-31 used as a test crop. Mustard crop was raised as per the standard agronomic practices. During the study post-harvest observations like main shoot length, length of siliqua, number of siliqua per plant and number of siliqua on main shoot, number of seed per siliqua, test weight seed yield and oil content, economic return were measured.

Table 1: Physico-chemical properties of experiment soils

Soil characteristics	Value
Physical properties	
Coarse sand (%)	21.5
Fine sand (%)	54.2
Silt (%)	16.2
Clay (%)	8.2
Textural class	Loamy sand
EC (dSm^{-1})	1.3
pH (1:2 soil water suspension)	8.3
Bulk density (Mg m^{-3})	1.5
Particle density (Mg m^{-3})	2.5
Field capacity (%)	12.5
Permanent wilting point (%)	2.4
Chemical properties	
Organic carbon (g kg^{-1})	0.24
Available N (kg ha^{-1})	126.3
Available P (kg ha^{-1})	17.2
Available K (kg ha^{-1})	149.3
SO_4^{-2} (mg kg^{-1})	8.3

The collected data were analyzed in Split plot design (SPD) with 3 replications as per the procedure mentioned in Gomez and Gomez (1984). The significance of treatments was compared at 5 percent level of significance (p=0.05).

Results and Discussion

Effect on yield attributes

During the experiment yield attributes of mustard crop were significantly influenced by FYM and micro nutrient enriched FYM. The data on effect of FYM on length of siliqua and main shoot was influenced by the applied treatments (Table 2). The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly highest length of siliqua and main shoot (4.71 and 96.1 cm), which followed by F_1 (FYM @ 5 t ha^{-1}). Similarly, effect of nutrient source on length of siliqua and main shoot was also observed. The treatment M_5 (5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S Enriched FYM @ 500 kg ha^{-1}) showed significantly highest length of siliqua and main shoot (4.9 and 98.3 cm). The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum number of siliqua on main shoot and per plant (56.71 and 619.18) which followed by F_1 (FYM @ 5 t ha^{-1}). The data on effect of nutrient sources on number of siliqua on main shoot and per plant is presented in the Table 2. The treatment M_5 (5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1}) recorded significantly maximum number of siliqua on main shoot and per plant 60.5 and 742.9, respectively. The data on effect of FYM on number of seed per siliqua and test weight (g) are presented in the Table 2. At the FYM levels treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum number of seed per siliqua (16.9) and test weight (6.06gm). Similarly, effect of nutrient source on seed per siliqua and test weight was also observed. The treatment M_5 (5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1}) produced significantly maximum number of seed per siliqua (16.9) and test weight (6.5g).

Table 2: Mustard yield attributes influenced by different level of FYM and nutrient enriched organic sources.

Treatment	No. of siliqua/ plant	Length of siliqua (cm)	No. of seed/ siliqua	Test weight (g)	Main shoot	
					Length	No of siliqua
FYM level						
F_0 –Control	504.4	4.6	15.6	5.47	90.9	51.7
F_1 -FYM @ 5 t ha^{-1}	548.1	4.7	16.9	5.93	92.4	54.7
F_2 -FYM @ 10 t ha^{-1}	619.2	4.7	16.9	6.06	96.1	56.7
SEm±	8.94	0.0	0.06	0.04	0.2	0.67
CD (p=0.05)	35.09	0.05	0.2	0.17	0.9	2.6
Sources of nutrient						
M_1- Control	397.3	4.4	15.9	5.11	88.5	49.1
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	479.8	4.6	16.2	5.53	90.2	51.5
M_3-5 kg Zn + 2 kg B+ 10 kg Fe +20 kg S ha^{-1}	554.7	4.7	16.5	5.84	92.9	53.9
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}	611.3	4.7	16.9	6.07	95.7	56.8
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S En-FYM @ 500 kg ha^{-1}	742.9	4.9	16.9	6.54	98.3	60.5
SEm±	9.10	0.01	0.04	0.10	0.28	0.21
CD (p=0.05)	26.56	0.03	0.13	0.29	0.81	0.63

*En- FYM-Enriched FYM

Yield attributes like shoot length, length of siliqua, number of siliqua per plant and number of siliqua on main shoot, number of seed per siliqua and test weight were significantly influenced by FYM levels and sources of nutrients. The application FYM @10 t ha^{-1} is sufficient to maintain soil fertility and for improving microbial population in soil. Favorable effect of organics on these parameters might be due to direct addition of nutrients including micronutrients, decrease the losses of nutrients (Aswini *et al.*, 2015), and also improvement in soil physical and biological properties (Meena *et al.*, 2021). Moreover, use of FYM also increase cation exchange capacity of soil which minimizes leaching losses, improve buffering and also improve redox potential of the soil (Dotaniya and Meena, 2013; Yadav *et al.* 2013; Kansotia *et al.* 2015). Similarly, Growth attributes were also influenced by fortification of FYM with Zn, B, Fe and S, which increased their availability in soil solution. Meena *et al.* (2016) also reported that adequate supply of S significantly increased vegetative as well as reproductive growth of crop. With the FYM fortification; these essential micronutrients can be prevented from transformation to unavailable form under calcareous soil condition. Similar results wrer also reported by Hadiyal *et al.* (2017). This increasing trend in oil content in mustard seed could be an account of role of zinc for activating the enzymes responsible for oil synthesis (Tisdale *et al.,* 1997; Meena *et al.,* 2016).

Effect on mustard yield and oil content

Application of FYM and nutrient enriched FYM significantly increased the seed yield (Table 3). Use of FYM @ 10 t ha^{-1} produced significantly (p=0.05) higher seed yield (29.9 q ha^{-1}), followed by F1 (FYM @ 5 t ha^{-1}). However, non- significant (p=0.05) effect of FYM on oil content was observed. Positive effect of nutrient enrichment on seed yield and oil content was also observed. Use of micro and secondary nutrients at rate of 5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S Enriched FYM @ 500 kg ha^{-1} produced significantly highest seed yield (29.64 q ha^{-1}, but at par effect was also observed in treatment M_4 (2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S enriched FYM @ 500 kg h^{-1}). Similarly, the treatment M_5 (5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1}) showed significantly maximum oil content (43.1%).

Interactive effect of different level of FYM and sources of nutrient seed yield of mustard showed positive response on mustard yield. The findings revealed highest mustard yield (34.60 q/ha) was obtained by applying 10 t ha^{-1} FYM in combination of M5 (5 kg Zn + 2 kg B+ 10kg Fe+20 kg S En-FYM @ 500 kg ha^{-1}); whereas lowest yield (19.8 q/ha) also reported in absolute control (Table 4).

Improvement in seed yield of mustard might be attributed to organic manures which act as good source of nutrients and also improve physico-chemical and biological properties of calcareous soil. These results are in close conformity with the findings of Yadav *et al.* (2013) and Kansotia *et al.* (2015). Organic manures play a vital role in improving availability of Zn by direct contribution as well as indirectly by influencing chemical transformation reaction and microbial activity (Rathod *et al*., 2012). Use of organics increases the cation exchange capacity (CEC) and microbial activity of soil results in enhancement of soil buffering capacity also. Higher buffering and CEC reduces the leaching losses of nutrients (Aswini *et al.*, 2015) and also kept the nutrients in its available form for longer duration. The Zn and Fe enriched FYM improved average mustard seed yield by 20 per cent over control;

Table 3: Yield and oil contents influenced by different level of FYM and nutrient enriched organic sources

Treatment	Oil content (%)	Seed yield (q ha^{-1})
FYM Level		
F_0 –Control	42.2	22.3
F_1 -FYM @ 5 t ha^{-1}	42.2	27.5
F_2 -FYM @ 10 t ha^{-1}	42.5	29.9
SEm±	0.08	0.5
C.D.(p=0.05)	NS	1.96
Sources of nutrient		
M_1- Control	41.5	23.3
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	42.1	24.7
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	42.4	26.8
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}	42.51	28.51
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S En-FYM @ 500 kg ha^{-1}	43.11	29.64
SEm±	0.18	0.42
C.D.(p=0.05)	0.52	1.23

Table: 4 Interactive effects of different level of FYM and sources of nutrient on seed yield (q ha^{-1}) of mustard

Treatments	FYM Levels (t ha^{-1})		
	0	5	10
M_1- Control	19.8	24.2	25.7
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	21.6	24.7	27.8
M_3-5 kg Zn + 2 kg B + 10kg Fe + 20 kg S ha^{-1}	22.6	28.3	29.4
M_4-2.5 kg Zn + 1 kg B + 5 Kg Fe + 10 kg S En- FYM @ 500 kg h^{-1}	23.6	29.7	32.2
M_5-5 kg Zn + 2 kg B+ 10kg Fe + 20 kg S En-FYM @ 500 kg ha^{-1}	24.0	30.3	34.6
SEm±		0.73	
C.D. (p=0.05)		2.14	

whereas, it was 11 per cent over straight Zn and Fe application. The Zn and Fe enriched FYM enhanced uptake of N, S and micronutrients by mustard, and improved oil and protein content of mustard seed (Meena *et al.,* 2008). Sipai *et al. (*2015) reported that sulphur availability in soil increase multiplication and elongation of the cell, chlorophyll content in the leaves results in improvement of rate of photosynthesis and higher dry matter accumulation in plant. Likewise, favorable effect of B on mustard yield might be attributed to its role in flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development (Yadav *et al.* 2016).

Economics of the treatments

Economics of the experiment was calculated and found that increasing the FYM level control to 5 t ha^{-1} improved the B:C ratio upto 2.55, whereas further enhancement reduced 10.6%. The increasing the FYM levels increased the net income from Rs. 56119 to 72727, however increasing cost of cultivation (Rs./ha) 22066 to 36066 reduced the B:C ratio. The different nutrient sources are also affected the B:C ratio of the experiment, treatment M_4 (2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}) recorded highest B:C ratio (3.22), whereas, lowest ratio was calculated in control (Table 5). Increasing the cost of cultivation reduced the net profit during the investigation lower down the B:C ratio. Even partial factor productivity decline rate also lower down the net profit from the treatments.

Table 5. Economic return influenced by different treatments

Treatments	Cost of cultivation	Gross income	Net income	B:C ratio
		(Rs./ha)		
FYM Level				
F_0 –Control	22066	78185	56119	2.54
F_1 -FYM @ 5 t ha^{-1}	27066	96075	69009	2.55
F_2 -FYM @ 10 t ha^{-1}	36066	104793	72727	2.27
Sources of nutrient				
M_1- Control	22066	81368	59302	2.69
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	23126	86472	63346	2.74
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	24186	93714	69528	2.87
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}	23626	99776	76150	3.22
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S En-FYM @ 500 kg ha^{-1}	24686	103757	79071	3.20

Conclusions

Increasing oil demand force to enhance the oil seed production in the country. Among the oilseed, rapeseed-mustard playing a crucial role to fulfill the demand of growing population. In this regard, a field experiment was conducted to assess the impact of micronutrient and secondary nutrient delivery through FYM graded doses of FYM in calcareous soil. The experiment results showed that delivery of secondary and micronutrients through significantly enhanced yield 28.5 q/ha with B:C ratio 3.22. It indicated that application of balance amount of micro and secondary nutrients (treatment M_4) through 500 kg FYM improve mustard yield and economic return of the farmers. Such studies are much important for enhancing the mustard yield in abiotic salinity stress areas of Indian boundaries.

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