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Improvement in growth and yield of Indian mustard by using micro and secondary nutrients fortified FYM in calcareous soil

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Abstract

A field experiment was conducted to enhance the micro and secondary nutrient availability to Indian mustard (*Brassica juncea* L) in arid and semi-arid regions using split plot design with three replications. The experiment was consisted with three treatments of FYM level (control, 5 t ha^{-1} and 10 t ha^{-1}) and five treatment of nutrient sources (control, 2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}, 5 kg Zn + 2 kg B+ 10kg Fe +20 S kg ha^{-1}, 2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S enriched with FYM @ 500 kg ha^{-1} and 5 kg Zn + 2 kg B+ 10kg Fe+20 kg S enriched FYM @ 500 kg ha^{-1}). The results revealed that application of FYM @ 10 t ha^{-1} along with5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1} found significantly (p=0.05) improved plant height, number of primary and secondary branches, chlorophyll content (90 DAS), LAI, basal girth, maximum seed yield (29.64 q ha^{-1}), stover yield (76.25q ha^{-1}) and oil content (12.78q ha^{-1}). Such studies could play crucial role in balance application of plant nutrient for enhancing Indian mustard yield.

Key words: *Carbon, irrigation water, mustard, nutrient dynamics, organic amendments*

Introduction

This study was proposed to enhance the micro and secondary nutrient availability to Indian mustard (*Brassica juncea* L) in arid and semi arid regions. The problem is aggravated in these areas when saline/sodic groundwater is used as a chief source of irrigation in shortage of good quality water. Long-term application of poor quality water accumulated salt ions in soils and mediated the plant nutrient dynamics specially micro-nutrient in soil (Bidalia *et al.,* 2019). However, it can be used for growing salt tolerant crops such as mustard by using suitable management practices (Meena *et al.,* 2016). Indian mustard, in general is very sensitive to micro-nutrient deficiency, especially zinc (Zn) and boron (B). As per the published documents Zn, Fe, Mn and 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). Moreover, problem of micro-nutrient deficiency aggravated with application of high saline groundwater as major source of irrigation water in water scarcity areas (Meena *et al*., 2016). Uses of organic sources are one of the yield improving soil amendments, which mediate the plant nutrient dynamics, microbial population and diversity (Singh *et al.*, 2019). Application of micro-nutrient through FYM is the one of the best plant nutrient delivery option to improve soil health and crop yield. The 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. 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). Apart from these, sulphur (S) which is proved essential to plant has emerged as the third important plant nutrient to oil seed crops and plays a vital role in metabolic activities of a plant. Its deficiency may be responsible for poor flowering, fruiting, cupping of leaves, reddening of stems and petiole and stunted growth (Singh *et al.,* 2020).

There is a role of organic material in enhancing of micro-nutrient and promoting reclamation of saline/sodic soils through improvement of soil physico-chemical properties, biological process. During the mineralization process of organic substances, micro-organism produce organic acids, which are reduced soil pH, increase plant nutrient concentrations and enhancement of biological activities in soil (Dotaniya and Meena, 2013; Singh *et al.,* 2017). These release nutrients slowly but steadily for longer duration thus preventing their losses by leaching and other means. Similarly, organic materials also having buffering effect on soil reaction. Apart from these characters, decomposition products of organic materials form chelates which help in the nutrition of plants and also regulate the thermal regimes of soil. In this backdrop, a field experiment was conducted to see the effect of micro and secondary nutrients fortified FYM in calcareous soil on mustard yield and growth parameters.

Materials and Methods

The experiment was conducted at Research farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur,India 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 conducted during *Rabi* (winter) season 2016-17. The soil samples were collected and analysed as per the methods were described by Singh et al. (2005). The experimental soil were loamy sand in texture, bulk density 1.52 Mg m^{-3},pH (1:2.5 ratio) alkaline in reaction (8.3),electric conductivity of saturation extract (EC_e) 1.30dSm^{-1}. The organic carbon (0.24 %) and available N (126.30 kg ha^{-1}) while moderate in 0.5*N* $NaHCO_3$ extractable P (17.23 kg ha^{-1}) and 1*N* NH_4OAc exchangeable K (149.26 kg ha^{-1}) (Table 1).The experiment comprising 15 treatment combination, *i.e.*three treatment of FYM levels (control-F_0, FYM @ 5 t ha^{-1}-F_1, FYM @ 10 t ha^{-1}-F_2) and five treatment of sources of nutrient (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 + 10kg Fe + 20 kg S enriched FYM @ 500 kg ha^{-1}-M_5). Indian mustard variety DRMR IJ-31 was used as test crop and raised as per the recommended agronomic practices. During the study different parameters like plant height and primary branches were measured at 45 days after sowing (DAS), 90 DAS and at harvest stage, whereas girth and secondary branches were measured at 90 DAS and harvest stage. Chlorophyll and leaf area index (45 DAS, 90 DAS) were also measured during the investigation. After maturity of the mustard crop yield and yield parameters were measured. The collected data were analysed in Split plot design (SPD) with 3 replications as per the procedure mentioned in Gomez and Gomez (1984). The significance of treatments were compared at 5 percent level of significance (p=0.05).

Table 1: Physico-chemical properties of experiment field

Soil characteristics	Value
Coarse sand (%)	21.50
Fine sand (%)	54.20
Silt (%)	16.15
Clay (%)	8.15
Textural class	Loamy sand
pH (1:2 soil water suspension)	8.3
EC_e (dSm^{-1})	1.3
Bulk density (Mg m^{-3})	1.52
Organic carbon (g kg^{-1})	0.24
Available N (kg ha^{-1})	126.30
Available P(kg ha^{-1})	17.23
Available K (kg ha^{-1})	149.26
SO_4^{-2} (ppm)	8.3

Results and Discussion

Effect on growth and yield attributes

The growth and physiological parameters like plant height, number of primary and secondary branches ($plant^{-1}$), chlorophyll content, leaf area, and girth were significantly influenced by FYM and FYM and micro nutrient enriched FYM.

The data on effect of FYM on plant height at all the growth stages were influenced by the applied treatments (Table 2). The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly highest plant height 61.24, 188.85 and 193.79 cm at 45 DAS, 90 DAS and harvest stage which followed by F_1 (FYM @ 5 t ha^{-1}).Similarly, effect of nutrient source on plant height at all growth stages.The treatmentM_5 (kg Zn + 2 kg B + 10 kg Fe + 20 kg S Enriched FYM @ 500 kg ha^{-1}) showed significantly highest plant height 64.0, 194.7 and 198.7 cm. The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum girth 8.21 cm and 7.30 cm at 90 DAS and harvest stage which followed by F_1 (FYM @ 5 t ha^{-1}).The data on effect of nutrient sources on girth 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 girth 8.71 cm and 7.93 cm at 90 DAS and harvest stage, respectively.The data on effect of FYM on number of primary branches are presented in the Table 3. At the FYM levels, treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum number of primary branches and at the nutrient levels, treatment M_5 showed significantly maximum numbers of branches, i.e. 6.80, 7.92 & 8.31 at 45, 90 DAS and at harvest stages respectively.

The data on effect of FYM on number of secondary branches are presented in the Table3. The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum number of secondary branches 19.28 and 19.70 at 90 DAS and harvest stage which followed by F_1 (FYM @ 5 t ha^{-1}). 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 secondary branches,*i.e.* 21.82 and 21.85 at 90 DAS and harvest stage respectively.The data on effect of FYM on chlorophyll content is presented in the Table 4. The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly maximum chlorophyll content 34.8% at 90

Table 2: Plant height and girth influenced by different level of FYM and fortified sources of nutrient

Treatments	Plant height (cm)			Girth (cm)	
	45 DAS	90 DAS	At harvest	90 DAS	At harvest
FYM Level					
F_0 –Control	56.03	179.9	183.3	7.09	6.72
F_1 -FYM @ 5 t ha^{-1}	57.92	182.9	188.3	7.29	6.83
F_2 -FYM @ 10 t ha^{-1}	61.24	188.9	193.8	8.21	7.30
SEm±	0.44	0.47	0.52	0.09	0.09
C.D.(p=0.05)	1.74	1.8	2.0	0.36	0.34
Sources of Nutrient					
M_1- Control	53.58	175.4	179.6	6.64	6.03
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	55.18	178.7	183.7	6.91	6.49
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	58.29	182.5	187.8	7.38	6.91
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}	60.96	188.0	192.5	8.02	7.38
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S En-FYM @ 500 kg ha^{-1}	63.98	194.7	198.7	8.71	7.93
SEm±	0.40	0.29	0.52	0.07	0.06
C.D.(p=0.05)	1.17	0.84	1.52	0.21	0.17

Table 3: Branching influenced by different level of FYM and fortified sources of nutrient

Treatments	Primary branches			Secondary branches	
	45 DAS	90 DAS	At harvest	90 DAS	At harvest
FYM Level					
F_0 –Control	5.39	6.22	6.75	18.44	18.56
F_1 -FYM @ 5 t ha^{-1}	5.55	7.23	7.70	19.05	19.23
F_2 -FYM @ 10 t ha^{-1}	5.87	7.65	8.01	19.28	19.70
SEm±	0.05	0.10	0.03	0.24	0.25
C.D.(p=0.05)	0.18	0.39	0.12	0.93	0.97
Sources of Nutrient					
M_1- Control	4.56	6.10	6.40	16.24	16.46
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	4.98	6.66	7.12	17.42	17.88
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	5.50	7.07	7.65	18.89	19.09
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S En- FYM @ 500 kg h^{-1}	6.18	7.42	7.96	20.24	20.53
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S en-FYM @ 500 kg ha^{-1}	6.80	7.92	8.31	21.82	21.85
SEm±	0.06	0.05	0.07	0.23	0.20
C.D.(p=0.05)	0.17	0.15	0.19	0.68	0.58

DAS.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 chlorophyll content 39.96%.

The data on effect of FYM on leaf area index (LAI) are presented in the Table 4. The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly highest LAI 4.83 and 5.48 at 45 and 90 DAS, respectively. The data on effect of nutrient sources on LAI showed that 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 LAI 4.95 and 5.53 at 45 and 90 DAS, respectively.

Growth parameters viz., plant height, LAI, girth and numbers of primary & secondary branches per plant were significantly influenced by FYM levels and sources of nutrients. The highest value of these growth parameters were observed with application of FYM @ 10 tha^{-1}. FYM is essential for maintaining soil fertility and increasing microbial population and diversities. Improvement in these parameters might be due to supply of plant nutrients including micronutrients, decrease the nutrient losses

Table4: Effect of different level of FYM and nutrient enriched organic sources on chlorophyll content and Leaf Area Index (LAI) on different growth stages

Treatments	Chlorophyll (%)	Leaf Area Index	
		45DAS	90DAS
FYM Level			
F_0 –Control	31.87	3.91	4.86
F_1 -FYM @ 5 t ha^{-1}	33.16	4.60	5.29
F_2 -FYM @ 10 t ha^{-1}	34.81	4.83	5.48
SEm±	0.18	0.01	0.01
C.D.(p=0.05)	0.69	0.04	0.02
Sources of Nutrient			
M_1- Control	26.56	3.90	4.84
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	28.87	4.17	5.06
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	33.36	4.44	5.23
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S Enriched FYM @ 500 kg h^{-1}	37.67	4.77	5.41
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S Enriched FYM @ 500 kg ha^{-1}	39.96	4.95	5.53
SEm±	0.22	0.02	0.02
C.D. (p=0.05)	0.65	0.05	0.05

(Aswini *et al.,* 2015), improvement in soil physical and biological properties and increased availability of nutrients. Favorable effect of nutrients to produce larger cell with thinner cell wall and its contribution in cell division and cell elongation improve vegetative growth and ultimately increased plant height and number of primary & secondary branches per plant. FYM also increases cation exchange capacity and microbial activity in soil besides supplying macro and micro plant nutrients. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil (Dotaniya and Meena, 2013). Similar results were also reported by Yadav *et al.* (2013) and Kansotia *et al.* (2015).

Growth attributes were significantly influenced by adequate availability of Zn, B, Fe, S and enriched FYM in soil solution. It might be due to adequate supply of readily available nutrients to plant. In calcareous soil conditions, these essential micronutrients can be kept in available form for longer duration with the help of FYM enrichment. These results are in close conformity with the findings of Hadiyal *et al.* (2017). Improvement in concentration of S in particular and other nutrients in plant due to adequate supply of S seems to have resulted in vigorous vegetative as well as reproductive growth of crop as reflected through increase in growth attributes (Meena et al. 2016). The increase in number of branches might be due to the role of B in cell division, tissue differentiation, carbohydrate metabolism and maintenance of conducting tissue with regulatory effect on other element (Yadav *et al.,*2013). Increase in growth characters might be due to zinc involves in various enzyme systems as prosthetic group and metallic constituents, in photosynthetic pigment bio-synthesis and bio-synthesis of auxin which in turn enabled the plant to grow taller and produce more dry matter (Chaudhary *et al.,* 2020).

Effect on mustard yield

The beneficial effect of FYM and micro nutrient enriched FYM on seed, stover and oil yield was observed (Table 5). The treatment F_2 (FYM @ 10 t ha^{-1}) recorded significantly (p=0.05) higher seed, stover and oil yield of 29.94, 75.29, 12.75 q ha^{-1} ,respectively. The treatment M_5 (5 kg Zn + 2 kg B + 10 kg Fe + 20 kg S Enriched FYM @ 500 kg ha^{-1}) produced significantly highest seed, stover and oil yield of 29.64, 76.25 and 12.78 q ha^{-1}respectively, and 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}).

The increase in seed and stover yield of mustard might be attributed to role of FYM as a good source of all the nutrients and organic matter which improves the physico-chemical and biological properties of soil. Application of FYM also increases cation exchange capacity and microbial activity in soil. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil (Dotaniya and Meena, 2013; Chaudhary *et al.,* 2020). Enhancement in seed and stover yield might be due to improvement in nutrient availability in soil resulted to more vegetative growth and dry matter accumulation in plants. Sulphur nutrition also enhances cell multiplication, elongation, expansion and imparts a deep green colour to leaves due to better chlorophyll synthesis, which in turn increases the effective area for

Table 5: Effects of different level of FYM and sources of nutrient on seed, stover and oil yield

Treatments	Yield (q ha^{-1})		
	Seed	Stover	oil
FYM Level			
F_0 –Control	22.34	59.54	9.43
F_1 -FYM @ 5 t ha^{-1}	27.45	68.86	11.61
F_2 -FYM @ 10 t ha^{-1}	29.94	75.29	12.75
SEm±	0.50	1.01	0.22
C.D.(p=0.05)	1.96	3.96	0.87
Sources of Nutrient			
M_1- Control	23.25	58.45	9.64
M_2-2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}	24.71	63.06	10.40
M_3-5 kg Zn + 2 kg B+ 10kg Fe +20 kg S ha^{-1}	26.78	68.44	11.35
M_4-2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S Enriched FYM @ 500 kg h^{-1}	28.51	73.29	12.13
M_5-5 kg Zn + 2 kg B+ 10kg Fe+20 kg S Enriched FYM @ 500 kg ha^{-1}	29.64	76.25	12.78
SEm±	0.42	1.47	0.19
C.D. (p=0.05)	1.23	4.28	0.57

photosynthesis, resulting in relatively greater amount of dry matter accumulation in plants (Sipai *et al.,* 2015).The beneficial effect of B on yield attributes might be due to its major role in flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development (Jaiswal *et al.* 2015). Mir *et al.* (2004) reported the favorable effect of Zn on activation of enzymes and chlorophyll synthesis and ultimately increased in carbohydrate metabolism. The favorable effects, thus led to increased translocation of photosynthates towards seeds resulting in formation of bold seeds. 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).

Conclusion

Mustard is an oilseed crop and mostly grown in arid and semi arid region of Rajasthan, Haryana, Gujarat and part of Punjab. It requires less amount of irrigation water, and more popular in water scarcity area. Most of the groundwater is saline and alkaline in nature and long term application accumulated significant amount of salt over a period. This will reduce the soil health and crop yield potential. For enhancing the mustard production by mediating soil properties and enhancing plant nutrient availability through secondary and micro-nutrient enriched FYM. Results showed that application of 10 t ha^{-1} FYM gave significant effect on yield and growth parameters. Delivery of micronutrients and S through FYM showed significant improvement in seed yield of mustard crop over control. Treatment M5 showed maximum seed yield of mustard. Such finding are very much useful for planning plant nutrient management for enhancing mustard yield in saline -sodic soils.

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