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Effect of zinc and iron fertilization on growth, yield and nutrient uptake of mustard (*Brassica juncea* L.) in loamy sand soil

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Abstract

A field experiment was conducted during *rabi* season 2021-22 at Sardarkrushinagar, Gujarat in loamy sand soil. Total eight treatments were tested in randomized block design with four replications. Mustard variety GDM 4 was sown at a distance of 45 cm x 15 cm. Various growth parameters *viz*. plant height and number of branches/plant, yield attributing characters and seed yield (2324 kg/ha) and stover yield (5381 kg/ha) were recorded significantly maximum with the application of RDF+ 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_8). While, number of siliquae per plant was found significantly higher in application of RDF+ 8.0 kg $ZnSO_4$/ha and 15.0 kg $FeSO_4$/ha soil application at basal. Application of RDF+ 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_8) recorded significantly higher nutrients uptake of nitrogen, phosphorus, potash, sulphur, zinc and iron by mustard crop.

Keywords : *Iron, mustard, nutrients, siliquae, zinc*

Introduction

Rapeseed-mustard is the third most important edible oilseed crop in India. Mustard is one of the major sources of oil in India. Indian mustard [*Brassica juncea* (L.) *Czern.* & *Coss*.] is the most important winter season oilseed crop, which thrives best in light to heavy loam soil in areas having 25 to 40 cm rainfall. Rapeseed-mustard is the major source of income especially to the marginal and small farmers in rainfed areas. Since these crops are cultivated mainly in the rainfed and resource scarce regions of the country, their contribution to livelihood security of the small and marginal farmers in these regions is also very important. By increasing the domestic production of oilseeds, substantial import substitution can be achieved. In India during last ten years, there has been a considerable increase in productivity of mustard from 1185 kg/ha in 2008-09 to 1524 kg/ha in 2020-21 and production has also been increased from 7.20 MT in 2008-09 to 10.21 MT in 2020-21 (Anonymous, 2021). Currently the area, production and productivity of rapeseed-mustard in Gujarat was 2.14 lakh ha, 4.24 lakh tonnes and 1976 kg/ha, respectively (Anonymous, 2021). Mustard oil is mainly used for cooking, frying and in pickles. Oil is also used in preparing vegetable, hair oil, medicines, soaps, lubricating oil and in tanning industries. The oil cake left after extraction is utilized as cattle feed and manure. Its oil cake contains 5.2, 1.8 and 1.2 per cent N, P and K, respectively. It has 38 to 42% oil and 24% protein. Mustard is rich in minerals like Calcium, Manganese, Copper, Iron, Selenium, Zinc, Vitamin (A, B and C) and Proteins. The 1000 g mustard seed contains 508 k. cal. energy, 28.09 g carbohydrates, 26.08 g proteins, 26.08 g total fat and 12.2 g dietary fiber, 4.73 mg niacin, 7.1 mg vitamin C, 266mg calcium, 9.21 mg Iron, 370 mg magnesium, 13 mg sodium and 738 mg potassium (Dharavath *et al*., 2017). The green tender plant is used for preparing vegetable commonly called "*Sarson ka saag*". The whole seed is used in preparing pickle and flavouring vegetable and curries. The yield level of mustard in India is below than Gujarat and the factors mainly responsible for the low yield includes deficiencies of micronutrients especially of Zn and Fe in the soils. The light textured soils of north Gujarat where these crops are mainly grown have been reported to be widely deficient in micronutrients especially in Zn and Fe. The percentage of Zn and Fe deficiencies reported in the soils of Gujarat are 24 and 8, respectively (Patel *et al*., 1999). However, deficiency of Zn and Fe in the soils of North Gujarat where mustard cultivation is practiced has been reported to be wide spread and showed their deficiencies above the state average deficiency as the soils are light textured and having low organic carbon status.

Materials and Methods

A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Geographically, Sardarkrushinagar is situated at 24° 19' North latitude and 72° 19' East longitude with an elevation of 154.52 meter above the mean sea level and situated in the North Gujarat

Agro-climatic region. Climate of this region is sub-tropical monsoon type and falls under semi-arid region. In general, the monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry. The soil of experimental field was loamy sand in texture, low in organic carbon (0.27%), electrical conductivity (0.13 dSm^{-1}) and low available nitrogen (135.3 kg/ha), medium in available phosphorus (40.52 kg/ha), medium in available potash (272.4 kg/ha), low available sulphur (9.91 ppm), DTPA- extractable Zn (0.31 mg/kg), and DTPA extractable Fe (3.55 mg/kg) having pH value of 7.3. Total eight treatments were laid out in randomized block design with four replications.T_1: RDF (50-50-00-40 kg N-P_2O_5-K_2O-S/ha), T_2: RDF + 8.0 kg $ZnSO_4$/ha and 15.0 kg $FeSO_4$/ha soil application at basal, T_3: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS, T_4: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS, T_5: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS, T_6: RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS, T_7: RDF + 4.0 kg $ZnSO_4$/ha and 7.50 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS, T_8: RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS. Uniformly 0.025% lime solution will be used with foliar spray of $FeSO_4$ and $ZnSO_4$ for neutralize the solution.Mustard variety GDM 4 was sown at a distance of 45 cm × 15 cm. After preparation of the field, the experiment was laid out. The recommended doses of 50 kg nitrogen/ha, 50 kg phosphorus/ha, 40 kg sulphur/ha were applied uniformly to all the plots and zinc sulphate and iron sulphate were given as per treatments. Full dose of phosphorus, sulphur and half dose of nitrogen were applied at the time of sowing and the remaining half dose of nitrogen was applied at 30-35 DAS. The sources for nitrogen, phosphorous and sulphur are urea, Diammonium phosphate, bentonite sulphur. Nitrogen content was determined by Micro Kjeldahl's method (Jackson, 1973). Phosphorus content was determined by using nitric acid and perchloric acid. Phosphorus was determined by venadomolybdo phosphoric acid yellow colour method (Jackson, 1973). Potash content was determined by Flame photometer method (Jackson, 1973). Sulphur content was estimated by turbidimetrically (Chaudhary and Cornfield, 1966). Zn and Fe content was estimated by Atomic Absorption spectrophotometer (AAS Model PE - 3110) (Diacid digestion), Elwell and Grindley (1967).

Results and Discussion

Growth and yield attributes

Plant height at harvest (181.8 cm), number of primary branches/plant (6.55), secondary branches/plant (16.8), number of siliquae/plant (347.6) of mustard was recorded significantly higherwith RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (Table 1). It was remained statistically at par with RDF + 8.0 kg $ZnSO_4$/ha and 15.0 kg $FeSO_4$/ha soil application at basal (T-$_2$), RDF + 4.0 kg $ZnSO_4$/ha and 7.50 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS (T_7), RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS (T_6) and RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_5). While, length of siliqua, seeds/siliqua and 1000 seed weight of mustard was not influenced significantly due to various treatments of iron and zinc fertilization (Table 1). The increase in the plant height, branches/plant and siliquae/plant of mustard in all the soil and foliar nutrition treatments was due to the micro nutrients (Zn, Fe) play an important role in the metabolic processes that take place inside the plantas zinc activate plant enzymes which are involved in carbohydrate metabolism and also require for the synthesis of growth hormone auxin leading to cell enlargement and increase in normal cell divisionwhich favors retention of more number of flowers ultimately leading to more number of reproductive parts per plant. These results are in close conformity with the findings of Kumar *et al*. (2014) and Sipai *et al*. (2015).

Yield

An application of RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_8) produced significantly the higher seed yield (2324 kg/ha) and stover yield (5381 kg/ha) (Table 1) over rest of the treatments., which was statistically at par with treatments RDF + 8.0 kg $ZnSO_4$/ha and 15.0 kg $FeSO_4$/ha soil application at basal (T_2), RDF + 4.0 kg $ZnSO_4$/ha and 7.50 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS (T_7), RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS (T_6) and RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_5). The positive effect on seed yield and stover yield might be due to easy transfer of nutrients and to plants through foliar spray of optimum dose of zinc and iron enhancement in plant growth and yield attributes. The increase in yield might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. Iron is a

Table 1: Effect of zinc and iron fertilization on growth and yield characters of mustard

Treatment	Plant height (cm)	Primary branches /plant (no.)	Secondary branches /plant (no.)	Siliquae /plant (no.)	Length of siliqua (cm)	Seeds /siliquae (no.)	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1: RDF (50-50-00-40 kg N-P_2O_5-K_2O-S/ha)	159.5	5.10	14.2	290.0	4.80	14.20	4.88	1947	4471
T_2: RDF + 8.0 kg $ZnSO_4$/ha and 15.0 kg $FeSO_4$/ha soil application at basal	180.8	6.40	16.7	350.0	5.30	16.10	5.27	2289	5300
T_3: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS	162.7	5.25	14.6	297.0	4.95	14.35	4.93	1963	4560
T_4: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS	165.8	5.55	14.9	306.8	4.95	14.80	5.00	2008	4711
T_5: RDF + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS	173.6	5.90	15.8	327.2	5.10	15.45	5.15	2060	4971
T_6: RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS	177.1	6.30	16.3	339.2	5.20	15.90	5.21	2181	5207
T_7: RDF + 4.0 kg $ZnSO_4$/ha and 7.50 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS	179.7	6.35	16.6	345.2	5.25	16.05	5.27	2271	5277
T_8: RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS	181.8	6.55	16.8	347.6	5.30	16.20	5.30	2324	5381
SEm±	5.53	0.23	0.61	13.1	0.20	0.59	0.15	95.31	228.62
LSD (p=0.05)	16.3	0.66	1.79	38.6	NS	NS	NS	280	672

structural component of porphyrin molecules cytochromes, hemes, haematin, ferrichrome and leg hemoglobin. These substances are involved in oxidation reductions in respiration and photosynthesis. It performs an essential role in nucleic acid metabolism. It is essential for many of the enzymatic transformations. Thus, iron helps indirectly in crop production. These results are in agreement with the finding of Adkine *et al*. (2017).

Nutrient uptake

The data revealed that the total nitrogen, phosphorus, potash, sulphur, iron and zinc uptake by mustard was influenced significantly by different treatments. Significantly higher total N, P, K, S, Fe and Zn uptake (99.9 kg/ha, 24.8 kg/ha, 33.7 kg/ha, 24.5 kg/ha, 217 g/ha and 1127 g/ha, respectively) by mustard was recorded with an application of RDF + 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS (T_8) over rest of the treatments, but it was remained statistically at par with (T_2), (T_7), (T_6) treatments except K, Zn and Fe uptake.

The increase in nitrogen uptake might be due to higher nitrogen uptake in seed and stover yield (Table 2) ultimately led to higher nitrogen uptake. The increase in phosphorus uptake by plant due to foliar application of micronutrients resulted a good response by the plants leading to enhanced translocation of nutrients to reproductive structure. Application of iron had favourable effect on the absorption of various nutrients due to low status of their availability in experimental soil.Similar results were also reported by Singh *et al*. (1990) and Kumar *et al*. (2014).The increase in potassium uptake might be as the experimental site was rich in available potassium status which attributed to higher dry matter accumulation besides application of deficient micronutrients such as iron and zinc, similar results were also reported Singh *et al*. (1990) and Polara *et al*. (2010). The higher uptake of S might be the outcome of increases the seed yield of mustard, the increase in iron and zinc uptake by plant might be due to the soil of experimental site was deficient in iron and zinc and due to their application, the availability of these micronutrients is increased in the soil and ultimately increased uptake of iron by crop. As higher uptake of Fe under iron application and in combination with zinc was due to their increased concentration in seed and stover coupled with more seed and stover yield. The results were corroborated to the finding of Polara *et al*. (2010) and Jat *et al*. (2013).

Table 2: Effect of zinc and iron fertilization on nutrient uptake by mustard

Treatment	Total nutrient uptake					
	N (kg/ha)	P(kg/ha)	K(kg/ha)	S (kg/ha)	Zn (g/ha)	Fe (g/ha)
T_1: RDF (50-50-00-40 kg N-P_2O_5-K_2O-S/ha)	75.5	18.9	25.5	18.7	139	749
T_2: RDF+ 8.0 kg $ZnSO_4$/haand 15.0 kg $FeSO_4$/ha soil application at basal	97.0	24.0	32.5	24.0	200	1105
T_3: RDF+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS	78.0	19.4	26.1	19.2	146	792
T_4: RDF+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar sprayat 45 DAS	81.5	20.2	27.3	20.1	156	853
T_5: RDF+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS	85.3	21.2	28.6	21.1	164	911
T_6: RDF+ 4.0 kg $ZnSO_4$/haand 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 DAS	91.0	22.7	30.4	22.5	180	999
T_7: RDF+ 4.0 kg $ZnSO_4$/haand 7.50 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 45 DAS	94.8	23.5	31.8	23.6	194	1070
T_8: RDF+ 4.0 kg $ZnSO_4$/haand 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS	99.9	24.8	33.7	24.5	217	1127
SEm±	3.71	0.84	1.07	0.77	7.07	38.49
LSD (p=0.05)	10.9	2.5	3.1	2.3	20.8	113.2

Conclusion

It light of the results obtained from the present investigation, it is concluded that mustard crop should be fertilized with RDF+ 4.0 kg $ZnSO_4$/ha and 7.5 kg $FeSO_4$/ha soil application at basal + 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 30 and 45 DAS for achieving better growth, yield attributes, yield and total nutrient uptake in loamy sand soil of Gujarat.

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