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Short Communication

Effect of Sulphur and Iron Application on their Concentrations in Mung Bean Grown on Calcareous Soil

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Mung bean (*Vigna radiata* L.) ranks fourth among grain legumes in India after chickpea, pigeonpea and black gram. It is cultivated during kharif as well as zaid season over a wide range of agro-climatic conditions in India. However, productivity of mung bean is very low in Rajasthan (99 kg ha^{-1}) compared to its genetic potential (FAI, 2001). Among the several constraints, unavailability of SO_4-S, and ferrous form of iron are considered important impediments for increasing the productivity of mung bean in Rajasthan under high pH, course textured and calcareous soils (Das *et al.*, 1993). Ali and Mishra (2000) reported beneficial effects of S in increasing the seed yield of mung bean. Importance of Fe in realizing the productivity potential of pulses received increasing attention during past few years (Marschner and Romheld, 1994). In the present study, an attempt has been made to evaluate the effects of S and Fe on mung bean grown on calcareous soils.

The experiment was conducted at RAU, Bikaner, Rajasthan, during zaid 2002 and 2003 under irrigated condition. The soil of the experimental field was loamy sand in texture having 0.11% organic carbon, 122.80 kg ha^{-1} available N, 9.45 kg ha^{-1} P, 205.78 kg ha^{-1} K, 12.92 kg ha^{-1} S, 4.61 kg ha^{-1} DTPA extractable Fe and 2.55% free $CaCO_3$ with pH of 8.3. The experiment was laid out in split plot design with four levels of sulphur (0, 20, 40, and 60 kg ha^{-1}) in main plots and eight levels of iron (0, 12.5 and 25.0 kg $FeSO_4$ ha^{-1} as basal application and 0.5% $FeSO_4$ + 0.1% citric acid at branching, 0.5% $FeSO_4$ + 0.1% citric acid at flowering, 0.5% $FeSO_4$ + 0.1% citric acid both at branching and flowering, 0.5% $FeSO_4$ both at branching and flowering and 0.1% citric acid both at branching and flowering as foliar application) in sub plots. Each treatment of sulphur and iron was replicated three times. Sulphur was applied 50:50 through elemental sulphur (85.0% commercial grade) and gypsum (16.0% S). Iron was applied through $FeSO_4.7H_2O$ (20.5% Fe) as per treatment. Excess S supplied with the basal application of $FeSO_4$ was compensated with the gypsum in rest of the treatments.

Mung bean (var. RMG-62) was sown @ 20 kg seed ha^{-1} at 30 x 10 cm spacing after applying presowing irrigation. As per treatment, required quantity of $FeSO_4$ and citric acid were dissolved in water and aqueous solution was sprayed @ 400 and 600 L on the crop at branching and

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flowering, respectively. Fully opened leaves (emerged from the whorl) were used for the determination of active Fe at 20 and 40 DAS corresponding the mung bean growth stages of branching and flowering (Katyal and Sharma, 1980). Following standard procedures S and Fe were estimated from the samples of above ground plant parts collected at branching, flowering and maturity stages.

Application of 40 kg S ha^{-1} had 31.6, 25.2, 91.0 and 62.7% higher S content in dry matter over control at branching, flowering, maturity and grains, respectively (Table 1). Increased availability of S with 40 kg S ha^{-1} in the root zone coupled with increased metabolic activity at the cellular level probably enhanced nutrient uptake, which improved the S content in different plant parts including grains. The concentration of S in mung bean also increased significantly with basal application of 25.0 kg $FeSO_4$ ha^{-1} at all the stages of plant growth. However at maturity, soil applied $FeSO_4$ @ 25.0 kg ha^{-1} and foliar applied 0.5% $FeSO_4$ + 0.1% citric acid both at branching and flowering remained statistically at par in this regard. The

Table 1. Effect of sulphur and iron on sulphur content (%) in mung bean (mean of 2002 and 2003)

Treatments	Whole plant			Grains
	Branching[1]	Flowering[1]	Maturity[1]	
Sulphur				
S_0	0.24	0.11	0.08	0.10
S_{20}	0.29	0.12	0.12	0.15
S_{40}	0.31	0.14	0.15	0.17
S_{60}	0.32	0.15	0.16	0.17
SEm±	0.004	0.003	0.003	0.002
CD at 5%	0.012	0.009	0.008	0.006
Iron				
Fe_0	0.27	0.11	0.10	0.09
$Fe_{12.5}$	0.31	0.14	0.14	0.16
$Fe_{25.0}$	0.35	0.17	0.15	0.21
FeCAB*	0.28	0.13	0.13	0.15
FeCAF*	0.27	0.11	0.12	0.14
FeCABF*	0.28	0.13	0.15	0.20
FeBF*	0.28	0.12	0.12	0.13
CABF*	0.28	0.12	0.12	0.11
SEm±	0.004	0.004	0.003	0.002
CD at 5%	0.010	0.011	0.008	0.006

[1]Branching, flowering and maturity stages were 20, 40 and 60 days after sowing, receptively.
*FeCAB = Foliar application of 0.5% $FeSO_4$+0.1% citric acid at branching.
*FeCAF = Foliar application of 0.5% $FeSO_4$+0.1% citric acid at flowering.
*FeCABF = Foliar application of 0.5% $FeSO_4$+0.1% citric acid both at branching and flowering.
*FeBF = Foliar application of 0.5% $FeSO_4$ both at branching and flowering.
*CABF = Foliar application of 0.1% citric acid both at branching and flowering.

Table 2. Effect of sulphur and iron on total iron and active iron content in mung bean (mean of 2002 and 2003)

Treatments	Total iron (mg kg^{-1} dry matter)				Active iron (mg g^{-1} fr. leaf)	
	Whole plant			Grains	Branching[1]	Flowering[1]
	Branching[1]	Flowering[1]	Maturity[1]			
Sulphur						
S_0	1087.18	769.37	608.31	223.70	15.96	25.56
S_{20}	1232.75	951.10	712.25	294.39	18.08	42.20
S_{40}	1392.43	1143.20	822.04	380.56	19.10	52.78
S_{60}	1436.22	1178.60	840.12	394.35	19.18	55.66
SEm±	19.78	17.60	10.60	7.29	0.13	0.89
CD at 5%	60.96	54.24	32.67	22.47	0.40	2.89
Iron						
Fe_0	1177.50	825.12	596.00	262.62	17.21	31.12
$Fe_{12.5}$	1440.00	1158.25	797.95	340.45	18.97	52.80
$Fe_{25.0}$	1622.50	1323.66	924.20	419.95	22.36	63.37
FeCAB*	1190.00	1079.16	765.08	302.08	17.21	47.97
FeCAF*	1186.25	830.12	742.25	293.75	17.21	31.99
FeCABF*	1155.00	1086.95	912.12	411.75	17.22	48.86
FeBF*	1186.58	923.75	622.29	285.45	17.22	40.27
CABF*	1188.33	857.54	605.25	269.95	17.21	36.03
SEm±	30.18	21.59	10.60	9.32	0.16	1.10
CD at 5%	85.50	60.49	29.71	26.13	0.46	3.09

[1]Branching, flowering and maturity stages were 20, 40 and 60 days after sowing, receptively.
*FeCAB = Foliar application of 0.5% $FeSO_4$+0.1% citric acid at branching.
*FeCAF = Foliar application of 0.5% $FeSO_4$+0.1% citric acid at flowering.
*FeCABF = Foliar application of 0.5% $FeSO_4$+0.1% citric acid both at branching and flowering.
*FeBF = Foliar application of 0.5% $FeSO_4$ both at branching and flowering.
*CABF = Foliar application of 0.1% citric acid both at branching and flowering.

magnitude of increase in S concentrations in straw and grains was 43.1 and 119.1%, respectively with 25.0 kg $FeSO_4$ ha^{-1} over control. The improvement in concentration of S with these treatments might be due to increased sulphur assimilation and other physiological functions that favor greater absorption and translocation of S to vegetative and reproductive structures (Brand *et al.*, 2000).

Successive increase in sulphur levels from 0 to 40 kg ha^{-1} significantly increased active Fe content in fresh leaves of mung bean at branching and flowering from 15.96 to 19.10 and 25.56 to 52.78 mg g^{-1} fresh leaf, respectively (Table 2). Similarly, total Fe concentration in plant dry matter at branching, flowering, maturity and grains increased by 28.7, 48.6, 35.1 and 70.1%, respectively, following application of 40 kg S ha^{-1} over control. Patel and Patel (1985) were of the view that addition of elemental S in soil causes solubilization of Fe salts in the root zone of plants by creating reduced conditions and thus increased the availability of Fe to plants.

The soil application of 25.0 kg ha^{-1} $FeSO_4$ significantly increased active Fe content of green leaves by 31.2 and 103.3% over control at branching and flowering, respectively (Table 2). Methods of iron application and frequency of foliar application had considerable effect on the concentration of Fe both in plant dry matter and grains. At branching and flowering, soil application of 25.0 kg $FeSO_4$ had 36.8 and 60.4% higher Fe content than control, respectively. At maturity soil applied 25 kg $FeSO_4$ together with foliar applied 0.5% $FeSO_4$ + 0.1% citric acid both at branching and flowering found significantly superior over rest of the treatments in increasing the total Fe content of mung bean. Significant improvement in active Fe and total Fe content with soil applied Fe salt was attributed to greater availability of Fe in its ferrous form and better absorption and translocation of reduced Fe within the plants (Patel and Patel, 1985). The higher active Fe content with foliar applied 0.5% $FeSO_4$ + 0.1% citric acid both at branching and flowering might be due to maintenance of Fe in soluble form (Fe^{++}) due to acidity of citric acid (Mengel, 1994)

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