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SHORT COMMUNICATION

EFFECT OF SULPHUR AND IRON ON CROP GROWTH ATTRIBUTES IN SUMMER GREEN GRAM

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The experiment was conducted during summer seasons of 2002 and 2003, to examine the effects of application of different levels of sulphur and iron on dry matter accumulation, crop growth rate (CGR), net assimilation rate (NAR), specific leaf weight (SLW) and leaf area index (LAI) in green gram [*Vigna radiata* (L.) Wilczek] cv. RMG-62. Four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and eight levels of iron (three levels were soil application, viz. 0, 12.5 kg and 25.0 kg $FeSO_4$ ha^{-1} and remaining five were foliar sprays, viz. 0.5% $FeSO_4$ at both preflowering and flowering, 0.5% $FeSO_4$ + 0.1% citric acid at preflowering, 0.5% $FeSO_4$ + 0.1% citric acid at flowering, 0.5% $FeSO_4$ + 0.1% citric acid at both preflowering and flowering, and foliar spray of 0.1% citric acid at both preflowering and flowering). The application of 40 or 60 kg sulphur ha^{-1} significantly increased the dry matter accumulation, LAI, CGR, NAR and SLW at various growth stages as compared to plants grown without sulphur and with 20 kg S ha^{-1}. The dry matter accumulation and other growth attributes (LAI, CGR, NAR and SLW) increased with the soil application of $FeSO_4$ @ 12.5 and 25.0 kg ha^{-1} at 20 and 40 DAS as compared to other iron treatments. At maturity significant increase in dry matter accumulation and various growth parameters (LAI, CGR, NAR and SLW) was noticed with the soil application of 25.0 kg $FeSO_4$ as well as with the foliar application of 0.5% $FeSO_4$+ 0.1 % citric acid at both preflowering and flowering as compared to other iron treatments.

***Key words*: CGR, green gram, iron, NAR, SLW, sulphur**

Summer green gram [*Vigna radiata* (L.) Wilczek] is a short duration crop suitable for multiple cropping systems and intercropping. The productivity of green gram in Rajasthan state is 99.0 kg ha^{-1} which is very low as compared to India's average (380 kg ha^{-1}) (Anonymous 2000). The important factors which reduce the green gram yield in hot arid ecosystem (e.g., Rajasthan) are high pH and calcium carbonate content of the soil. These soil conditions reduce the availability of SO_4^{2-} and iron to plants (Das 2000). Studies on other legumes showed the role of sulphur in the uptake and physiological activity of iron (Singh 1970, Mehta and Singh 1979 and Sahu and Singh 1987). Therefore, present study was conducted to examine the effects of sulphur and iron nutrition on the growth attributes of summer green gram.

The experiment was conducted at Research Farm, College of Agriculture, Beechwal, Rajasthan Agricultural University, Bikaner (28°01" N latitude, 73°22" E longitude and 234.70 m altitude) during summer 2002 and 2003. It falls under agro-ecological region No. 2 (M9E1) under arid ecosystem (hot arid eco-region with desert and saline soils). The soil was loamy sand in texture, having 2.55 % free $CaCO_3$, pH 8.3, EC 0.17 dS m^{-1}, 0.10 –

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0.11% carbon, 125.1 – 122.8 kg ha^{-1} available nitrogen , 9.5 – 10.1 kg ha^{-1} available phosphorus, 201.0 – 205.8 kg ha^{-1} available potassium, 12.8 – 12.9 kg ha^{-1} available sulphur and 2.05 – 2.06 ppm DTPA – extractable iron. Basal dose of 40 kg P_2O_5 and 20 kg N was applied through DAP and urea. The experiment was laid out in split plot design with three replications. Four levels of sulphur were taken in main plots (0, 20, 40 and 60 kg S ha^{-1}) and there were eight levels of iron in sub plots (three levels were soil application viz. 0, 12.5 and 25.0 kg $FeSO_4$ ha^{-1}; and remaining five were foliar sprays viz. 0.5% $FeSO_4$ at both preflowering and flowering, 0.5% $FeSO_4$ + 0.1% citric acid at preflowering, 0.5% $FeSO_4$ + 0.1% citric acid at flowering, 0.5% $FeSO_4$ + 0.1%citric acid at both preflowering and flowering, and foliar spray of 0.1% citric acid at both preflowering and flowering). Sulphur was applied as elemental sulphur (85% commercial grade) and gypsum (16% commercial grade) in 50:50 ratio at the time of sowing and mixed thoroughly in the top 10 cm layer of soil. Iron was applied as $FeSO_4$. $7H_2O$ (20.5% Fe) as per the treatments. For soil application, $FeSO_4$ was thoroughly mixed in top 10 cm layer of the soil. For foliar application, $FeSO_4$ was mixed with water and aqueous solution was sprayed with or without citric acid solution (0.1%) on the crop at 20 and 40 days after sowing (DAS) corresponding preflowering and flowering stages of crop, respectively. Sulphur supplied through soil applied $FeSO_4$ was compensated from gypsum. After a pre-sowing irrigation, the green gram cultivar RMG-62 was sown on 17.3.2002 and 12.3.2003. The seeds were treated with copper oxychloride (2 g kg^{-1} seed) as prophylactic measure against seed borne diseases (bacterial blight). Sowing was done manually at 30 cm row spacing using a seed rate of 20 kg ha^{-1}. The plant to plant spacing was kept at 10 cm within each row. Dry matter accumulation of plant parts (root, stem, leaves, pods and nodules) was recorded at 20 & 40 days after sowing (DAS) and at maturity (60 DAS) from five plants (50cm) in a row. The mean weekly minimum and maximum temperature during the crop season of first year fluctuated from 14.6°C to 27.3°C and 33.2°C to 45.0°C, respectively. Corresponding temperature during second year ranged from 13.2°C to 21.2°C and 31.2°C to 41.6°C, respectively. Average relative humidity varied from 16.5 to 31.0 per cent in 2002 and from 9.0 to 41.0 per cent in 2003. Leaf area was recorded by using leaf area meter (Model CI-203 Area Meter, USA). The samples were oven dried at 70°C for about 72 hours and dry weight was recorded. Leaf area index (LAI), specific leaf weight (SLW), crop growth rate (CGR) and net assimilation rate (NAR) were calculated (Gardner *et al*. 1985).

The application of sulphur at 40 and 60 kg ha^{-1} enhanced dry matter accumulation by 30.8 and 34.4 per cent, respectively, as compared to control at maturity (Table 1). The application of soil applied $FeSO_4$ at 25.0 kg ha^{-1} significantly enhanced the dry matter accumulation at all stages of crop growth (Table 1). At early stage of plant growth (20 DAS), both the soil applied treatments of iron ($Fe_{12.5}$ and $Fe_{25.0}$) enhanced the dry matter accumulation as compared to control. But at later stage (40 DAS), all the iron treatments resulted in higher accumulation of dry matter over control. At maturity, the soil applied $FeSO_4$ at 25.0 kg ha^{-1} and foliar application of 0.5 % $FeSO_4$ + 0.1% citric acid both at preflowering and flowering were at par and showed significantly higher dry matter yield over rest of the iron treatments.

The physiological parameters, viz. LAI, CGR, NAR and SLW were significantly influenced by the application of sulphur at 40 kg ha^{-1} over 0 and 20 kg S ha^{-1} at all stages of crop growth except NAR at 40 DAS- maturity. However, it remained at par with 60 kg S ha^{-1} in improving all these physiological parameters at all the stages of crop growth (Table 1). Application of 40 kg S ha^{-1} increased CGR at 20-40 DAS and 40 DAS – maturity by 57.1 and 24.4 per cent, respectively as compared to control. The increase in LAI at 20 & 40 DAS and at maturity over control due to application of 40 kg S ha^{-1} being 24.1, 17.4 and 18.3 per cent, respectively. The increase in SLW over control at 20 & 40 DAS and at maturity was 45.5, 52.2 and 25.4 per cent, respectively. The increased plant growth with sulphur application may be due to improved availability of sulphur as well as of other plant nutrients (Patel and Patel 1985). The observed improvement in growth parameters due to S application has also been reported in pea by Kasturikrishna and Ahlawat (2000).

At 20 DAS, basal application of $FeSO_4$ at 25.0 and 12.5 kg ha^{-1} significantly increased all the physiological parameters viz. LAI, CGR, NAR and SLW. At 40 DAS

Table 1. Effect of sulphur and iron on leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR), specific leaf weight (SLW) and dry matter production in green gram (pooled data of two years, 2002 and 2003).

Treatments	LAI			Dry matter (g m^{-2})			SLW (mg cm^{-2})			CGR(g m^{-2} day^{-1})		NAR (g m^{-2} day^{-1})	
	20 DAS	40 DAS	Maturity	20 DAS	40 DAS	Maturity	20 DAS	40 DAS	Maturity	20-40 DAS	40-maturity DAS	20-40 DAS	40-maturity DAS
Sulphur													
S_0	0.29	1.49	1.26	5.62	69.36	375.12	1.23	2.45	6.41	3.54	16.99	2.06	5.38
S_{20}	0.31	1.62	1.38	8.19	85.20	399.68	1.59	3.00	6.35	4.28	17.47	2.26	5.07
S_{40}	0.36	1.75	1.49	10.38	110.42	490.80	1.79	3.73	8.04	5.56	21.13	2.70	5.70
S_{60}	0.37	1.77	1.50	10.70	112.77	504.24	1.82	3.76	8.42	5.67	21.75	2.71	5.82
CD at 5%	0.03	0.10	0.09	0.78	8.28	23.18	0.20	0.42	0.95	0.64	2.28	0.35	0.46
Iron													
Fe_0	0.32	1.53	1.30	6.92	61.17	346.43	1.39	2.08	5.91	3.01	15.85	1.68	4.90
$Fe_{12.5}$	0.37	1.77	1.51	11.60	114.21	472.65	1.97	3.86	7.63	5.70	19.91	2.75	5.29
$Fe_{25.0}$	0.41	1.94	1.65	16.12	162.91	559.39	2.53	4.96	8.29	8.16	22.03	3.59	5.33
*FeCAB	0.32	1.68	1.43	6.98	98.12	438.10	1.39	3.50	7.15	5.06	18.89	2.65	5.29
*FeCAF	0.32	1.53	1.30	7.01	61.42	418.70	1.39	2.09	7.52	3.02	19.85	1.68	6.11
*FeCABF	0.32	1.69	1.44	7.04	98.93	535.94	1.39	3.46	8.67	5.04	24.35	2.63	6.79
*FeBF	0.32	1.56	1.33	7.06	81.97	388.88	1.39	3.04	6.79	4.16	17.05	2.29	5.14
*CABF	0.32	1.55	1.32	7.05	76.76	379.60	1.40	2.89	6.49	3.94	16.76	2.19	5.09
CD at 5%	0.02	0.08	0.06	0.92	6.77	20.81	0.21	0.31	0.93	0.41	1.43	0.21	0.47

DAS= Days after sowing
FeCAB= Foliar spray of 0.5%$FeSO_4$ + 0.1% citric acid at branching
FeCAF = Foliar spray of 0.5%$FeSO_4$ + 0.1% citric acid at flowering
FeCABF= Foliar spray of 0.5%$FeSO_4$ + 0.1% citric acid both at branching and flowering
FeBF= Foliar spray of 0.5%$FeSO_4$ both at branching and flowering
CABF= Foliar spray of 0.1% citric acid both at branching and flowering

and maturity, both the basal applications as well as foliar applications of 0.5 % $FeSO_4$ + 0.1% citric acid at preflowering and both at preflowering and flowering were found significantly better over control. Yadav (1998) also reported that application of iron significantly increased dry weight of root nodules, CGR, LAI, NAR and dry matter accumulation at all stages of green gram growth.

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