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Response of Blackgram (*Vigna mungo* L. Hepper) to Soil and Foliar Application of Iron Sulfate and Zinc Sulfate in Vertisol of Northern Transition Zone of Karnataka

R. Karthikeyan, S.S. Gundlur, M.S. Venkatesh, N. Bindu

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ABSTRACT

A field experiment was conducted at IIPR, Regional Center, UAS campus, Dharwad to study the response of blackgram to soil and foliar application of iron sulfate and zinc sulfate. The treatment consists of basal soil application (10 kg ha^{-1}) and foliar spray (0.5 %) of iron sulfate and zinc sulfate at flowering and pod setting stages along with recommended package of practices (FYM 5 t + 20:50:0 kg ha^{-1}) laid out in a completely Randomized Block Design with thirteen treatments.

The results revealed that foliar spray of 0.5 % iron sulfate and 0.5 % zinc sulfate at the time of flowering and pod setting recorded highest growth parameters such as plant height (50.70 cm), number of branches per plant (7.00), dry matter production per plant (16.87 g), number of effective nodules per plant (39), dry weight of effective nodules per plant (15.78 mg) and significantly higher yield parameters such as number of pods per plant (22.33), pod weight per plant (10.48 g), seed weight per plant (6.20 g), seed yield (8.78 kg ha^{-1}) and haulm yield (20.20 kg ha^{-1}) were recorded in the same treatment. The lowest growth and yield parameters were recorded in control that received only recommended package of practices. The highest protein content (24.15) in seeds of blackgram and protein yield (212.20 kg ha^{-1}) was recorded in treatment T_{13} that received RPP + foliar application of 0.5% iron sulfate and 0.5 % zinc sulfate at flowering and pod setting.

Keywords Blackgram, Iron sulfate, Zinc sulfate, Soil and foliar application, *Vertisol*.

INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper) also called as urdbean is the third most important pulse crop after pigeonpea and chickpea in India. It is grown mostly in *kharif* than *rabi* season where it is grown as rice follow pulse crop. Blackgram has an average of 24 % protein content. India produces about 3.56 million tonnes of blackgram annually in an area of 5.44 million hectare with an average productivity of 654 kg per hectare.

R. Karthikeyan, S.S. Gundlur, M.S.Venkatesh, N. Bindu
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dharwad, India
Dr S. S. Gundlur*
Assistant Professor
Soil Science Dept., University of Agricultural Sciences
College of Agriculture, Dharwad 580005, Karnataka, India
Email : gundlurss@uasd.in
*Corresponding author

Table 1. Effect of iron sulfate and zinc sulfate application on plant height, number of branches per plant, dry matter production per plant of blackgram at harvest and number of effective root nodules per plant and their dry weight of blackgram at 45 DAS. RPP- Recommended package of practice (FYM 5t, 20:50:0:: N:P_2O_5: K_2O kg ha^{-1}).

Treatments		Plant height (cm)	Number of branches per plant	Dry matter production per plant (g)	Number of effective root nodules per plant	Dry weight of effective root nodules (mg $plant^{-1}$)
T_1	RPP	39.07	6.40	13.10	28.67	11.60
T_2	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} at sowing	43.35	6.73	14.00	33.33	13.48
T_3	RPP + soil application of 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	42.35	6.80	14.13	32.33	13.08
T_4	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} + 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	49.87	6.87	16.27	39.00	15.78
T_5	RPP + 0.5% $ZnSO_4$. $7H_2O$ foliar spray at flowering	41.53	6.80	15.63	27.00	11.06
T_6	RPP + 0.5% $FeSO_4$. $7H_2O$ foliar spray at flowering	42.30	6.80	15.60	28.33	11.46
T_7	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at pod setting	41.63	6.67	14.40	27.33	11.06
T_8	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	42.30	6.60	14.63	29.00	11.73
T_9	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering and pod setting	47.95	6.67	16.60	28.00	11.33
T_{10}	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	46.27	6.80	16.52	28.67	11.60
T_{11}	RPP + 0.5% $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	47.56	6.80	16.45	29.33	11.87
T_{12}	RPP + 0.5% $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	42.17	6.47	14.30	28.67	11.60
T_{13}	RPP + 0.5% $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	50.70	7.00	16.87	29.33	11.87
	SEm ±	2.35	0.38	0.50	1.62	0.66
	CD (0.05)	6.87	NS	1.46	4.75	1.94

Karnataka ranks fourth in pulses cultivation with average area 2.57 million hectare and ranks seventh in pulses production with average of 1.42 million tonnes having mean yield of 554 kg ha^{-1}. Among the areable soils of India, 48.1% deficient in zinc, 33 % deficient in boron, 11.2 % deficient in iron, 7 % deficient in copper and 5.1 % deficient in manganese. The deficient of zinc and iron in soils are due to various reasons such as parent material, climate, the type of cropping system and management also play important role in influencing the build-up or depletion of native soil zinc and iron. Around one third of world population is suffering from zinc deficiency and approximately four percent of world population faces morbidity, mortality and children dwarfism in below five year children and in adults it causes diarrhea and pneumonia.

Above 60% of world population suffers from iron deficiency and it is considered highly important nutrient for children and pregnant women. The Recommended Dietary Allowances (RDA) of pulses for adult male is 60 g and 55 g for female per day but the per capita availability of pulses in India is 42 g per day only. Hence, increasing these deficient micro nutrients in the grains might help in reducing this malnutrition among human beings.

Table 2. Effect of iron sulfate and zinc sulfate application on yield parameters on blackgram. RPP- Recommended package of practice (FYM 5t, 20:50:0::N:P_2O_5 : K_2O kg ha^{-1}).

	Treatments	No. of pods $plant^{-1}$	Pod weight $plant^{-1}$ (g)	Seed weight $plant^{-1}$ (g)	Seed yield (q ha^{-1})	Haulm yield (q ha^{-1})
T_1	RPP	15.93	8.17	4.90	6.64	14.67
T_2	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} at sowing	17.07	9.04	5.27	7.46	17.07
T_3	RPP + soil application of 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	17.00	8.95	5.20	7.55	16.68
T_4	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} + 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	21.87	10.04	5.66	7.88	17.71
T_5	RPP + 0.5% $ZnSO_4$. $7H_2O$ foliar spray at flowering	19.00	9.23	5.39	7.76	17.59
T_6	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	18.68	9.18	5.32	7.63	17.53
T_7	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at pod setting	16.13	8.99	5.22	7.38	16.34
T_8	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	16.07	8.82	5.05	7.32	16.75
T_9	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering and pod setting	20.32	9.81	5.89	8.43	18.45
T_{10}	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	20.03	9.79	5.82	8.35	18.58
T_{11}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	20.45	9.85	5.95	8.46	18.91
T_{12}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	16.47	9.04	5.35	7.53	17.09
T_{13}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5% $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	22.33	10.48	6.20	8.78	20.20
	SEm±	1.16	0.39	0.17	0.15	0.47
	CD(0.05)	3.41	1.15	0.49	0.44	1.37

MATERIALS AND METHODS

A field experiment was conducted to study the response of blackgram (*Vigna mungo* L. Hepper) to soil and foliar application of iron sulfate and zinc sulfate in *Vertisol* of Northern Transition Zone of Karnataka at the Indian Institute of Pulses Research (IIPR), Regional center, UAS campus, Dharwad, during *kharif* 2019. The treatment consists of basal soil application (10 kg ha^{-1}) of iron sulfate and zinc sulfate and foliar spray (0.5 %) of iron sulfate and zinc sulfate at flowering and pod setting stages along with recommended package of practices (FYM 5 t + 20:50:0 kg ha^{-1}) laid out in a completely Randomized Block Design with thirteen treatments. The initial experimental soils was found to be clayey texture, neutral in reaction (pH 2.5: 7.45), low in salt content (EC: 0.26 dS m^{-1}), having slightly high in calcium carbonate content (5.02%). The experimental plot was found to be low in available nitrogen (N) (265.00 kg ha^{-1}), medium in phosphorus (P_2O_5) (28.32 kg ha^{-1}), medium in potassium (K_2O) (285.00 kg ha^{-1}), medium in sulfur (SO_4-S) (31.46 kg ha^{-1}). DTPA extractable iron (3.92 mg kg^{-1}) and zinc (0.48 mg kg^{-1}) in initial experimental site was found to be deficient. Iron sulfate and zinc sulfate were cured with vermicompost in the ratio of 1:2 one week prior to soil application. The foliar spray of 0.5% iron sulfate and 0.5% zinc sulfate were pH adjusted with 0.25% lime to avoid scorching effect.

RESULTS AND DISCUSSION

Growth parameters

The results revealed that there was a significant

Table 3. Effect of iron sulfate and zinc sulfate application on protein and protein yield of blackgram. RPP- Recommended package of practice (FYM 5t, 20:50:0::N:P_2O_5: K kg ha^{-1}).

	Treatments	Crude protein (%)	Crude protein yield (kg ha^{-1})
T_1	RPP	22.60	150.06
T_2	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} at sowing	23.10	172.48
T_3	RPP + soil application of 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	23.13	174.63
T_4	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} + 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	23.27	183.45
T_5	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering	23.35	181.20
T_6	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	22.81	181.75
T_7	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at pod setting	22.96	169.44
T_8	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	23.04	168.65
T_9	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering and pod setting	23.90	201.56
T_{10}	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	24.06	198.90
T_{11}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5% $FeSO_4$. $7H_2O$ foliar spray at flowering	23.75	200.93
T_{12}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	23.33	175.83
T_{13}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	24.15	212.20
	SEm±	0.09	3.61
	CD (0.05)	0.26	10.54

difference due to application of iron sulfate and zinc sulfate in the plant growth parameters except number of branches per plant. It has also confirmed that combined application is better than their individual application to blackgram.

It was revealed that treatment T_{13} that received foliar spray of 0.5% iron sulfate and zinc sulfate recorded highest plant height (50.70 cm), number of branches per plant (7.00) and dry matter production per plant (16.87 g) at harvest (Table 1). The increase in plant height may be due to direct absorption of iron and zinc by the plant stem and leaves during foliar spray that triggered the metabolic activity of blackgram. Foliar spray of micronutrients especially zinc that are directly absorbed by the stems, leaves, flowers and pods encouraged the auxin synthesis in plants there by stimulated the growth of the shoot in the plant, plant vigor, physiological activity and assimilation of photosynthetic products and produced significant increase in the dry matter production of the plant. Soil application of iron sulfate and zinc sulfate had been positively increased the number of effective root nodules per plant in blackgram. Highest number of effective root nodules per plant (39.00) and their dry weight (15.78 mg $plant^{-1}$) was recorded in T_4 that received 10 kg each iron sulfate and zinc sulfate each at the time of sowing along with RDF (Table 1). The iron deficiency in soils reduced the initiation and development of root nodules in legumes and there was an positive effect on number of root nodules were recorded with application of iron and zinc, also confirmed that zinc application ultimately increased the number of root nodules thereby increasing dry weight of root nodules.

Yield parameters

The experiment results revealed that significantly higher yield parameters such as number of pods per plant (22.33), pod weight per plant (10.48 g), seed weight per plant (6.20 g), seed yield (8.78 kg ha^{-1}) and haulm yield (20.20 kg ha^{-1}) were recorded in T_{13} that received 0.5 % foliar spray of iron sulfate and zinc sulfate each at the time of flowering and pod setting (Table 2). The foliar applications of micronutrients were directly absorbed by the plants thereby increasing the metabolism of the plants resulting in increased synthesis of photosynthetic products. These micronutrients also helped in efficiently transferring

Table 4. Effect of iron sulfate and zinc sulfate application on available nutrients in soil after harvest of blackgram. RPP- Recommended package of practice (FYM 5t, 20:50:0::N:P_2O_5: K_2O kg ha^{-1}).

	Treatments	N	P_2O_5 kg ha^{-1}	K_2O	SO_4-S	Fe mg kg^{-1}	Zn
T_1	RPP	248	42.50	227	23.20	3.81	0.45
T_2	RPP + soil application of 10 kg $ZnSO_4.7H_2O$ ha^{-1} at sowing	239	41.61	223	25.31	3.74	0.72
T_3	RPP + soil application of 10 kg $FeSO_4.7H_2O$ ha^{-1} at sowing	241	41.27	224	24.23	4.33	0.37
T_4	RPP + soil application of 10 kg $ZnSO_4$. $7H_2O$ ha^{-1} + 10 kg $FeSO_4$. $7H_2O$ ha^{-1} at sowing	233	40.87	220	26.39	4.40	0.78
T_5	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering	238	41.05	221	22.01	3.72	0.39
T_6	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	239	40.91	221	21.94	3.84	0.36
T_7	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at pod setting	242	41.62	223	22.28	3.76	0.41
T_8	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at pod setting	240	41.54	222	22.15	3.82	0.40
T_9	RPP + 0.5 % $ZnSO_4$. $7H_2O$ foliar spray at flowering and pod setting	233	40.66	219	21.21	3.65	0.37
T_{10}	RPP + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	234	40.59	218	21.14	3.76	0.35
T_{11}	RPP + 0.5 % $ZnSO_4$. $7H_2O$ + 0.5 % $FeSO_4$. $7H_2O$ foliar spray at flowering	236	40.48	218	21.08	3.68	0.36
T_{12}	RPP + 0.5% $ZnSO_4$. $7H_2O$ + 0.5% $FeSO_4$. $7H_2O$ foliar spray at pod setting	242	41.14	223	22.10	3.77	0.39
T_{13}	RPP + 0.5% $ZnSO_4$. $7H_2O$ + 0.5% $FeSO_4$. $7H_2O$ foliar spray at flowering and pod setting	230	39.83	216	20.62	3.61	0.34
	Initial	265	28.32	285	31.46	3.92	0.48
SEm±		1.77	0.18	0.77	0.16	0.03	0.04
CD(0.05)		5.36	0.54	2.26	0.47	0.10	0.11

photosynthetic products from source to sink, thereby increasing seed weight in pods ultimately resulting in higher seed yield.

Protein content in blackgram and protein yield

The highest protein content (24.15) in seeds of blackgram and protein yield (212.20 kg ha^{-1}) was recorded in treatment T_{13} that received RPP + foliar application of 0.5 % iron sulfate and 0.5 % zinc sulfate at flowering and pod setting. Treatments T_9, T_{10} and T_{11} were on par with T_{13} with respect to protein content. Lowest seed protein content (22.60 %) and protein yield (150.06 kg ha^{-1}) were recorded in control (Table 3).

Available nutrients in soil after harvest

The highest available nitrogen, phosphorus and potassium (248, 42.50 and 227 kg ha^{-1}, respectively) were noticed in control that received only RPP while the lowest available nitrogen, phosphorus and potassium (230, 39.83 and 216 kg ha^{-1}, respectively) in soil was recorded in treatment T_{13} that received RPP + 0.5 % foliar spray of each iron sulfate and zinc sulfate. Highest available sulfur, iron and zinc (26.39 kg ha^{-1}, 4.40 and 0.78 mg kg^{-1}, respectively) were recorded in treatment that received soil application of 10 kg ha^{-1} each iron sulfate and zinc sulfate. The lowest sulfur, iron and zinc (20.62 kg ha^{-1}, 3.61 and 0.34 mg ha^{-1}, respectively) were recorded in treatment that received RPP + 0.5 % iron sulfate and zinc sulfate each at the time of flowering and pod setting in the (Table 4).

CONCLUSION

The above experiment concluded that foliar spray of 0.5 % iron sulfate and 0.5 % zinc sulfate along with recommended package of practices at the time of flowering and pod setting stages to blackgram re-

corded higher growth, yield parameters and quality than soil application and recommended package of practices alone in the *Vertisol* of Northern Transition Zone of Karnataka.

REFERENCES

Abdulameer AS (2011) Impact of rhizobial strains mixture, phosphorus and zinc applications in nodulation and yield of bean (*Phaseolus vulgaris* L.). *Baghdad Sci J* 8 : 357—365.

Behara SK, Singh MV, Lakaria B (2009) Micronutrient deficiencies in Indian soil and their amelioration through fertilization. *Ind Fmg* 5 : 28—31.

Brear EM, Day DA, Smith PMC (2013) Iron : An essential micronutrient for the legume-rhizobium symbiosis. *Frontier Pl Sci* 4 : 359—365.

Hidoto L, Worku W, Mohammed H, Taran B (2017) Effect of zinc application strategy on zinc content and productivity of chickpea grown under zinc deficient soils. *J Soil Sci Pl Nutri* 17 : 112—126.

Kobraee S, Shamsi K, Ekhtiari S (2011) Soybean nodulation and chlorophyll concentration (SPAD value) affected by some of micronutrients. *Ann Biol Res* 2 : 414—422.