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Effects of Fe Chelates on Growth and Yield Attributes of Blackgram on a Black Calcareous Soil

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Iron deficiency is the major limitation in crop production due to its oxidation power which drastically affects the crop yield by rendering the nutrient unavailable. Chelating agents are widely used to increase the solubility of micronutrients, for stable and sustainable crop production. A pot experiment was conducted to study the effect of foliar and soil application of amino acids and organic acids chelated micronutrients on growth and yield of blackgram during 2018 at Tamil Nadu Agricultural University, Coimbatore. The plants were sprayed with single dose of organically chelated iron (1%) along with common ferrous sulphate on 25 and 45 DAS and untreated control. The results showed that foliar application of 1% ferrous glycinate chelate at resulted in maximum plant height, SPAD value, number of pods plant^{-1}, number of seeds pod^{-1}, pod length and 100 grain weight of blackgram in calcareous black soil.

Key words: Iron deficiency, Chelates, Ferrous glycinate, SPAD value, Blackgram, Yield.

Micronutrients are required in lower concentration, for crop plants, nevertheless are vital to growth and productivity of many crops. Among the micronutrients, iron plays an important role by involving electron transport, redox reactions and functions as cofactors (Benepal, 1967). A relatively large amount of iron is accumulated in plant tissue and its essential role in metabolic reactions make it as the most important nutrient among transition metals. The chloroplast contains relatively larger amount of iron compared to other cell organ Terry and Abadía (1986); (Morrissey and Guerinot, 2009) and is essential for chlorophyll synthesis (Duy *et al.*, 2007). Iron deficiency in plants occurs mostly in calcareous and alkaline soils (Zhang *et al.*, 1995); (Mengel, 2001). Deficiency of iron in plants is the most serious problem in recent agricultural practices due to the introduction of high yielding varieties, loss through leaching and reduced farm yard manure application (Bose *et al.*, 2006). A chelate describes a kind of organic chemical complex in which the metal part of the molecule is held so tightly that it cannot be 'stolen' by contact with other substances, or could convert it to an insoluble form. Chelating agents are organic molecules that can trap or encapsulate certain metal ions like Ca, Mg, Fe, Co, Cu, Zn and Mn and then release these metal ions slowly so that they become available to plants (Sekhon, 2003). The most commonly used chelating agents such as EDTA complexes contains six atoms inside its structure which able to bond the metal cation to form a six membered ring like structure with maximum stability constant. EDTA combined with iron at octahedral positions owing to six bonding sites of EDTA. Some of the drawbacks associated with EDTA chelated iron are less solubility and low uptake by plants. Gluconic acid contains only three empty orbitals which forms weak bonds with water molecules for each empty orbital (Clemens *et al.*, 1990). Iron and aluminum ions complexes with citric acid to increase the nutrients solubility (Jones *et al.*, 1996); (Ebbs *et al.*, 1998) indicating that solubilization of these metals increased the concentrations of citrate added to soil which may have been physically destructive to the soil. Hence, the present investigation was aimed to study the effect of amino acid and organic acid chelated Fe fertilizers for improving crop productivity and soil health.

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Material and Methods

The pot experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to find out the effect of amino acid and organic acid chelated iron on growth and productivity of blackgram. The seeds of blackgram were obtained from Department of Pulses, TNAU, Coimbatore and the soils were collected from farmer's field of Thondamuthur, Coimbatore. Seeds were sown in the pots at three seeds pots^{-1} with nine treatments involving T_1 - NPK control, T_2 – $FeSO_4$ 25 kg ha^{-1} as basal soil application, T_3 - Ferrous glycinate chelate @ 5 kg ha^{-1}, T_4 - Ferrous citrate chelate @ 5 kg ha^{-1}, T_5 - Fe – EDTA chelate @ 5 kg ha^{-1}, T_6 - 1% $FeSO_4$ as foliar spraying on 25 & 45 DAS, T_7 - 1% Ferrous glycinate as foliar spray on 25 & 45 DAS, T_8 - 1% Ferrous citrate as foliar spraying on 25 and 45 DAS, and T_9 – 1% Fe – EDTA as foliar spray on 25 and 45 DAS was planned in potted plants with three replicates. The growth characters like plant height, root length and SPAD value (chlorophyll content) number of pods plant^{-1}, number of seeds pod^{-1} and 100 grain weight was measured at harvest stage.

Results and Discussion

Plant height

The data on plant height at different growth stages increase with the advancement of crop growth period and furnished in Table 1. The highest plant height at all the growth stages was registered with treatment T_7 (1% ferrous glycinate as foliar spraying on 25 & 45) and it was on par with (T_3) soil application of ferrous glycinate @ 5 kg ha^{-1} and (T_4) soil application ferrous citrate chelate @ 5 kg ha^{-1}. The lowest plant height was noticed in absolute control (T_1) and the mean values varied from 13.1 cm at vegetative, 25.7 cm at flowering and 28.3 cm at harvest stages respectively. The application of ferrous glycinate has enhanced the plant height significantly which might be due to the production phenolic acid, enhanced nutrient concentration, and pod vitamin C. The data shows that iron is a critical nutrient in phenolic biosynthesis, ascorbic acid and protein synthesis. This results can also be recognized due to the enhancement of other nutrient status owing to ferrous glycinate application. Similar results was also reported by Marschner *et al.* (2011).

Table 1. Effect of iron chelates on growth and yield attributes of blackgram

Treatments	Plant height (cm)			Root length (cm)			SPAD value			Pod length (cm)	Test weight (g)
	Vegetative	Flowering	Harvest	Vegetative	Flowering	Harvest	Vegetative	Flowering	Harvest		
T_1	13.1	25.7	39.5	11.9	14.9	15.5	39.5	43.4	41.6	3.90	4.90
T_2	14.7	27.8	43.8	11.2	13.7	14.3	43.8	46.9	44.7	4.90	4.80
T_3	17.9	33.4	47.9	15.3	19.3	19.9	47.9	51.2	49.5	5.50	5.70
T_4	17.3	32.7	45.3	10.9	13.2	14.1	45.3	49.1	47.3	4.80	5.50
T_5	15.0	30.2	42.1	14.8	18.8	19.4	42.1	45.5	43.9	5.20	5.60
T_6	15.8	28.0	41.5	12.3	13.6	14.1	41.5	44.2	42.8	5.00	5.10
T_7	19.4	36.5	52.5	14.0	16.3	17.1	52.5	55.2	53.7	6.02	6.30
T_8	17.2	31.7	45.8	11.8	13.3	13.9	45.8	48.3	46.5	5.40	5.80
T_9	16.3	26.4	42.5	10.9	12.8	13.5	42.5	45.7	42.1	5.30	5.70
Mean	16.3	30.3	44.5	12.6	15.1	15.7	44.5	47.7	45.8	5.11	5.49
SEd	0.84	2.05	0.93	0.24	0.98	0.98	0.93	0.88	1.06	0.07	0.12
CD (P=0.05)	1.77	4.30	1.97	0.51	2.06	2.07	1.97	1.85	2.22	0.16	0.25

T_1 - NPK control; T_2 –$FeSO_4$ 25 kg ha^{-1} as basal soil application; T_3 - Ferrous glycinate chelate @ 5kg ha^{-1}; T_4 - Ferrous citrate chelate @ 5kg ha^{-1}; T_5 - Fe – EDTA chelate @ 5kg ha^{-1}; T_6 - 1% $FeSO_4$ as foliar spraying on 25 & 45 DAS; T_7 - 1% Ferrous glycinate as foliar spray on 25 & 45 DAS; T_8 - 1% Ferrous citrate as foliar spraying on 25 & 45 DAS; T_9 – 1% Fe – EDTA as foliar spray on 25 and 45 DAS

Root length

The data on root length of the crop at different growth stages increased with the advancement of growth stages of black gram and furnished in Table 1. The highest root length at all the growth stages was registered with treatment T_3 (soil application of ferrous glycinate @ 5 kg ha^{-1}) and it was on par with T_5 (soil application of Fe – EDTA @ 5 kg ha^{-1}) and T_7 (1% ferrous glycinate as foliar spraying on 25 and 45). The lowest root length was observed in absolute control (T_1) and mean valves varied from 11.9 cm at vegetative, 14.9 cm at flowering and 15.5 cm at harvest stages respectively. Application of amino acid chelates significantly increase the iron, copper, manganese, calcium and potassium nutrient concentration and plant growth compared to absolute control. Also, ferrous glycinate chelates improved the shoot nutrient concentration and enhanced the growth of blackgram plants when compared with control. The results was in concurrence with the finding of Garcia *et al.* (2011).

SPAD values

The chlorophyll content of black gram was significantly influenced by the application of iron chelates. The chlorophyll content increased from vegetative to flowering stages and thereafter decreased drastically at harvest stages. Higher chlorophyll content in the leaves indicated the iron sufficiency due to the application of chelates to black gram crop. The highest mean chlorophyll content of 52.5, 55.2 and 53.7 at vegetative, flowering and harvest stages respectively, was recorded in the treatments that received 1% ferrous glycinate as foliar spraying on 25 and 45 DAS (T_7) (Table 1). Iron plays an important role in the synthesis of chloroplastic mRNA and rRNA, which regulate chlorophyll synthesis (Noort and Wallace, 1966). The continuous supply of iron in soluble chelated form increased chlorophyll content in these treatments because of its involvement in the pathway of chlorophyll synthesis as discussed in earlier report by Beale (1999).

Number of pods per plant

Application of iron chelates influenced the number of pods per plant and it ranged from 16.0 to 26.0 (Fig.1). Among the treatments, the highest number of pods $plant^{-1}$ was recorded in treatment receiving foliar spraying of 1% ferrous glycinate on 25 and 45 DAS (T_7) of 26.0 followed by T_3 (soil application ferrous glycinate @ 5kg ha^{-1} 23.0), while control recorded the least number of pods $plant^{-1}$ (16.0 Fig. 1d). The results showed that amino acids remains a key role in several plant metabolic responses *viz*., synthesis of peptides, proteins, enzymes, nitrogen transformation and assimilation and several secondary important metabolics. This findings are supported by the Causin (1996).

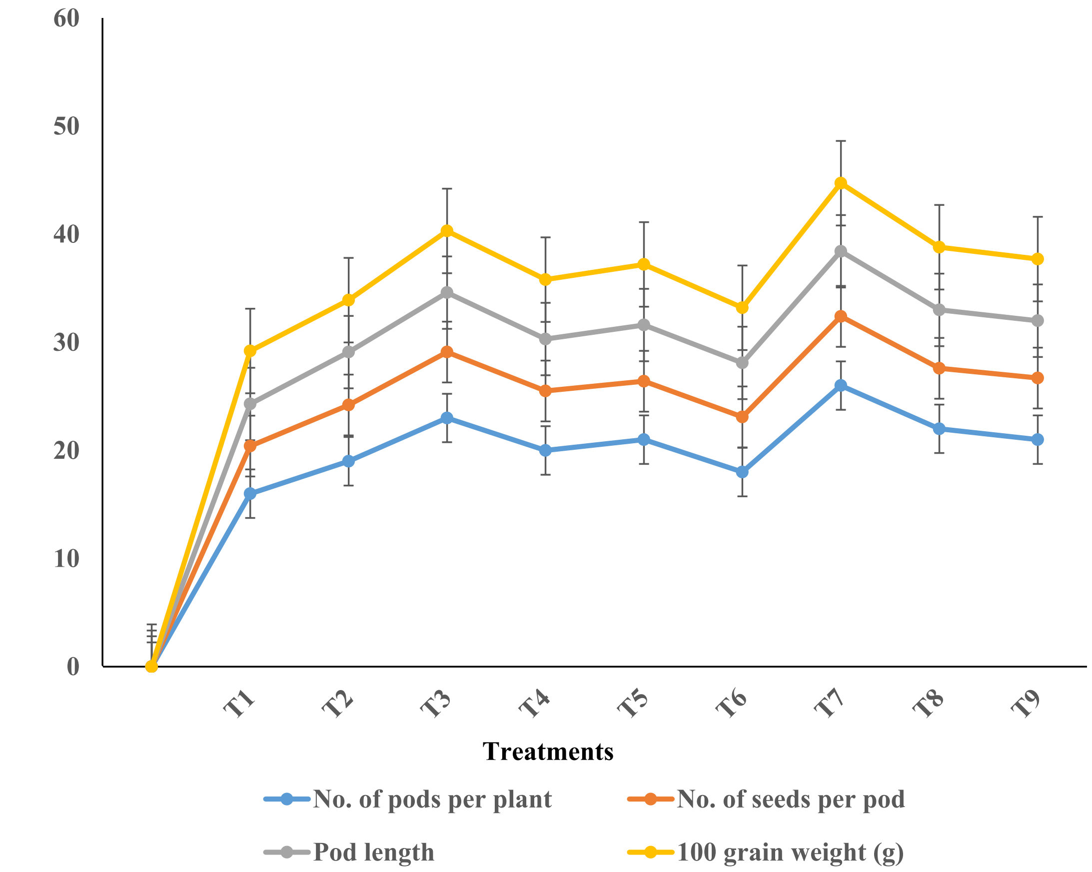

Fig. 1.Effects of iron chelates on yield attributes

T_1 - NPK control; T_2 – $FeSO_4$ 25 kg ha^{-1} as basal soil application; T_3 - Ferrous glycinate chelate @ 5kg ha^{-1}; T_4 - Ferrous citrate chelate @ 5kg ha^{-1}; T_5 - Fe – EDTA chelate @ 5kg ha^{-1}; T_6 - 1% $FeSO_4$ as foliar spraying on 25 & 45 DAS; T_7 - 1% Ferrous glycinate as foliar spray on 25 & 45 DAS; T_8 - 1% Ferrous citrate as foliar spraying on 25 & 45 DAS; T_9 – 1% Fe – EDTA as foliar spray on 25 and 45 DAS.

Number of seeds per pod

The results envisaging that the number of seeds per plant varied from 4.40 to 6.40 (Fig.1) and the highest number of seeds pod^{-1} was registered in the treatment receiving foliar spraying of 1% ferrous glycinate on 25 and 45 DAS (T_7 of 6.40) followed by T_3 (soil application ferrous glycinate @ 5kg ha^{-1} 6.10) in black calcareous soil, while control recorded the lesser number of seeds pod^{-1} (4.40). This was in agreement with the findings of Marschner *et al.* (2011); Causin (1996) and Näsholm *et al.* (2009).

Pod length

Application of iron chelates influenced the pod length significantly and it ranged from 3.90 to 6.02 in black calcareous soil (Table 1 and Fig. 1). Among the treatments, the highest pod length was recorded in the treatment receiving foliar spraying of 1% ferrous glycinate on 25 and 45 DAS (T_7). Besides, iron application increases the photosynthetic activity, root length, and number branches is all growing environment and greater partitioning of metabolites and adequate translocations of nutrients to developing structure leads to increased number of pods per plant in blackgram. This was in agreement with the findings of Marschner *et al.* (2011).

Test weight

A significant influence was confabulated on the 100 seed weight by applying iron chelates and it varied from 4.90 to 6.30 g (Table 1 and Fig. 1). The highest hundred grain weight of 6.30 g was recorded with foliar spraying of 1% ferrous glycinate on 25 and 45 DAS (T_7). This was augmented that foliar spraying of ferrous glycinate increases the yield by increasing iron from source (assimilate) to sink (seed) which would have increased the 100 seed weight and similar results was also reported by Garcia *et al.* (2011).

Conclusion

The results revealed that in black gram, foliar spraying of 1% ferrous glycinate on 25 and 45 DAS was effective in increasing the growth and yield attributes of pulses in black calcareous soil. Among the various iron chelates tested in the present investigation, Ferrous glycinate was the best in increasing the growth and yield attributes of blackgram followed by Ferrous citrate either a foliar or as soil application. Recommended practice of ferrous sulphate as soil application (25 kg ha^{-1}) or foliar spraying (1%) was found ineffective.

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