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Enhancing Quality of Fodder Sorghum through Application of Fe Chelates

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SSS, DJ, TC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CB, LL aided in conducting of the experiment, managed the analyses of data and supported in overall conduct of research. All authors read and approved the final manuscript.

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ABSTRACT

Sorghum (*Sorghum bicolor (L.) Monech*) is one of the important fodder crops for ruminants and it is a dual-purpose crop used as a food and fodder but one of the great limiting factors with the forage sorghum is that it is having an anti-nutritional factor cyanogen, which is extremely toxic to the animals feeding on them. The present experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to study the effect of iron on the quality of fodder crop. The experiment was laid in Factorial CRD with 3 factors namely seven sources of Iron (Fe glycinate citrate, Fe tartrate, Fe glutamate, $FeSO_4$, Fe-EDDHA, Fe malate) four levels ($FeSO_4$ - 0, 25, 37.5 and 50 kg ha $^{-1}$ and Fe chelates - 0, 1, 2.5 and 5 kg ha $^{-1}$) and two different soils (non-calcareous and calcareous). The experiment was carried out with 2 replications. It was seen that application of Ferrous citrate at 5 kg ha $^{-1}$ has shown the maximum reduction in cyanogen content and it has shown an increase in crude protein and decreased crude fibre content, which are desirable qualities in fodder crop. The variation in above parameter may be due to the fact that Fe is a constructive component of different enzymes (hematian, cytochroms, propyrin and ferrichrome) that favourably improves the nutritional

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environment of crop and final yield. All treatments supplied with micronutrients irrespective of the soil has shown decreased cyanogen levels below the threshold of 200 ppm, which is safe for feeding cattle as green forage under normal cultivation.

Keywords: Fe chelates; sorghum; cyanogenic glycoside, crude protein; crude fibre.

1. INTRODUCTION

Micronutrient deficiency is widespread in many Asian countries due to the calcareous nature of soils, high pH, low organic matter, salt stress, continuous drought, high bicarbonate content in irrigation water, and imbalanced application of fertilizers. Some of the adverse effects of micronutrient deficiency-induced stress in plants include low crop yield and quality, imperfect plant morphological structure (such as fewer xylem vessels of small size), widespread infestation of various diseases and pests, low activation of phytosiderophores, and lower fertilizer use efficiency. The absence of micronutrient fertilizers results in inadequate absorption of trace elements by plants, which causes substantial yield losses in different crops and forages, and eventually results in poor health for domestic animals and humans [1].

Iron is involved in many physiological processes of plants such as activation of many enzymes which are used in photosynthesis and respiration along with synthesis of chlorophyll. Iron is associated with heme and non-heme proteins such as ferrodoxin, main constituent in the chloroplast where it participates in sulphur and nitrogen metabolism and has important role in energy transfer within plants. Deficiency results in chlorosis in young leaves that is shown by yellow and green strips along the length which is avoided by spraying iron complexes [2-4].

Sorghum is an important forage crop grown for green as well as dry forage production over wide areas. It is fast growing, palatable, nutritious and mainly utilized as green forage. Forage sorghum is a valuable fodder and is relished by ruminants, which can be grazed (young or as deferred fodder), cut fresh, made into hay or ensiled [5]. Being an exhaustive crop, yield and quality of sorghum fodder suffers heavily if proper amount of fertilizer is not applied.

Sorghums contain a cyanogenic glucoside, dhurrin, which hydrolyses to form the respiratory poison hydrogen cyanide when ingested by stock. The level of dhurrin in sorghums can vary substantially. Young regrowth, for example, is much more dangerous than more mature crops [6]. The hydrogen cyanide in sorghum is stored in the form of non-poisonous cyanogenic glycosides. When the leaf tissue is ruptured – such as when chopping for forage or chewing by animals- these glycosides come in contact with enzymes in other parts of the plant and/or saliva and get broken down into their constituent compounds: hydrogen cyanide and sugar causing the animal to suffocate leading to death.

In India, due to increased population pressure and competing demand for food crops, it is not possible to increase the area under fodder crops. Present area under fodder crops in India is around 8.6 million hectare. Further increase in the acreage of the fodder crops is not possible due to increased competition between various land uses for the cultivable land in the country. Only way to meet the fodder needs of livestock may be possible by increased productivity per unit land area and also through integration of fodder crops in the existing cropping systems and utilizing marginal and sub marginal dry lands and problematic soils for developing feed and fodder resources [7]. With this aim the study was conducted to see the effect of different iron sources on the quality of the forage crops and its effectiveness in controlling iron induced deficiency.

2. MATERIALS AND METHODS

The experiment was conducted in a pot house of Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University. The experimental design used was factorial CRD with two replications. The treatment comprised of seven sources of iron (Fe glycinate citrate, Fe tartarate, Fe glutamate, $FeSO_4$, Fe-EDDHA, Fe malate) four levels ($FeSO_4$ - 0, 25, 37.5 and 50 kg ha $^{-1}$ and Fe chelates - 0, 1, 2.5 and 5 kg ha $^{-1}$) and two different soils (Non-calcareous and Calcareous). The treatment application was made through soil application of $FeSO_4$ and Fe chelates. Planting was done during May and harvested during August to determine the fresh and dry forage yield. The dried samples were ground to determine forage nutritive value. Crude protein was determined by the micro-Kjeldahl method [8], whereas crude fiber was determined according to the method of AOAC [9].

The method used for estimation of HCN content was as suggested by [10]. A quantity of 0.15 g of green plant material was cut into short pieces with scissors and dropped in a test tube and 3 to 4 drops of chloroform were added. A strip of moist filter paper saturated with sodium picrate solution was suspended above the moist sample. Then, saturated filter paper was held in place with a cork stopper which served to seal the test tube and it was incubated at room temperature (20˚C) for 12 to 24 hours. The sodium picrate which prevailed in the filter paper was reduced to a reddish compound in proportion to the amount of hydrocyanic acid which evolved from the sample. The colour produced was dissolved by placing the filter paper in a clean test tube containing 10 ml of distilled water after which the colour of the sample was matched with colour standards and concentration of HCN content was measured in spectrophotometer and then expressed in ppm. The data obtained from the investigations were subjected to the analysis of variance to find out the significance as suggested by Panse and Sukhatme [11].

3. RESULTS AND DISCUSSION

3.1 Cyanogenic Glycoside Content

Hydrocyanic acid (HCN) is an antinutritional factor which is potentially toxic to the animal which feeds on 30–35-day-old sorghum crops [12]. The cyanogenic glycoside, dhurrin found in sorghum can be hydrolysed in the rumen and liberate deadly hydrocyanic acid. Hydrocyanic acid content in excess of 200 ppm (on wet weight basis) in the forage sorghum is toxic to the animal health.

The application of metal-amino acid chelates significantly affect the forage glycoside content, yield and the quality parameters like crude protein and crude fibre compared with control (no fertilizer applied) and non-chelated and synthetic chelated micro-nutrients. In soil 1, the HCN content was reduced when compared to soil 2 (Fig. 1) and within the treatment application the one applied with ferrous citrate recorded the lowest content of HCN irrespective of the soil. Increase in yield was noted with amino acid chelates of micro-nutrients as compared with control.

The statistical analysis obtained for the three-way ANOVA on the effects of sources, different levels and different soils on cyanogenic glucoside production in sorghum leaves is given in Fig 1 where it can be seen that sources, different levels and different soils have all significantly influenced cyanogenic production in sorghum leaves. This showed that each factor had an important influence on cyanogenic glucoside production in sorghum, confirming that different sources, soil and the levels of their application significantly influence the cyanogen content in leaves. The cyanogen content varied based on the different sources, its corresponding levels and also showed significant difference between soils. Here it is seen that there is a significant reduction in the levels of HCN as the levels of different treatments are increased and it was seen that the effect of treatments on the soil is also significant. Calcareous and non-calcareous soils showed high response to the treatment application and even thought the latter was found to bring out much more drastic reduction when compared to the former. This shows that there is influence of nutrients and mainly micronutrients have a major role in the suppression of anti-nutritional factors.

3.2 Crude Protein

The crude protein content in dry matter is of utmost importance in forage crop as it determines the palatability and digestibility of forage crops. The application of different amino acid chelates has shown significant differences in the crude protein content (Fig 2). The maximum crude protein (12%) was recorded by the treatment supplied with ferrous citrate irrespective of soil and was statistically superior to all the other treatments. The protein contents increased by the application of amino acid chelated micronutrients. It was also seen that there was proportionate increase in the protein content with respect to the different levels applied. The higher protein contents in dry matter ultimately will result higher protein yield on unit area. The significant differences in crude protein contents in dry matter have also been confirmed by Nabi et al. [13], Filho et al. [14] and Tauqir et al. [15]. Improved protein contents might be due to better uptake of nutrients which is an integral part of protein synthesis.

3.3 Crude Fibre

The crude fibre in forage material has adverse effect on forage quality as it affects the digestibility. The data presented in Table 2 show that the highest value for crude fibre was recorded by Ferrous sulphate (29.18 %). Lowest value of crude fibre was seen in dry matter produced by Ferrous citrate and it could be taken as good quality forage (Fig 3). The significant differences among sorghum genotypes have already been confirmed by studies conducted by Mahmud et al. [16] and Nabi et al. [13].

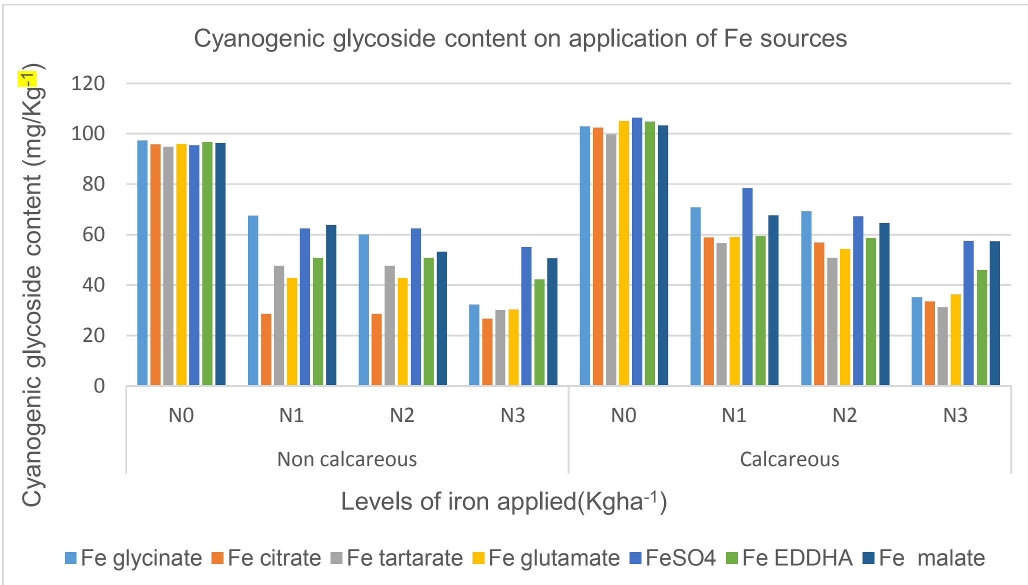

Fig. 1. Effect of different sources of iron and soils on the cyanogenic glycoside content

Levels of Fe sources - $FeSO_4$ – N_0-0, N_1-25, N_2-37.5 and N_3-50 kg ha $^{-1}$ and Fe chelates – N_0-0, N_1-1, N_2-2.5 and N_3-5 kg ha $^{-1}$

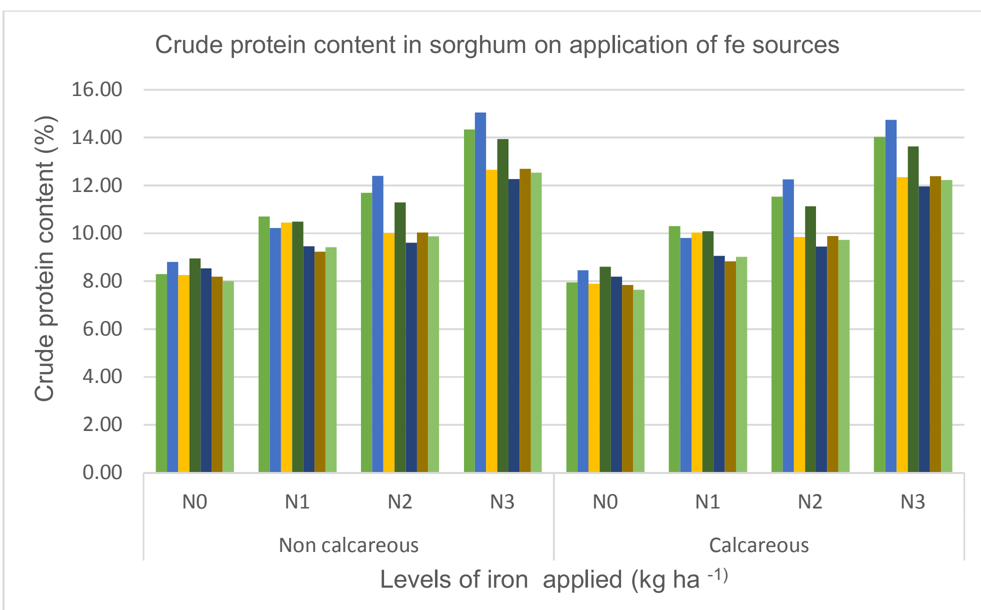

Fig. 2. Response of Fe sources and soil on crude protein content

Levels of Fe sources - $FeSO_4$ – N_0-0, N_1-25, N_2-37.5 and N_3-50 kg ha $^{-1}$ and Fe chelates – N_0-0, N_1-1, N_2-2.5 and N_3-5 kg ha $^{-1}$

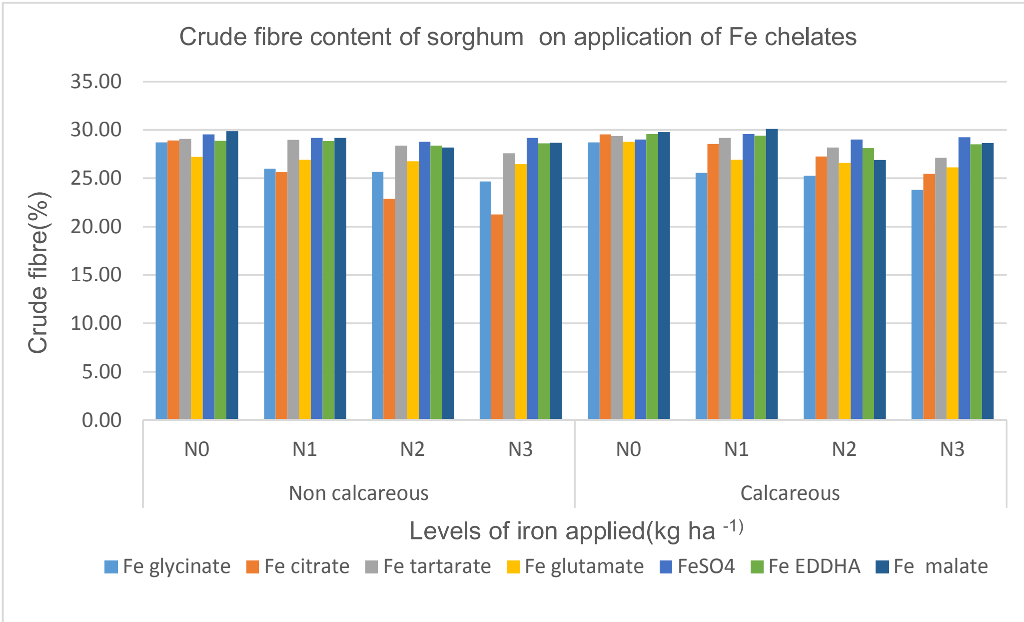

Fig. 3. Response of Fe sources and soil on crude fibre content (%)

Levels of Fe sources - $FeSO_4$ – N_0-0, N_1-25, N_2-37.5 and N_3-50 kg ha $^{-1}$ and Fe chelates – N_0-0, N_1-1, N_2-2.5 and N_3-5 kg ha $^{-1}$

4. CONCLUSION

The outcome of the experiment suggested application of micronutrients irrespective of soil has a greater potential in improving the quality of forage crop. Under the light of present study, the application of Fe Citrate is found to have brought about lower cyanogen content, crude fibre, higher crude protein content and yield. The result of the improvement in quality is due to the effect of Fe which is a constructive component of different enzymes (hematian, cytochroms, propyrin and ferrichrome) that favourably improve the nutritional environment of crop and final yield. Irrespective of soil, there was improvement in the quality of sorghum for forage purpose.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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