ENHANCING FODDER YIELD OF SORGHUM THROUGH FOLIAR APPLICATION OF IRON AND ZINC

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SUMMARY

Micronutrients like iron (Fe) and zinc (Zn) play a crucial role in the growth and development of sorghum. This study, conducted at ARS Keshwana, Jalore, Rajasthan, aimed to evaluate the impact of foliar applications of Fe and Zn on sorghum growth and fodder yield. The experiment followed a Randomized Block Design (RBD) with nine treatments and three replications. Results indicated that foliar application of Zn and Fe significantly enhanced plant height, leaf area, stem diameter, and fodder yield, with the combined application of RDF + 0.5% $ZnSO_4$ at 25 DAS + 0.5% $FeSO_4$ at 35 DAS yielding the highest green and dry fodder output. The findings suggest that integrating Fe and Zn foliar applications can improve the productivity and nutritional value of sorghum, making it a viable strategy for farmers in semi-arid regions.

Key words: Fodder Sorghum. Foliar application, Iron & Zinc, Growth and Fodder yield

Fodder sorghum, scientifically known as *Sorghum bicolor* L., is a versatile and valuable crop primarily cultivated for its high-quality forage and biomass production. Sorghum belongs to a grass family Poaceae and is widely grown in various regions worldwide, particularly in arid and semi-arid areas where other forage crops struggle to thrive. It is drought as well as heat resistant fodder crop with fairly high biomass (Iqbal and Iqbal, 2015). Fodder sorghum is valued for its ability to withstand harsh environmental conditions such as drought, heat, and poor soil fertility, making it a resilient option for livestock feed production. It exhibits rapid growth and can reach maturity in a relatively short period, typically within 70 to 120 days depending on the variety and environmental conditions. The average productivity of green fodder from single-cut forage sorghum is to the tune of 40-50 t/ha (Satpal *et al*., 2020). The green fodder is rich in carbohydrates, proteins, vitamins, and minerals, making it a nutritious feed option for various livestock species, including cattle, sheep, goats, and poultry. Due to its adaptability, high productivity and nutritional value, fodder sorghum plays a significant role in sustainable agriculture, especially in regions facing challenges such as water scarcity and climate change. Its cultivation contributes to food security, livestock nutrition, and economic stability for farmers, making it an important crop in agricultural systems worldwide. Proper fertilization is another important factor to realize the potential forage sorghum production (Kaur and Satpal, 2019). Iron and zinc play crucial roles in improving the yield of fodder sorghum. Iron is essential for photosynthesis, enzyme activation, and chlorophyll synthesis, enhancing overall plant growth and development. Ca, Zn and Fe contents are low in sorghum and their deficiency in livestock resulted in serious health problems (Abdelhalim *et al.*, 2019). Zinc aids in various metabolic processes, including enzyme activation, protein synthesis and carbohydrate metabolism, contributing to better nutrient uptake and utilization in sorghum plants. Adequate levels of iron and zinc in the soil promote healthier plant growth, increased biomass production, and ultimately higher yields of fodder sorghum. Additionally, these micronutrients help in enhancing plant resistance to environmental stresses, such as drought and disease, further boosting crop productivity. However, several factors can contribute to low yields of fodder sorghum. (Chattha *et al*., 2017). Nutrient deficiencies can hinder plant growth and development, leading to reduced yields. Plant nutrition depends on the availability and uptake of nutrients from the soil and it plays a vital role in dry matter production of all crops (Mousavi *et al.*, 2013).

Studying the effects of zinc and iron application in fodder sorghum is important for nutrient deficiency correction. Zinc and iron deficiencies are common in many soils, particularly in areas with alkaline or acidic soils or where intensive farming practices have depleted soil nutrients. Understanding how these micronutrients affect fodder sorghum growth and productivity can help develop strategies to correct deficiencies and optimize crop yields. Adequate levels of these nutrients promote healthy root development, efficient photosynthesis, and optimal nutrient uptake, leading to increased biomass production and higher yields of fodder sorghum. Fodder sorghum is primarily grown for livestock feed. Studying the effects of zinc and iron on fodder sorghum can help improve the nutritional quality of the forage, enhancing livestock health and performance. Optimizing nutrient management practices, including zinc and iron application, can contribute to sustainable agricultural systems by reducing nutrient losses to the environment and minimizing the need for synthetic fertilizers. Understanding the effects of these micronutrients on fodder sorghum can help develop nutrient management strategies that promote both crop productivity and environmental stewardship. Zinc and iron play critical roles in plant stress response mechanisms. Studying their effects on fodder sorghum can help identify varieties and management practices that improve the crop's resilience to environmental stresses such as drought, heat, and pest infestations, ultimately enhancing agricultural resilience and food security. Overall, studying the effects of zinc and iron application in fodder sorghum is essential for optimizing crop productivity, improving livestock nutrition, promoting environmental sustainability. The present field experiment was, therefore, conducted to analyze the influence of foliar application of zinc and iron at different growth stages of crop on productivity of fodder sorghum.

MATERIALS AND METHODS

Field experiment during *kharif* 2020 and 2021 were conducted at Agricultural Research Station (ARS), Keshwana, Jalore, Rajasthan, which falls under the transitional plain zone of the Luni Basin. The experiment was laid out in RBD in nine treatments with replicated thrice. *viz*. T_0: Control (No foliar application), T_1: RDF (Recommended Dose of Fertilizers), T_2: RDF + 0.5% $ZnSO_4$ Foliar Spray at 25 DAS, T_3: RDF + 0.5% $ZnSO_4$ Foliar Spray at 35 DAS, T_4: RDF + 0.5% $ZnSO_4$ Foliar Spray at 25 & 35 DAS, T_5: RDF + 0.5% $FeSO_4$ Foliar Spray at 25 DAS, T_6: RDF + 0.5% $FeSO_4$ Foliar Spray at 35 DAS, T_7: RDF + 0.5% $FeSO_4$ Foliar Spray at 25 & 35 DAS and T_8: RDF + 0.5% $ZnSO_4$ at 25 DAS + 0.5% $FeSO_4$ at 35 DAS.

The soil was loamy sandy in texture, with pH (1:2 soil: water) of 8.02, organic C content of 0.23%, $KMnO_4$-oxidizable N of 166 kg ha^{-1}, 0.5 M $NaHCO_3$ extractable P of 18 kg ha^{-1}, and NH_4OAc-exchangeable K of 280 kg ha^{-1}, Sulphur 14.44 kg ha^{-1}, DTPA extractable Zn 0.17 mg kg^{-1} and DTPA extractable Fe 2.70 mg kg^{-1}. The recommended dose of fertilizer was applied to the crop. The half dose of nitrogen and full dose of phosphorus was applied as basal dose at the time of sowing of sorghum crop and remaining half dose of nitrogen was top dressed at crop knee high stage. As per the treatment foliar spray of 0.5 % $ZnSO_4$ and FeSO4 were done. ZnSO4 and FeSO4 @ 500 g each were dissolved in 100 liters of water and then sprayed in the experimental plots as per treatments. The other agronomic (management) practices like irrigation application, pests control and weed control measures were done as per recommended package of practices of. Growth parameters and yield attributes of fodder sorghum were recorded on randomly selected tagged plants.

Dry matter percentage

The dry matter percentage of fodder sorghum was calculated by measuring the weight of the fodder sorghum before and after drying, then dividing the weight of the dry matter by the weight of the initial sample and multiplying by 100 to get the percentage.

$$\text{Dry matter percentage} = \frac{\text{Weight of dry matter}}{\text{Weight of initial sample}} \times 100$$

The dry matter is determined by drying the sample in an oven until it reaches a constant weight, indicating that all moisture has been removed.

RESULTS AND DISCUSSION

Effect of foliar application of Zn and Fe on growth parameters of fodder sorghum

Plant height is a key indicator of vegetative growth. The results indicated that foliar application of Zn and Fe significantly increased plant height compared to the control. Treatment T_8 (RDF + 0.5% $ZnSO_4$ at 25 DAS + 0.5% $FeSO_4$ at 35 DAS) recorded the highest plant height (120.63 cm & 195.33 cm) during 2020 and 2021, respectively. During pooled analysis it was recorded significantly highest (157.98 cm) from the RDF and control (Table 1). Leaf area plays a crucial role in light interception and photosynthesis. The maximum leaf area was observed in T_8 (2854 cm²) and T_4 (2736 cm²), indicating better vegetative growth. Increased leaf area is associated with enhanced photosynthetic activity, leading to higher biomass accumulation. The increase in plant height is attributed to the role of Zn in cell elongation and Fe in chlorophyll synthesis. This may be due to the fact that both zinc and iron are essential components of chlorophyll, the pigment responsible for photosynthesis. Adequate levels of these micronutrients ensure efficient photosynthetic activity, leading to enhanced energy production and biomass accumulation in sorghum plants. Plant height increased upon application of zinc, possibly as a result of its interaction with auxin production. The production of indole 3-acetic acid involves zinc, a key plant growth promoter that controls cell enlargement and the elongation of internodes, which in turn causes stem elongation. As, zinc is also important for the synthesis of chlorophyll which increased photosynthetic activity which provides more energy thus contribute to building blocks for growth, ultimately leading to taller plants height. These results were consistent with research Akhila *et al.* (2021) and Asif *et al.* (2024). The positive effect of zinc fertilization on plant height and leaf area of fodder maize planted in spring season was also reported by Sewhag *et al.* (2022). Results is collaborated with results of Vinita *et al.* (2021), she also recorded the significant results of plant height with the application of RDF + foliar application of Fe and Zn at 45 DAS, respectively. Similar results for fodder sorghum were also reported by Asif *et al.* (2020).

A significant increase in stem diameter was recorded in treatments receiving Fe and Zn foliar sprays (Table 2). T_8 exhibited the highest pooled stem diameter (12.37 cm), suggesting that micronutrient supplementation improved plant structural integrity. Numerically higher dry matter percentage found with the T_8 and lowest with the T_2. Dry matter percentage did not give any significant response with respect to foliar application of Fe and Zn on the fodder sorghum. Dry matter percentage is the ratio of dry matter and green fodder yield of crop. So that it gives response with respect to particular treatment.

Effect of foliar application of Zn and Fe on Green and Dry fodder yield of fodder sorghum

Green fodder yield is a direct measure of the economic value of sorghum as a forage crop (Table 3). The higher green fodder yield during 2020 and 2021 were recorded with the treatments T_8. During pooled it was also recorded with T_8 (370.52 q/ha) but it found significantly at par with the T_3, T_4 and T_7, respectively. It is showing a 43.3% increase over the control. This increase can be attributed to improved nutrient uptake, better photosynthesis, and higher biomass production. Maximum dry fodder yield during both the years were recorded with the T_8. During pooled analysis it was found superior (65.05 q/ha) in T_8, which was significantly higher than the control (45.28 q/ha). Dry fodder is crucial for livestock

TABLE 1

Effect of foliar application of Fe and Zn on plant height and leaf area of sorghum

Treatments		Plant height (cm)			Leaf area per plant (cm²)		
		2020	2021	2020	2021	2020	2021
T_0	Control	82.50	146.37	114.43	2062	2246	2154
T_1	RDF	109.53	169.63	139.58	2410	2659	2535
T_2	RDF+0.5 % ZnSO4 Foliar Spray at 25 DAS	112.03	178.37	145.20	2477	2794	2635
T_3	RDF+ 0.5 % ZnSO4 Foliar Spray at 35 DAS	113.87	178.67	146.27	2508	2798	2653
T_4	RDF+ 0.5 % ZnSO4 Foliar Spray at 25 & 35 DAS	119.67	187.03	153.35	2597	2874	2736
T_5	RDF+ 0.5 % FeSO4 Foliar Spray at 25 DAS	107.93	175.57	141.75	2383	2752	2568
T_6	RDF+ 0.5 % FeSO4 Foliar Spray at 35 DAS	111.93	179.83	145.88	2463	2816	2640
T_7	RDF+ 0.5 % FeSO4 Foliar Spray at 25 & 35 DAS	114.63	181.67	148.15	2497	2844	2671
T_8	RDF+ 0.5 % ZnSO4 at 25 DAS + 0.5 % FeSO4 at 35 DAS	120.63	195.33	157.98	2657	3052	2854
S. Em. ±		4.96	6.92	4.26	101	98	70
C. D. (P=0.05)		14.86	20.74	12.26	302	295	203

TABLE 2

Effect of foliar application of Fe and Zn on stem diameter and dry matter percentage of sorghum

Treatments		Stem diameter (cm)			Dry matter percentage		
		2020	2021	Pooled	2020	2021	Pooled
T_0	Control	11.77	10.50	11.13	17.35	17.64	17.51
T_1	RDF	11.93	10.63	11.28	16.92	17.54	17.25
T_2	RDF+0.5 % ZnSO4 Foliar Spray at 25 DAS	12.30	10.93	11.62	17.28	17.64	17.47
T_3	RDF+ 0.5 % ZnSO4 Foliar Spray at 35 DAS	12.47	11.13	11.80	17.33	17.66	17.50
T_4	RDF+ 0.5 % ZnSO4 Foliar Spray at 25 & 35 DAS	12.53	11.13	11.83	17.25	17.66	17.46
T_5	RDF+ 0.5 % FeSO4 Foliar Spray at 25 DAS	12.07	10.77	11.42	17.26	17.64	17.46
T_6	RDF+ 0.5 % FeSO4 Foliar Spray at 35 DAS	12.53	11.17	11.85	17.22	17.68	17.47
T_7	RDF+ 0.5 % FeSO4 Foliar Spray at 25 & 35 DAS	12.53	11.13	11.83	17.19	16.47	16.80
T_8	RDF+ 0.5 % ZnSO4 at 25 DAS + 0.5 % FeSO4 at 35 DAS	13.10	11.63	12.37	17.45	17.65	17.56
S. Em. ±		0.39	0.35	0.26	-	-	-
C.D. (P=0.05)		1.16	1.04	0.75	-	-	-

TABLE 3

Effect of foliar application of Fe and Zn on green and dry fodder yields of sorghum

Treatments		Green fodder yield (q/ha)			Dry fodder yield (q/ha)		
		2020	2021	Pooled	2020	2021	Pooled
T_0	Control	226.72	290.44	258.58	39.34	51.22	45.28
T_1	RDF	285.83	343.74	314.79	48.35	60.28	54.31
T_2	RDF+0.5 % ZnSO4 Foliar Spray at 25 DAS	317.33	363.24	340.29	54.83	64.09	59.46
T_3	RDF+ 0.5 % ZnSO4 Foliar Spray at 35 DAS	323.17	367.14	345.15	56.00	64.83	60.41
T_4	RDF+ 0.5 % ZnSO4 Foliar Spray at 25 & 35 DAS	337.17	371.91	354.54	58.15	65.69	61.92
T_5	RDF+ 0.5 % FeSO4 Foliar Spray at 25 DAS	301.00	358.48	329.74	51.94	63.22	57.58
T_6	RDF+ 0.5 % FeSO4 Foliar Spray at 35 DAS	312.67	364.76	338.71	53.85	64.48	59.17
T_7	RDF+ 0.5 % FeSO4 Foliar Spray at 25 & 35 DAS	322.00	366.28	344.14	55.35	60.32	57.83
T_8	RDF+ 0.5 % ZnSO4 at 25 DAS + 0.5 % FeSO4 at 35 DAS	345.72	395.31	370.52	60.34	69.77	65.05
S. Em. ±		15.40	13.80	10.34	2.69	2.60	1.87
C. D. (*P*=0.05)		46.16	41.39	29.79	8.07	7.79	5.39

feeding during the offseason, and an increase in dry matter accumulation suggests better crop productivity. The significant yield improvements observed in T8 can be explained by the synergistic effects of Fe and Zn in improving chlorophyll formation, enzymatic activities, and overall plant vigor. The combined application of Fe and Zn at different growth stages ensured continuous nutrient availability, reducing stress-related yield losses. This significant improvement in productivity of fodder sorghum by the influence of foliar spray of zinc fertilization might be due to the fact that both zinc and iron facilitate the uptake and translocation of other essential nutrients within the plant. Zinc is involved in the synthesis of amino acids and proteins, while iron is necessary for the formation of chloroplasts and mitochondrial proteins. Overall, zinc and iron improve crop growth of sorghum by enhancing photosynthesis, enzyme activation, root development, nutrient uptake, and stress tolerance. Ensuring adequate levels of these micronutrients in the soil and optimizing their availability to sorghum plants are essential for maximizing crop productivity and yield. Another reason might be that due to increased application of zinc and iron, nutrients remained available to crop plants throughout the crop growth period (Kumar *et al.*, 2019). Similar were the findings of Durgude *et al.* (2019) who reported higher leaf area of sorghum due to zinc and iron application than all other treatments.

CONCLUSION

The study demonstrated that foliar application of iron and zinc plays a crucial role in improving the growth and fodder yield of sorghum. Among the treatments, RDF + 0.5% ZnSO4 at 25 DAS + 0.5% FeSO4 at 35 DAS (T_8) was the most effective, significantly enhancing plant height, leaf area, stem diameter, and fodder yields. These findings highlight the importance of integrating micronutrient foliar applications into sorghum cultivation practices to improve productivity in semi-arid regions. Future research should focus on optimizing foliar application frequencies and evaluating their impact on fodder nutritional quality.

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