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Effect of soil and foliar application of iron on productivity and nutrient uptake by parching sorghum

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ABSTRACT

An experiment on the comparative performance of foliar vs. soil application of $FeSO_4$ was conducted in the research field of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the Kharif season of 2020-21. The experiment was laid in Factorial Randomized Block Design (FRBD) with twelve treatments in three replications. The treatments included a) soil application of $FeSO_4$, and b) foliar application of $FeSO_4$. The variety of parching sorghum was PKV-Kartiki. The recommended doses of macronutrient fertilizer i.e. 80:40:40 N, P_2O_5, and K_2O kg ha^{-1} were applied to all treatments. The results indicated that the green grain (hurda) yield, green fodder yield, oven-dry parching grain yield, leaf-stem yield, root yield, and panicle straw yield were recorded significantly highest with soil application of 30 kg $FeSO_4$ ha^{-1} and with the foliar application of 1.0% $FeSO_4$ at the flowering stage which was found to be at par with treatment of soil application of 20 kg $FeSO_4$ ha^{-1} and with the foliar application of 0.5% $FeSO_4$ at flowering stage respectively. The uptake of nitrogen, phosphorus, potassium, iron, copper, manganese and zinc by leaf-stem, root, parching grain, and panicle straw was also recorded highest with the soil application of 30 kg $FeSO_4$ ha^{-1} and with the foliar application of 1.0% $FeSO_4$ at flowering stage.

Keywords: Iron, soil application, foliar application, productivity, nutrient uptake

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Munch] is the king of millets and the third important crop in the country after rice and wheat. In India, it is most popularly known as Jowar. It is an important food, feed, fodder, and ration for humans, cattle, and poultry. Sorghum has a good nutritional composition similar to rice and wheat in some aspects. The grains contain high fiber, non-starchy polysaccharides, and starch with some unique characteristics. There is a considerable variation in sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine, and niacin (Shobha *et al*., 2008; Chavan *et al*., 2009).

Parching sorghum is harvested in the milk stage after pollination but before starch has formed. It is being very popular nowadays and is a good source of minerals and carbohydrates. The presence of iron in parching sorghum used during pregnancy reduces the risk of birth defects. Enrichment of iron in parching sorghum promotes antioxidant activity. Antioxidant activity helps to protect the body from cancer and heart disease (Joseph *et al*., 2005). It is beneficial for good digestion; preventing anemia, diabetes (Chung *et al*., 2011), and anticancer properties. The cultivars most suitable for roasting have a sweet endosperm that is dimpled at maturity. Vani sorghum (durra group) of India is especially popular in this respect.

Iron is one of the essential micronutrients required by plants. It plays an important role in the synthesis of chlorophyll, carbohydrate production, cell respiration, chemical reduction of nitrate and sulfate, and N assimilation. Iron deficiency symptoms appear on younger leaves indicating yellowish inter-veinal areas of leaves (commonly referred to as iron chlorosis). In case of severe deficiency, leaves become almost pale white due to loss of chlorophyll. In general, plants are prone to iron deficiency in alkaline, calcareous soils, coarse-textured soils, eroded soils, low organic matter soils, and cold weathered areas soils except for flooded rice field soils (Tandon, 1998). Micronutrient deficiency can greatly disturb plant yield and quality. By supplying plants with micronutrients, either through soil application, foliar spray or seed treatment, increased yield and high quality, as well as micronutrient use efficiency, can be achieved. The application of micronutrient fertilizers not only increases the yield of the crop, but also increases the density of nutrients in the grain which is now a prerequisite for human health (Imtiaz *et al.*, 2010).

MATERIALS AND METHODS

The experiment was conducted in the research field of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif* season of 2020-21. The experiment was laid in Factorial Randomized Block Design (FRBD) with twelve treatments in three replications. The treatments included two factors, a) soil application of $FeSO_4$, and b) foliar application of $FeSO_4$. The variety of parching sorghum was PKV-Kartiki. The recommended doses of macronutrient fertilizers i.e. 80:40:40 N, P_2O_5, and K_2O kg ha^{-1} were applied commonly to all treatments. The N, P, and K were applied in the form of urea, single super phosphate, and muriate of potash. Iron was applied through the ferrous sulfate. The basal dose of nitrogen (half) and a full dose of phosphorus and potassium were applied at the time of sowing. The plant samples were collected and analyzed for nutrient composition. The green grain yield, green fodder yield, and partitioning yield of various plant parts i.e. leaf-stem, root, parching grain, and panicle straw were recorded. Leaf-stem, root, parching grain, and panicle straw were analyzed for their N, P, K, and micronutrients Fe content as per standard methods.

RESULT AND DISCUSSION

Productivity of parching sorghum

The significantly highest green grain (hurda) and green fodder yield of parching sorghum (Table 1) were recorded with the soil application of 30 kg $FeSO_4$ ha^{-1} i.e. 37.74 and 140.47 q ha^{-1} respectively which was found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 36.57 and 137.33 q ha^{-1} respectively and superior over control. These results conform with results of Wankhade *et al.,* (1996), Wanjari *et al.*, (2003) and Malakouti (2001)

The foliar spray application of 1.0% $FeSO_4$ at flowering stage i.e. 37.24 and 139.59 q ha^{-1} was recorded significantly highest green grain (hurda) and green fodder yield of parching sorghum which was found at par with foliar application of 0.5% $FeSO_4$ at flowering stage i.e. 35.48 and 134.71 q ha^{-1} respectively and superior over the control. An increase in the grain and straw yield of sorghum might be due to an increase in growth parameters and yield attributes, assimilation, and synthesis of

Table 1. Effect of soil and foliar application of iron on yield of parching sorghum (wet basis)

Treatments	Green Grain (Hurda) yield (q ha^{-1})	Green fodder yield
a) Soil application		
S_0 - 0 kg $FeSO_4$ ha^{-1}	31.87	128.86
S_1 - 10 kg $FeSO_4$ ha^{-1}	35.21	131.60
S_2 - 20 kg $FeSO_4$ ha^{-1}	36.57	137.33
S_3 - 30 kg $FeSO_4$ ha^{-1}	37.74	140.47
SE(m)±	0.87	2.46
CD at 5 %	2.56	7.23
(b) Foliar application		
F_0 -0.0 % $FeSO_4$ at flowering stage	33.33	129.40
F_1-0.5 % $FeSO_4$ at flowering stage	35.48	134.71
F_2 -1.0 % $FeSO_4$ at flowering stage	37.24	139.59
SE(m)±	0.75	2.13
CD at 5 %	2.22	6.26
c) Interaction	NS	NS

Table 2. Effect of soil and foliar application of iron on partitioning yield of parching sorghum (oven dry basis)

Treatments	Leaf-stem yield	Root yield	Parching grain yield	Panicle straw yield
	($q\ ha^{-1}$)			
a) Soil application				
S_0 - 0 kg $FeSO_4$ ha^{-1}	89.29	20.29	20.83	16.89
S_1 - 10 kg $FeSO_4$ ha^{-1}	92.86	22.88	21.03	18.45
S_2 - 20 kg $FeSO_4$ ha^{-1}	105.52	25.00	24.36	20.12
S_3 - 30 kg $FeSO_4$ ha^{-1}	110.90	27.86	25.21	21.31
SE(m)±	5.36	0.76	1.06	0.43
CD at 5 %	15.73	2.24	3.12	1.29
b) Foliar application				
F_0 -0.0 % $FeSO_4$ at flowering stage	89.86	22.68	21.03	18.14
F_1-0.5 % $FeSO_4$ at flowering stage	99.18	24.12	22.69	19.37
F_2 -1.0 % $FeSO_4$ at flowering stage	109.89	25.23	24.85	20.07
SE(m)±	4.65	0.66	0.92	0.38
CD at 5 %	13.63	1.94	2.71	1.11
c) Interaction	NS	NS	NS	NS

protein and chlorophyll. Similar findings were also recorded by Amanullah *et al.,* (2007) and Singh *et al.*, (2008). Interaction among the soil and foliar application of $FeSO_4$ was found non-significant in respect of green grain (hurda) and green fodder yield of parching sorghum.

Partitioning yield

The significantly highest leaf-stem yield, root yield, parching grain yield, and panicle straw yield of parching sorghum (Table 2) were observed with the soil application of 30 kg $FeSO_4$ ha^{-1} i.e. 110.90, 27.86, 25.21, and 21.31 q ha^{-1}, respectively which were found at par with soil application of 20 kg $FeSO_4$ ha^{-1} i.e. leaf-stem yield (105.52 q ha^{-1}), parching grain yield (24.36 q ha^{-1}) and panicle straw yield (20.12 q ha^{-1}) and superior over control. Similar results finding were noticed by Hadson *et al.* (1992). The significantly highest leaf-stem yield, root yield, parching grain yield, and panicle straw yield by parching sorghum were recorded with foliar application of 1.0% $FeSO_4$ spray at flowering stage i.e. 109.89, 25.23, 24.85, and 20.07 q ha^{-1} respectively which were found at par with foliar application of 0.5% $FeSO_4$ at flowering stage i.e. 99.18, 24.12, 22.69 and 19.37 q ha^{-1} respectively and superior over the control. This might be due to the application of Fe resulting in improved photophosphorylation during cell respiration; this may result in increased yield. Similar findings to the results were attributed by Whitty and Chambliss (2005) and Singh *et al.*, (2008). Interaction among the soil and foliar application of $FeSO_4$ was found non-significant in respect of leaf-stem yield, root yield, parching grain yield, and panicle straw yield by parching sorghum.

Nitrogen uptake

The higher N uptake was recorded in the leaf stem part over the root, parching grain, and panicle straw of parching sorghum (Table 3). The soil application of 30 kg $FeSO_4$ ha^{-1} was recorded significantly highest N uptake by leaf-stem (67.97 kg ha^{-1}), root (6.10 kg ha^{-1}), parching grain (38.29 kg ha^{-1}), and panicle straw (27.81 kg ha^{-1}) which were found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 65.21, 5.31, 36.08 and 25.66 kg ha^{-1}, respectively and superior over the control. However, the total uptake of nitrogen by parching sorghum (140.17 kg ha^{-1}) was recorded significantly highest with the soil application of 30 kg $FeSO_4$ ha^{-1} which was found at par with the 20 kg $FeSO_4$ ha^{-1} i.e. 132.26 kg ha^{-1}. The results conform with the findings of Keram *et al.* (2012).

The significantly highest N uptake by leaf-stem, root, parching grain, and panicle straw was observed with foliar application of 1.0% $FeSO_4$ spray at flowering stage i.e. 65.14, 5.02, 37.02, and 25.70 kg ha^{-1} respectively which were found at par with the foliar application of 0.5% $FeSO_4$ at flowering stage i.e. 58.16, 4.74, 33.54 and 24.72 kg ha^{-1} respectively and superior over the control. Whereas the foliar application of 1.0% $FeSO_4$ was noticed significantly highest total N uptake (132.88 kg ha^{-1}) by parching sorghum which was found at par with the foliar application of 0.5% $FeSO_4$ i.e. 121.16 kg ha^{-1} and superior over the control. This increased N uptake

Table 3. Effect of soil and foliar application of iron on N uptake by various plant parts of parching sorghum.

Treatments	Nitrogen uptake (kg ha^{-1})				
	Leaf-stem	Root	Parching grain	Panicle straw	Total
a) Soil application					
So - 0 kg $FeSO_4$ ha^{-1}	46.86	3.12	29.50	20.76	100.24
S1 - 10 kg $FeSO_4$ ha^{-1}	51.56	4.20	31.00	23.18	109.94
S2 - 20 kg $FeSO_4$ ha^{-1}	65.21	5.31	36.08	25.66	132.26
S3 - 30 kg $FeSO_4$ ha^{-1}	67.97	6.10	38.29	27.81	140.17
SE(m)±	4.63	0.44	1.86	0.72	5.85
CD at 5 %	13.58	1.29	5.46	2.12	17.16
b) Foliar application					
F0 - 0.0 % $FeSO_4$ at flowering stage	50.39	3.48	30.60	22.64	107.92
F1 - 0.5 % $FeSO_4$ at flowering stage	58.16	4.74	33.54	24.72	121.16
F2 - 1.0 % $FeSO_4$ at flowering stage	65.14	5.02	37.02	25.70	132.88
SE(m)±	4.01	0.48	1.61	0.63	5.07
CD at 5 %	12.03	1.44	4.73	1.83	14.86
(c) Interaction	NS	NS	NS	NS	NS

Table 4. Effect of soil and foliar application of iron on P uptake by various plant parts of parching sorghum

Treatments	Phosphorus uptake (kg ha^{-1})				
	Leaf-stem	Root	Parching grain	Panicle straw	Total
a) Soil application					
S_0 - 0 kg $FeSO_4$ ha^{-1}	58.83	9.23	13.49	15.70	97.26
S_1 - 10 kg $FeSO_4$ ha^{-1}	63.43	11.87	14.70	18.25	108.24
S_2 - 20 kg $FeSO_4$ ha^{-1}	75.47	12.96	18.59	20.72	127.73
S_3 - 30 kg $FeSO_4$ ha^{-1}	83.93	16.03	20.33	22.48	142.77
SE(m)±	4.38	0.94	1.04	0.73	4.88
CD at 5 %	12.84	2.74	3.05	2.13	14.32
b) Foliar application					
F_0 - 0.0 % $FeSO_4$ at flowering stage	61.75	11.27	14.94	17.68	105.63
F_1 - 0.5 % $FeSO_4$ at flowering stage	69.06	12.68	16.70	19.46	117.90
F_2 - 1.0 % $FeSO_4$ at flowering stage	80.44	13.62	18.69	20.71	133.47
SE(m)±	3.79	0.81	0.90	0.63	4.23
CD at 5 %	11.12	2.33	2.65	1.84	12.40
c) Interaction	NS	NS	NS	NS	NS

might be due to the increased dry matter production and the related concentration of nitrogen as iron helps in the formation of nucleic acid, protein synthesis and play an active role in several enzymatic activities helping in photosynthesis and respiration. The results are in close conformity with the findings of Pawar *et al.* (2015). Interaction of the soil and foliar application of $FeSO_4$ was found non-significant with N uptake by leaf-stem, root, parching grain, panicle straw, and total uptake in parching sorghum.

Phosphorus uptake

The significantly highest P uptake (Table 4) by leaf-stem, root, parching grain, and panicle straw were recorded with soil application of 30 kg $FeSO_4$ ha^{-1} i.e. 83.93, 16.03, 20.33, and 22.48 kg ha^{-1} respectively in which the effect of soil application of 20 kg $FeSO_4$ ha^{-1} was found at par with leaf uptake (75.47 kg ha^{-1}), parching grain uptake (18.59 kg ha^{-1}) and panicle straw uptake (20.72 kg ha^{-1}) and superior over the control. Whereas the total phosphorus uptake was noticed significantly highest with soil application of 30 kg $FeSO_4$ ha^{-1} (142.77 kg ha^{-1}) which was found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 127.73 kg ha^{-1} and superior over the control. It might be due to the precise application of fertilizers in the right quantity at right time to match with the crop demand which resulted in higher P content which further increased the P uptake. The results conform with the findings of Meena *et al.,* (2018) , Sahu *et al.,* (2010), and Rathod *et al.* (2005).

Effect of foliar application of $FeSO_4$ on phosphorous uptake by leaf-stem, root, parching grain, panicle straw, and total uptake was found significant. The foliar application of 1.0% $FeSO_4$ spray at the flowering stage was recorded significantly highest P uptake by leaf-stem (80.44 kg ha^{-1}), root(13.62 kg ha^{-1}) parching grain (18.69 kg ha^{-1}), panicle straw (20.71kg ha^{-1}), and total uptake (133.47 kg ha^{-1}) which was found at par with foliar application of 0.5% $FeSO_4$ at the flowering stage by leaf-stem (69.06 kg ha^{-1}), root(12.68 kg ha^{-1}), parching grain (16.70 kg ha^{-1}) and panicle straw (19.46 kg ha^{-1}) and superior over the control. Similar results finding by Pawar *et al.* (2015). Interaction among the soil and foliar application of $FeSO_4$ was found non-significant in respect of P uptake by leaf-stem, root, parching grain, panicle straw, and total uptake in parching sorghum.

Potassium uptake

The soil application of 30 kg $FeSO_4$ ha^{-1} showed significantly highest K uptake (Table 5) by leaf-stem (98.22 kg ha^{-1}), root (18.80 kg ha^{-1}), parching grain (17.24 kg ha^{-1}), and panicle straw(12.48) which were found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 89.64, 16.18, 15.36 and 11.28 kg ha^{-1} respectively and superior over the control. However, the total uptake of potassium (146.74 kg ha^{-1}) was recorded significantly highest with the soil application of 30 kg $FeSO_4$ ha^{-1} which was at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 132.45 kg ha^{-1}.

The significantly highest potassium uptake by leaf-stem (91.98 kg ha^{-1}), root (16.53 kg ha^{-1}), parching grain (15.24 kg ha^{-1}), and panicle straw (11.29 kg ha^{-1}) were observed with foliar application of 1.0% $FeSO_4$ spray at the flowering stage which was found at par with the foliar application of 0.5% $FeSO_4$ at flowering stage i.e. 79.75, 15, 13.14 and 10.53 kg ha^{-1} and superior over the control. Whereas the total uptake of P was recorded significantly highest (135.05 kg ha^{-1}) with foliar application of 1.0% $FeSO_4$ spray at the flowering stage which was found at par i.e. 118.42 kg ha^{-1} with the foliar application of 0.5% $FeSO_4$. Similar findings have been reported by Pawar *et al.* (2015). Interaction between the soil and foliar application of $FeSO_4$ was found non-significant with K uptake by leaf-stem, root, parching grain, panicle straw, and total uptake by parching sorghum.

Iron uptake

The Fe uptake (Table 6) by leaf-stem, root, parching grain, and panicle straw was observed significantly highest with soil application of 30 kg $FeSO_4$ ha^{-1} i.e. 466.31, 177.14, 317.90, and 133.42 g ha^{-1} respectively in which leaf-stem uptake (433.40 g ha^{-1}) and parching grain uptake (300.25 g ha^{-1}) were found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} and superior over the control. The Fe uptake was found more in leaf-stem over the other part i.e. root, parching grain, and panicle straw of parching sorghum. However, the total Fe uptake by parching sorghum(1094.77 g ha^{-1}) was recorded significantly highest with soil application of 30 kg $FeSO_4$ ha^{-1} which was found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 1003.23 g ha^{-1} and superior over the control. The increase in Fe uptake in the plant might be due to the soil and foliar application of iron which helped in direct absorption and translocation by the plant as a result of that higher accumulation

Table 5. Effect of soil and foliar application of iron on K uptake by various plant parts of parching sorghum

Treatments	Potassium uptake (kg ha^{-1})				
	Leaf-stem	Root	Parching grain	Panicle straw	Total
a) Soil application					
S_0 - 0 kg $FeSO_4$ ha^{-1}	63.93	11.71	9.42	8.12	93.18
S_1 - 10 kg $FeSO_4$ ha^{-1}	70.45	14.44	11.63	9.96	106.47
S_2 - 20 kg $FeSO_4$ ha^{-1}	89.64	16.18	15.36	11.28	132.45
S_3 - 30 kg $FeSO_4$ ha^{-1}	98.22	18.80	17.24	12.48	146.74
SE(m)±	6.02	1.00	1.75	0.68	6.62
CD at 5 %	17.66	2.94	5.13	2.01	19.42
b) Foliar application					
F_0 - 0.0 % $FeSO_4$ at flowering stage	69.95	14.32	11.85	9.56	105.67
F_1 - 0.5 % $FeSO_4$ at flowering stage	79.75	15.00	13.14	10.53	118.42
F_2 - 1.0 % $FeSO_4$ at flowering stage	91.98	16.53	15.24	11.29	135.05
SE(m)±	5.22	0.87	1.51	0.59	5.73
CD at 5 %	15.30	2.18	3.35	1.47	16.82
(c) Interaction	NS	NS	NS	NS	NS

Table 6. Effect of soil and foliar application of iron on Fe uptake by various plant parts of parching sorghum

Treatments	Iron uptake (g ha^{-1})				
	Leaf-stem	Root	Parching grain	Panicle straw	Total
a) Soil application					
S_0 - 0 kg $FeSO_4$ ha^{-1}	319.06	114.44	224.87	80.26	738.64
S_1 - 10 kg $FeSO_4$ ha^{-1}	354.53	135.11	242.73	94.55	826.92
S_2 - 20 kg $FeSO_4$ ha^{-1}	433.40	153.12	300.25	116.46	1003.23
S_3 - 30 kg $FeSO_4$ ha^{-1}	466.31	177.14	317.90	133.42	1094.77
SE(m)±	21.54	4.81	17.94	3.51	35.75
CD at 5 %	63.17	14.10	52.60	10.28	104.85
b) Foliar application					
F_0 - 0.0 % $FeSO_4$ at flowering stage	339.91	132.86	235.91	96.37	805.05
F_1 - 0.5 % $FeSO_4$ at flowering stage	392.54	145.14	270.80	107.03	915.51
F_2 - 1.0 % $FeSO_4$ at flowering stage	447.53	156.86	307.60	115.11	1027.10
SE(m)±	18.65	4.16	15.53	3.04	30.96
CD at 5 %	54.71	12.21	45.56	8.90	90.80
(c) Interaction	NS	NS	NS	NS	NS

of iron in the plant. Similar results are confirmed with findings of Wanjari *et al.*, (2003.

The foliar application of 1.0% $FeSO_4$ spray at the flowering stage was recorded significantly highest Fe uptake by leaf-stem (447.53 g ha^{-1}), root (156.86 g ha^{-1}), parching grain (307.60 g ha^{-1}), and panicle straw (115.11 g h^{-1}) was recorded with foliar application of 1.0% $FeSO_4$ spray at the flowering stage which was found at par with the foliar application of 0.5% $FeSO_4$ at the flowering stage by root uptake (145.14 g ha^{-1}), parching grain uptake (270.80 g ha^{-1}) and panicle straw uptake (107.03 g ha^{-1}) and superior over the control. Whereas, the foliar application of 1.0% $FeSO_4$ spray was recorded significantly highest total Fe uptake (1027.10 g ha^{-1}) in parching sorghum and superior over the control (805.05 g ha^{-1}). This may be attributed to significantly higher dry matter accumulation and related concentration of iron as a result of the application of higher doses of soil and foliar application of $FeSO_4$. These results are similar to Jokar and Ronaghi (2015), Sahrawat *et al.*, (1998), and Siddhamalai *et al.,* (1999). The interaction between the soil and foliar application of $FeSO_4$ was found non-significant with Fe uptake by leaf-stem, root, parching grain, panicle straw, and total uptake in parching sorghum.

Apparent use efficiency of iron

The apparent Fe use efficiency by parching sorghum grain (Table 7) was increased with increased soil application of iron up to 20 kg $FeSO_4$ ha^{-1} after that decreased even increased dose of $FeSO_4$ ha^{-1}. The highest apparent Fe use efficiency was observed with the soil application of 20 kg $FeSO_4$ ha^{-1} i.e. 3.60% followed by the soil application of 30 kg $FeSO_4$ ha^{-1} i.e. 2.74%.

Table 7. Apparent use efficiency of iron as influenced by various levels of iron

Treatments	Apparent Fe use efficiency (%)
Soil application	
S_0 - 0 kg $FeSO_4$ ha^{-1}	
S_1 - 10 kg $FeSO_4$ ha^{-1}	2.44
S_2 - 20 kg $FeSO_4$ ha^{-1}	3.60
S_3 - 30 kg $FeSO_4$ ha^{-1}	2.74

Conclusion

The soil application of $FeSO_4$ @ 20 kg ha^{-1}, soil application of $FeSO_4$ @ 30 kg ha^{-1}, and foliar spray of $FeSO_4$ @ 1.0% at the flowering stage were found equally beneficial for higher green grain yield, green fodder yield, and uptake of nutrients (N, P, K, Fe, Cu, Mn, and Zn) in parching sorghum.

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