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Research Article

PRODUCTIVITY AND QUALITY DYNAMICS OF PARCHING SORGHUM AS INFLUENCED BY SOIL AND FOLIAR APPLICATION OF IRON

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Abstract: The experiment was conducted in the research field of Sorghum Research Unit, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2020-21. The experiment was laid in Factorial Randomized Block Design (FRBD) with twelve treatments in three replications. The treatments Factor-A as containing four levels of soil application of $FeSO_4$ and Factor-B consist three levels of foliar application of $FeSO_4$. The variety of parching sorghum was PKV-Kartiki. The recommended dose of fertilizer *i.e*., 80:40:40 N, P_2O_5 and K_2O kg ha^{-1} were applied common to all treatments. The results revealed 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 flowering stage which were found to be at par with treatment of soil application of 20 kg $FeSO_4$ ha^{-1} and with the foliar application 0.5% $FeSO_4$ at flowering stage respectively. The reducing sugar, non-reducing sugar, total sugar, crude fiber, ash content, fat content and protein content of parching grain were found significantly 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 which were found at par with the soil application of 20 kg $FeSO_4$ ha^{-1} and with the foliar application of 0.5% $FeSO_4$ at flowering stage respectively.

Keywords: *Iron, Soil application, Foliar application, Productivity, Quality*

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Introduction

Sorghum [*Sorghum bicolor* (L.) Munch] is the known to the king of millets and it is a third important crop in the country after rice and wheat. In India, it is most popularly known as Jowar. It is a mainly used as the food, feed, fodder and ration for human, cattle and poultry. Sorghum has very good nutritional compositions. The grains contain high fiber, non-starchy polysaccharides and starch with some unique characteristics. Sorghum is a considerable variation in proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine and niacin [1,2].

Sorghum is gaining importance as 'health food' now a day's, because of its higher dietary fiber (7.6% to 9.2%). It contains 72.6 per cent carbohydrate, 10 to 12 per cent protein, 1.6 per cent mineral matter and 1.9 per cent fat. It is rich source of amino acids mainly lysine, thiamine, riboflavin and folic acid along with vitamin-B complex specially niacin (vitamin B6). It contains in high quantity of nitrogen (212 mg), starch (5.6 % to 7.3 %) along with copper, zinc and molybdenum. The protein four times in bran, germ fractions in sorghum grain and four times the lysine contains and two times arginine and glycine than endosperm protein of sorghum grain. Near about 27 per cent of India's population and 20 per cent of world population consume this sorghum millet as their principal food [3].

Iron is a constituent of a large number of metabolically active compounds like cytochromes heme and non heme enzymes and other functional metalloproteins such as ferrodoxin and haemoglobin. Role of iron is its catalytic function in biological oxidation and reduction in plants like oxidative photophosphorylation during cell respiration [4].

The role of iron in crop nutrition is well recognized as it is used for biosynthesis of plant auxins, nitrogen metabolism, oxidation-reduction reactions, which are considered to be necessary for plant growth and development, chlorophyll formation, photosynthesis, important enzyme system and respiration in plants. Results of multi-location investigation have revealed significant increases in grain and fodder yield of sorghum due to zinc, iron and boron fertilization [5-9].

Application of micronutrient fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. The amount of nutrient required is much higher compared to foliar application. Foliar application is widely used to apply micronutrients for many crops. Soluble salts are generally effective in foliar sprays. Deficiency symptoms could be corrected within the few by sprayed with the appropriate micronutrients source [10]. Foliar application of nutrients can be highly effective than soil application. This holds particularly true for micronutrients, which in general are required in minor amount compared with macronutrients. Effects are much rapid and more even compared to soil application, but supply is only temporary [11]. It has been well established fact that majority of nutrients are absorbed through the leaves of plants in foliar application and their absorption is remarkably rapid and complete. It has been observed that the effect of nutrient sprays is usually about the same as of soil application [12].

Materials and methods

The experiment was conducted in the research field of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during Kharif season of 2020-21. The experiment was laid in Factorial Randomized Block Design (FRBD) with twelve treatments in three replications. The treatments were Factor-A as soil application of $FeSO_4$ and Factor-B as foliar application of $FeSO_4$. The variety of parching sorghum was PKV-Kartiki. The recommended dose of fertilizer *i.e.*, 80:40:40 N, P_2O_5 and K_2O kg ha^{-1} were common 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 sulphate. The basal dose of nitrogen (half) and full dose of phosphorus and potassium were applied at the time of sowing. The grain samples were collected and analyzed for quality parameter determination as per standard methods. The crude fiber content was estimated by the Loss on ignition method given by Maynard (1970) [13].

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

Treatments	Green Grain (Hurda) yield	Green fodder yield
	q ha^{-1}	
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 reducing sugar, non-reducing sugar and total sugar in parching grain of parching sorghum*

Treatments	Reducing sugar (%)	Non Reducing sugar (%)	Total sugar (%)
a) Soil application			
S_0 - 0 kg $FeSO_4$ ha^{-1}	0.43	11.87	11.28
S_1 - 10 kg $FeSO_4$ ha^{-1}	0.48	12.03	11.54
S_2 - 20 kg $FeSO_4$ ha^{-1}	0.52	12.71	12.24
S_3 - 30 kg $FeSO_4$ ha^{-1}	0.53	12.94	12.41
SE(m)±	0.03	0.22	0.19
CD at 5 %	0.09	0.64	0.56
b) Foliar application			
F_0 - 0.0 % $FeSO_4$ at flowering stage	0.44	11.99	11.55
F_1 - 0.5 % $FeSO_4$ at flowering stage	0.52	12.55	11.96
F_2 - 1.0 % $FeSO_4$ at flowering stage	0.53	12.63	12.10
SE(m)±	0.01	0.19	0.16
CD at 5 %	0.03	0.55	0.48
c) Interaction	NS	NS	NS

Protein content was calculated by multiplying the total nitrogen per cent in grain sample by constant factor 6.25. The mineral matter content was estimated by using Muffle furnace by the loss on ignition method as suggested by AOAC (1965) [14]. Crude fat content was estimated by the Soxhlet extraction method as given by AOAC (1965). Reducing Sugar was estimated by the DNS method using spectrophotometer as described by Miller (1972) [15]. Total Sugar was estimated by the Anthrone method Using spectrophotometer given by Hodge & Hofreiter (1962) [16]. 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. The data subjected to statistical analysis as per Gomez and Gomez (1984) [17].

Result and Discussion

Yield of parching sorghum

The data indicated [Table-1] that the significantly highest green grain (hurda) and green fodder yield of parching sorghum 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 are in conformity with results of Wankhade *et al*., (1996), Wanjari *et al*., (2003) and Zairian and Malakouti (2001) [18].

The significantly highest green grain (hurda) and green fodder yield of parching sorghum was recorded with foliar application of 1.0 % $FeSO_4$ spray at flowering stage *i.e.*, 37.24 and 139.59 q ha^{-1} respectively 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. Increased in the grain and straw yield of sorghum might be due to an increase in growth parameters and yield attributes, assimilation and synthesis of protein and chlorophyll. Similar findings were also recorded by Amanullah *et al*., (2007) [19] and Singh *et al*., (2008) [20]. 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.

Quality of parching sorghum

Reducing sugar, non reducing sugar and total sugar

The data pertaining to effect of soil and foliar application of iron on reducing, non-reducing and total sugar of parching grain by parching sorghum was found significant which are presented in [Table-2].The reducing sugar (0.53%), non-reducing sugar (12.94%) and total sugar (12.41%) were recorded significantly highest with the 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.*, 0.52, 12.71 and 12.24 percent respectively and superior over the control. Kagne *et al*., (2008) [21] reported the similar findings that application of 80:40:40 NPK kg per ha recorded highest values of TSS, reducing sugar, non-reducing sugar and total sugar percentage of sweet sorghum juice.

The reducing sugar (0.53%), non-reducing sugar (12.63%) and total sugar (12.10%) were recorded significantly highest with foliar application of 1.0 % $FeSO_4$ at flowering which was found at par with the foliar application of 0.5 % $FeSO_4$ at flowering stage *i.e.*, 0.52, 12.55 and 11.96 percent respectively. This might be due to the role of iron in the biosynthesis of chlorophyll, respiration, chloroplast development which improves the performance of photosystems. It is an essential part of many enzymes. Iron take part in oxidation process that releases energy from sugars and starches and results convert nitrate to ammonium in plant. It plays an essential role in nucleic acid metabolism reported by Romheld and Marschner, (1991) [22]. Interaction of the soil and foliar application of $FeSO_4$ was found non-significant with reducing sugar, non-reducing sugar and total sugar in parching grain by parching sorghum.

Biochemical properties of parching grain

The data in relation to effect of soil and foliar application of iron on crude fiber, ash, protein and fat in parching grain are presented in [Table-3]. The effect of soil application of iron on crude fiber, ash and fat was found significant. The crude fiber (2.34 %), ash (5.17 %) and fat (1.82 %) were recorded significantly highest with the soil application of 30 kg $FeSO_4$ ha^{-1} found at par with the soil application

Table-3 *Effect of soil and foliar application of iron on crude fiber, ash, protein and fat in parching grain*

Treatments	Crude fiber	Ash	Protein	Fat
	(%)			
a) Soil application				
S_0 - 0 kg $FeSO_4$ ha^{-1}	1.82	3.85	8.85	1.60
S_1 - 10 kg $FeSO_4$ ha^{-1}	1.90	4.46	9.22	1.70
S_2 - 20 kg $FeSO_4$ ha^{-1}	2.22	4.80	9.22	1.81
S_3 - 30 kg $FeSO_4$ ha^{-1}	2.34	5.17	9.47	1.82
SE(m)±	0.03	0.05	0.15	0.04
CD at 5 %	0.10	0.16	NS	0.12
b) Foliar application				
F_0 - 0.0 % $FeSO_4$ at flowering stage	1.93	4.35	9.06	1.69
F_1 - 0.5 % $FeSO_4$ at flowering stage	2.08	4.65	9.22	1.74
F_2 - 1.0 % $FeSO_4$ at flowering stage	2.20	4.70	9.29	1.77
SE(m)±	0.028	0.05	0.13	0.034
CD at 5 %	0.084	0.14	NS	0.10
c) Interaction	NS	NS	NS	NS

of 20 kg $FeSO_4$ ha^{-1}. However, the soil application of 30 kg $FeSO_4$ ha^{-1} was recorded maximum protein content (9.47 %) followed by the soil application of 20 kg $FeSO_4$ ha^{-1} (9.22 %). The lowest fiber, ash, protein and fat content were recorded in control. A similar finding was reported by Ananda *et al*., (2005) [23], where the combined application of Zn and Fe each @ 25 kg ha^{-1} recorded significantly higher protein as compared to control. The crude protein content increased with combined application of nitrogen and micronutrients, reported by Verma *et al*., (2005). The effect of foliar application of iron on crude fiber, ash and fat was found significant. The foliar application of 1.0% $FeSO_4$ at flowering stage was recorded significantly highest crude fiber (2.20 %), ash (4.70 %) and fat (1.77 %) which were found at par with the foliar application of 0.5 % $FeSO_4$ at flowering stage. Whereas the numerically higher protein (9.29 %) was observed with the foliar application of 1.0% $FeSO_4$ followed by the foliar application of 0.5% $FeSO_4$ at flowering stage. The results are in close conformity with findings of Pawar *et al*. (2015) [24] who observed that $ZnSO_4$ + 15 kg $FeSO_4$ ha^{-1} through soil and foliar application along with recommended dose of NPK fertilizers resulted in improvement of quality parameters like crude protein, crude fiber, ash, organic matter, crude fat. The increased in fat might be due to balance nutrition of crop resulting in increased growth, development and photosynthetic activity. Ash and crude protein content were significantly influenced due to application of NPK along with micronutrients. Interaction among the soil and foliar application of $FeSO_4$ was found non-significant in respect of crude fiber, ash, protein and fat in parching grain of parching sorghum [25-29].

Conclusion

The soil application of $FeSO_4$ @ 20 kg ha^{-1} and soil application of $FeSO_4$ @ 30 kg ha^{-1} along with foliar spray of $FeSO_4$ @ 1.0 % at flowering stage were found equally beneficial for higher green grain yield, green fodder yield and quality parameters (Total sugar, reducing sugar, fat, crude fiber, ash content and protein) of parching sorghum.

Application of research: These research findings will be helpful to bio fortification of sorghum grain with the iron. Iron enriched food could be helpful to mitigate the malnutrition in tribes and poor people in India.

Research Category: Bio fortification, Nutrient management

Abbreviations: kg ha^{-1} kilograms per hectare; g kg^{-1} - grams per hectare

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Study area / Sample Collection: Sorghum Research Center, Dr P D K V, Akola

Cultivar / Variety / Breed name: PKV Kartiki

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