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Iron fortification combined with NPK on the grain yield of barnyard millet cultivars in *Typic Haplustalf* soil, Madurai district, Tamil Nadu

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Abstract
A field experiment was conducted in farmers's field at lalapuram village, Kallikudi block, Madurai District Tamil Nadu with test crop of barnyard millet during the Kharif season in the year 2018-19 in *Typic Haplustalf* soil to study the impact of NPK levels and iron fertilization on grain yield of barnyard millet cultivars. Twenty four treatment combinations were tested in factorial randomised design with two replications. Among the two barnyard millet cultivars (MDU-1, ACM-15-353), MDU-1 (2590 Kg ha^{-1}) produced significantly higher yield than the ACM-15-353 (2108 Kg ha^{-1}). Experimental results revealed that application of 100% $FeSO_4$ soil application + Foliar spray of 0.5% $FeSO_4$ and 125% soil application $FeSO_4$ + Foliar spray of 0.5% $FeSO_4$ along with 100% NPK produced higher grain yield in the both the cultivars. Iron management at the rate of 100% $FeSO_4$ (50 kg ha^{-1} soil application) + Foliar spray of 0.5% $FeSO_4$ at vegetative and panicle initiation stages (Fe_4) recorded 20% increase over Fe_1 (no iron) in MDU-1 with 100% NPK. While with 75% NPK, Fe_6 (125% $FeSO_4$ (62.5 kg ha^{-1} soil application) + Foliar spray of 0.5% $FeSO_4$ at vegetative and panicle initiation stage) recorded 14% increase over Fe_1 (no iron) in MDU-1. Percentage increases in yield of 22% was recorded under 100% NPK by Fe_6 (soil application of 125% $FeSO_4$ (62.5 kg ha-1) + Foliar spray of 0.5% $FeSO_4$ at vegetative and panicle initiation stages) in the ACM-15-353 cultivar, while at 75% NPK Fe_6 (soil application of 125% $FeSO_4$ (62.5 kg ha-1) + Foliar spray of 0.5% $FeSO_4$ at vegetative and panicle initiation stages) recorded maximum yield.

Keywords: Barnyard millet - NPK level- iron fertilization- foliar spray- grain yield

Introduction
Indian Barnyard millet [*Echinochloa frumentacea* (L.)] (2n=6x=54) is a multipurpose crop grown for food and fodder. Among minor millets barnyard millet is second most minor millet next to finger millet. In India, its cultivation is confined to Tamil Nadu, Andhra Pradesh, Karnataka and Uttar Pradesh (Channappagoudar, Hiremath, Biradar, Koti, & Bharamagoudar, 2010) [6]. Barnyard millet is cultivated up to an altitude of 2000 m above mean sea level and has a wide adaptation capacity. It is highly nutritious, non-glutinous and non-acid forming foods containing 11.2 gm proteins, 10.1gm crude fiber, 4.4 gm minerals and 15.2 mg iron in 100 gm seeds (Anonymous, 2010) [2]

Producing nutritious and safe foods sustainably and sufficiently is a vital intention of modern agriculture. Green revolution has made self-reliance in food grain production, but significantly heightened the demand on soil nutrition due to the improved production and productivity. The advanced crop production per unit area has resulted in greater exhaustion of soil available nutrients. Although iron is fourth abundant element in the earth crust, its bioavailability is poor because it forms insoluble complexes and fix in the soil organic and inorganic fractions in the aerobic soils under neutral and alkaline pH (Gómez-Galera *et al*., 2010) [9]. Iron is taken up as ferrous (Fe^{2+}) ions, where Fe exists in either the ferrous (Fe^{2+}) or ferric (Fe^{3+}) ionic state in soil. Iron is a transition metals exhibits two oxidation state- Fe(II) and Fe(III) – in plants play a essential role in nucleic acid metabolism, respiration, synthesis and maintenance of chlorophyll, photosynthesis, and DNA synthesis (Briat, 2011) [4].

Iron is an important component of enzymes and a constituent of non heme iron proteins involved in photosynthesis, N_2 fixation, and respiration. Iron is an essential micronutrient for both plants and human beings with numerous physiological functions. Soil conditions, leading to iron deficiency, or increasing the uptake of Fe are widespread in nature. Iron is an essential element for all plants and has many important biological roles in processes as diverse as photosynthesis, chloroplast development and chlorophyll biosynthesis. As an electron carrier, it is involved in oxidation-reduction reactions. It is involved in nitrogen fixation, photosynthesis and electron transfer. It is also a component of many enzymes and involved in respiratory enzyme systems as a part of cytochrome and hemoglobin. Iron is a major constituent of the cell redox systems such as heme proteins including cytochromes, catalase, peroxidase and leg-hemoglobin and iron-sulfur proteins including ferredoxin, acotinase and superoxide dismutase (SOD).

Since, as a rule, iron deficient plants are low in protein, it is supposed that as a primary reaction, protein metabolism may be inhibited and as a result chlorophyll is not stabilized. Iron is necessary in the oxidation step from coproporphyrinogen to protoporphyrinogen in chlorophyll synthesis. Fe2+ fraction of total Fe is responsible for green or chlorotic plants which is indispensable for chlorophyll synthesis (Katyal & Sharma, 1980) [12].

Material and Methods

A field experiment was conducted in farmers's field at Lalapuram village, Kallikudi block, Madurai District, Tamilnadu with branyard millet as test crop during Kharif season in the year 2018-19 to study the impact of NPK levels and iron fertilization on grain yield of barnyard millet cultivars. The experimental site is located at 9º41'N and 77º56' E longitude at an elevation of 215 meters above mean sea level. The experimental soil belongs to *Typic Haplustalf* according to USDA soil taxonomy, silty clay in texture with bulk density of 1.05 Mg m^{-3}, particle density of 2.2 Mg m^{-3}, pH of 7.23, EC of 0.25 dS m^{-1} and soil organic carbon of 4.93 g kg^{-1}. The cation exchange capacity of the soil was 42.2 C mol (p^+) kg^{-1}. The available N, P, K of the experimental soil was low, medium and high with a value of 210, 18.2 and 311 kg ha^{-1}, respectively. The DTPA extractable Fe, Zn, Cu & Mn in the experimental soil was 2.58, 0.88, 1.84 and 9.26 mg kg^{-1} respectively. The micronutrients were estimated through Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), at the Department of Soils and Environment, AC&RI, Madurai.

The experiment was laid out in FRBD design with three factors with unequal levels of factors. Factor G was two cultivars i.e. G_1- High Fe containing cultivars (Acm 17-353), G_2- medium Fe containing cultivars (MDU-1). Factor F was soil application of NPK levels (40:20:20 Kg/ha) i.e. F_1- 75% NPK level and F_2- 100% NPK level. Factor Fe was iron management Fe_1– No iron, Fe_2 – Foliar spray of 0.5% $FeSO_4$ at both vegetative and tillering stage, Fe_3–soil application of 100% $FeSO_4$ (@ 50 Kg/ha), Fe_4– soil application 100% $FeSO_4$ + Foliar spray of 0.5% $FeSO_4$ at both stages, Fe_5 – soil application 125% $FeSO_4$ (@ 62.5 Kg/ha), Fe_6 – 125% $FeSO_4$ + foliar spray of 0.5% $FeSO_4$ at both stages. In total 24 treatment were implemented (2*2*6=24) replicated twice in a plot size of 20 m^2 (5*4 m^2).

In order to evaluate the response of different levels of factors on yield of barnyard millet, the data were statistically analyzed using "Analysis of variance test". The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Gomez, Gomez, & Gomez, 1984) [10]. SAS software (SAS 8.0, USA) was used for all analyses.

Table 1: Grain yield of barnyard millet as affected by iron management with NPK levels

	G_1	G_2	F_1	F_2	G_1F_1	G_1F_2	G_2F_1	G_2F_2	MEAN
Fe_1	1893	2361	2036	2218	1812	1974	2260	2462	2127
Fe_2	2032	2482	2147	2367	1876	2187	2417	2548	2257
Fe_3	2095	2624	2223	2496	1932	2257	2514	2734	2359
Fe_4	2205	2733	2284	2654	2058	2351	2509	2957	2469
Fe_5	2161	2599	2272	2488	2037	2284	2507	2692	2380
Fe_6	2263	2738	2342	2659	2113	2413	2572	2904	2501
MEAN	2108	2590	2217	2480	1971	2244	2463	2716	2349

	G	F	Fe	G*F	F*Fe	G*Fe	G*F*Fe
SED	15	15	26	21	37	37	52
CD(0.05)	31	31	53	44	76	76	107

* G_1- ACM-15-353
G_2- MDU 1

*F_1 – Soil application of 75%NPK (Kg/ha)
F_2 – Soil application of 100%NPK (Kg/ha)

* Fe_1– No iron
Fe_2 – Foliar spray 0.5% $FeSO_4$
Fe_3– Soil application of 100% $FeSO_4$ (@ 50 Kg/ha)
Fe_4– 100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$ at vegetative & panicle initiation stages
Fe_5 – Soil application of 125% $FeSO_4$ (62.5 Kg/ha)
Fe_6 – 125% $FeSO_4$ + foliar spray of 0.5% $FeSO_4$ at vegetative & panicle initiation stages

Result and Discussion

The yield of the experimental crop are represented in the Table 1 with the grand mean yield of 2349 Kg ha^{-1}. Among the two ciltivars MDU-1 variety recorded significantly higher yield than the ACM-15-353 (Fig. a) with grand mean of 2590 and 2108 Kg ha^{-1} respectively. Among the NPK level 100% NPK reported significantly higher yield (2480 Kg ha^{-1}) than 75% NPK level (2217 Kg ha^{-1}) (Fig. b). Similar result where reported by Triveni, Rani, Patro, Anuradha, and Divya (2018) [13] in finger millet, Jyothi, Sumathi, and Sunitha (2016) in foxtail millet and Chouhan, Gudadhe, KUMAR, Kumawat, and Kumar (2015) [8] in pearl millet. Effect of iron management shows significant increase in grain yield. Among the iron management factor Fe_6 reported the highest yield (Fig. c) of 2501 Kg ha^{-1} followed by Fe_4 (2469 Kg ha^{-1}). The Fe_6 and Fe_4 were on par, followed by Fe_5 and Fe_3 which were on par with each other. The interaction effect between genotype and NPK level (Fig. d), genotype and iron management (Fig. e) reported non-significant impact on grain yield. The grain yield was significantly increased by interaction between the NPK level and the iron management. Among interaction between the NPK level and the iron management, 100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$ and 125% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$ along with 100% NPK level (Fig. f) were on par with each other. Followed by 100% $FeSO_4$ and 125% $FeSO_4$ along with 100% NPK level were on par result on grain yield. Similar result where reported by Aciksoz, Yazici, Ozturk, and Cakmak (2011) in wheat crops and Chaturvedi and Chandel (2005) in soybean. Three factor interaction significantly influenced the yield of the barnyard millet. Among the three factor interaction MDU-1 + 100% NPK + Fe_4 (100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$) showed highest yield of 2957 Kg ha^{-1}. Above result were on par with MDU-1 + 100% NPK + Fe_6 (125% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$). In the ACM-15-353 cultivar the 100% NPK + Fe_6 (125% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$) showed maximum yield of 2413 Kg ha^{-1} and the result were also showed on par with 100% NPK + Fe_4 (100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$). Among all treatment 75% NPK + no iron fertilization in the both the genotypes recorded lowest grain yield barnyard millet.

Conclusion

Iron deficiency is a growing public health problem in human populations, associated with reduced dietary Fe intake (Bouis & Welch, 2010; Cakmak, 2010). Based on the result presented in this study, it can be suggested that 100% NPK with Fe_4 (100% soil application of $FeSO_4$ + Foliar spray of 0.5% $FeSO_4$) and Fe_6 (125% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$) together represent important fertilizer management to contribute to the grain yield of the barnyard millet. The result presented here have important implication on the growing human population and human malnutrition.

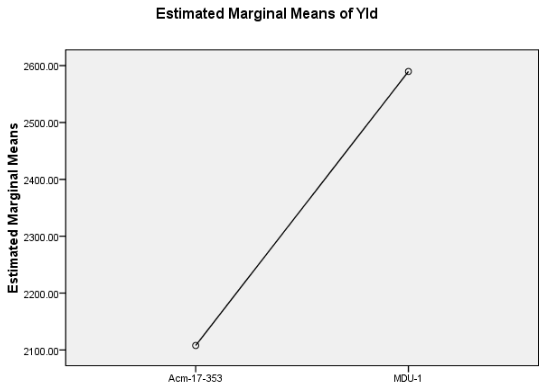

Fig. a

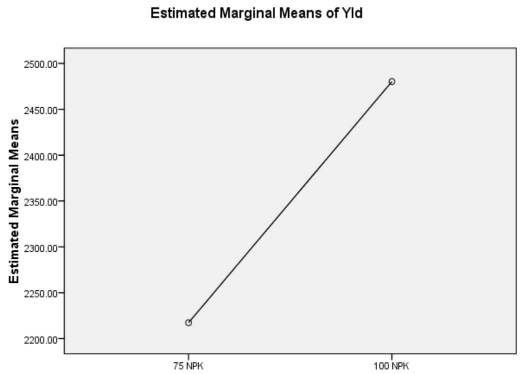

Fig. b

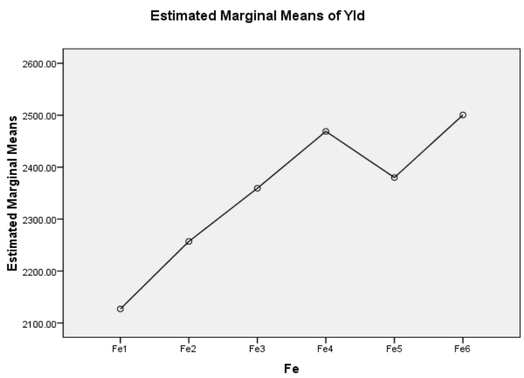

Fig. c

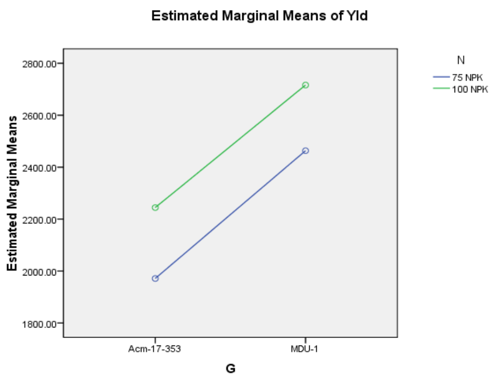

Fig. d

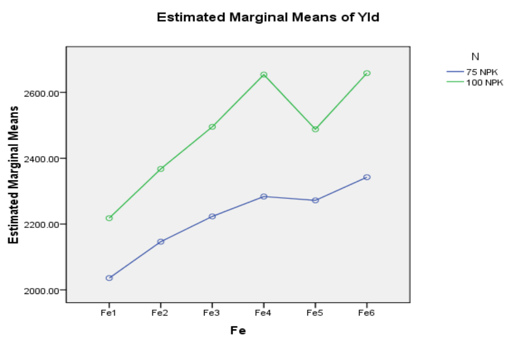

Fig. e

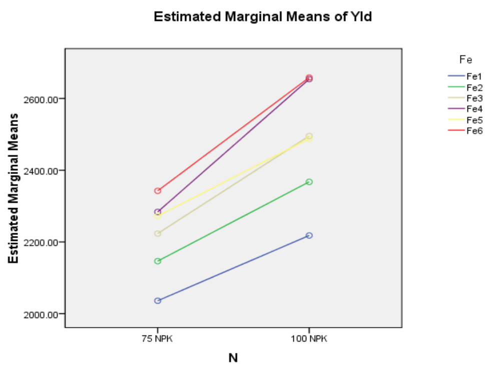

Fig. f

References

1. Aciksoz SB, Yazici A, Ozturk L, Cakmak I. Biofortification of wheat with iron through soil and foliar application of nitrogen and iron fertilizers. Plant and soil. 2011; 349(1-2):215-225. doi:10.1007/s11104-011-0863-2
2. Anonymous. Ministry of Agriculture Department of Agriculture and Cooperation. India: Status paper on millets Directorate of millets development, 2010.
3. Bouis HE, Welch RM. Biofortification—a sustainable agricultural strategy for reducing micronutrient

malnutrition in the global south. Crop Science. 2010; 50(1):S-20-S-32.
4. Briat JF. Iron nutrition and implications for biomass production and the nutritional quality of plant products. The Molecular and Physiological Basis of Nutrient Use Efficiency in Crops. 2011, 311-334.
5. Cakmak I. Biofortification of cereals with zinc and iron through fertilization strategy. Paper presented at the 19th World Congress of Soil Science, Brisbane, 2010.
6. Channappagoudar B, Hiremath S, Biradar N, Koti R, Bharamagoudar T. Influence of morpho-physiological and biochemical traits on the productivity of barnyard millet. Karnataka Journal of Agricultural Sciences. 2010; 20(3).
7. Chaturvedi S, Chandel A. Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (*Glycine max*). Indian Journal of Agronomy. 2005; 50(4):311-313.
8. Chouhan M, Gudadhe N, KUMAR D, Kumawat A, Kumar R. transplanting dates and nitrogen levels influences on growth, yield attributes, and yield of summer Pearl millet. The Bioscan. 2015; 10(3):1295-1298.
9. Gómez-Galera S, Rojas E, Sudhakar D, Zhu C, Pelacho AM, Capell T, Christou P. Critical evaluation of strategies for mineral fortification of staple food crops. Transgenic research. 2010; 19(2):165-180.
10. Gomez KA, Gomez KA, Gomez AA. Statistical procedures for agricultural research: John Wiley & Sons, 1984.
11. Jyothi KN, Sumathi V, Sunitha N. Productivity, nutrient balance and profitability of foxtail millet (*Setaria italica* L.) varieties as influenced by levels of nitrogen. Journal of Agriculture and Veterinary Science, 2016; 9(4):18-22.
12. Katyal J, Sharma B. A new technique of plant analysis to resolve iron chlorosis. Plant and soil, 1980; 55(1):105-119.
13. Triveni U, Rani YS, Patro T, Anuradha N, Divya M. Fertilizer responsiveness of short duration improved finger millet genotypes to different levels of NPK fertilizers. Indian Journal of Agricultural Research. 2018; 52(1).