Original Research Article

Evaluation of different doses and modes of application of ferrous ammonium sulfate for maximizing rice production

ABSTRACT

The field experiment on rice was carried out during the *Kharif* season 2021 at Agricultural Engineering Research Farm, JNKVV, Jabalpur (M.P.) to evaluate the effect of ferrous ammonium sulfate (FASt) on rice production. Eight treatments were applied, namely RDF- Recommended dose of fertilizer (N:P:K) (120:60:40), RDF + FASt at 15 kg/ha for soil application, RDF + FASt at 25 kg/ha for soil application, RDF + FASt at 35 kg/ha for soil application, RDF + 2 Spray of FASt 0.25% at 25 and 45 DAT, RDF + 2 Spray of FASt 0.50% at 25 and 45 DAT, RDF + 1 Spray of FASt 0.25% at 25 DAT, RDF + 1 Spray of FASt 0.50% at 25 DAT. The studies revealed that applying FASt to transplanted rice significantly increased grain yield over the control. All the growth parameters and yield attributes were found highest in the treatment soil application of ferrous ammonium sulfate (FASt) at 35 kg/ha with a recommended dose of fertilizer (RDF) and more effective comparatively foliar application of FASt at 0.25% and 0.50%. It recorded a maximum grain yield (5188 kg/ha) with a higher harvest index (38.85).

***Keywords**: Ferrous ammonium sulfate, Foliar application, recommended dose of fertilizer, Transplanted rice*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop of the world, feeding more than half of its population every day. Globally it is cultivated in an area of 161.28 million hectares with an annual production of 715.75 million tonnes. It accounts for about 42% of the country's total food grain production and 55% of cereal production. In Asia, about 90% of the rice is produced and consumed as a staple food [1, 2]. In India, rice contributes 45% to the total food grain production and is grown in an area of 44.1 million ha with a production of 106.64 million tonnes and productivity of 2.42 t/ha [3].

In Madhya Pradesh, it occupies an area of 2.29 ha with a production of 4.23 MT and productivity of 1847 kg/ha [4].

Most Indian soils are deficient in S, Zn, M, Cu, B, Fe and Mo. Rice crops under the Rice-Wheat cropping system (RWCS) struggle with iron and zinc deficiency. Iron chlorosis is most severe when the coarse-textured soils are brought into wider rice cultivation for the first time. Sometimes severe chlorosis due to Fe deficiency can lead to complete failure of the rice crop [5]. It happens even though the total iron content in soils is extraordinarily high. However, the amount of plant-usable iron is relatively low to moderate and depends on soil properties, cropping patterns and environmental conditions.

Sulfur is the fourth element essential for plant growth after nitrogen, phosphorus and potassium. It is involved in amino acid and protein synthesis, enzymatic and metabolic activities in plants, which account for approximately 90% of organic S in the plant [6,7]. The deficiency of sulfur is rising speedily in regions wherein constantly sulfur-free fertilizers like DAP and urea are being used. When S becomes limiting, adding N does not change plants' yield or protein level. Sulfur is needed early in the growth and development of rice plants. If it is limiting during the early growth period followed by tillering, finally, the yield will be reduced [8, 9].

Ammonium salts, which are used as nitrogen fertilizers in paddy fields, also impair the establishment of seedlings in submerged soil. It was the most detrimental among the major ammonium fertilizers for non-coated seeds in cold regions, although they did not discuss the possibility of sulfide ion generation as a cause of the impaired establishment associated with ammonium sulfate treatment [10]. One such product, which is the multi-nutrient fertilizer ferrous ammonium sulfate ($(NH4)_2 Fe(SO_4)_2.6H_2O$), claims to increase rice productivity. It is a crystalline water-soluble solid containing iron, nitrogen, and sulfur. It is used mainly in soils where iron is deficient, and the soil is neutral to alkaline. It eliminates iron chlorosis by enhancing chlorophyll synthesis and helps conditioning alkaline soils to allow the uptake of immobilized soluble micronutrient salts [11]. Hence, a study was undertaken to test ferrous ammonium sulfate's effect on rice growth and yield along with a recommended dose of fertilizer.

2. MATERIALS AND METHODS

The experiment was conducted at Agricultural Engineering Research Farm, JNKVV, Jabalpur (M.P.), during the *Kharif* season of 2021. The statistics on the weather conditions during the crop growing season of the ongoing study, including maximum weekly temperatures ranging from (26.8 to 35.7ºC) and minimum weekly temperatures ranging from (10.5 to 25.4ºC), maximum and minimum relative humidity morning (75 to 95 %) and evening (33 to 85 %), sunshine hours (0.2 to 9.0 hour) and total seasonal rainfall (462.1 mm) received with 43 rainy days. During the crop's entire growing period, the crop is exposed to a total of 118.2 hours of sunlight. All the treatments were arranged in a randomized block design with eight treatments and three replications. Total eight treatments, comprising RDF- Recommended dose of fertilizer (N:P:K) (120:60:40), RDF + FASt at 15 kg/ha for soil application, RDF + FASt at 25 kg/ha for soil application, RDF + FASt at 35 kg/ha for soil application, RDF + 2 Spray of FASt 0.25% at 25 and 45 DAT, RDF + 2 Spray of FASt 0.50% at 25 and 45 DAT, RDF + 1 Spray of FASt 0.25% at 25 DAT, RDF + 1 Spray of FASt 0.50% at 25 DAT. The soil was clay loam in texture, having 0.58% organic carbon, low in available nitrogen (238.14 kg/ha), medium in phosphorus (16.17 kg/ha), rich in available potassium (305.12 kg/ha) and neutral in reaction (pH 7.1) with normal electrical conductivity. The gross plot size was 5.0 m × 4.0 m. Dry seeds of the Kranti variety were sown in the bed and covered with FYM. Irrigation was applied to ensure proper germination of seeds in a nursery bed. In all plots, two seedlings per hill were manually transplanted at a planting geometry of 20 cm × 15 cm when they were 25 days old. Urea, single super phosphate, and muriate of potash were used to apply the recommended doses of plant nutrients at 120:60:40 NPK kg/ha, respectively. A spray of ferrous ammonium sulfate has been done by making a solution of 500 g FASt in 100 litres of water for 0.50% concentration. For 0.25% concentration, 250 g of FASt in 100 litres of water should be dissolved. After that, spray with the help of a knapsack sprayer was done at 25 and 45 DAT. The data from the various observations were tabulated for statistical analysis, and the analysis of variance (ANOVA) method was applied to analyze the data statistically. The F test was then used to evaluate the treatment. A critical difference (CD) was computed for each character at a 5% level of significance to assess the differences between treatment means. The data on weed population and dry weight were square roots transformed, i.e., $\sqrt{x+0.5}$, before analyzing variance, and only transformed values were compared.

3. RESULTS AND DISCUSSION

3.1 Growth parameters

The present results show the effect of different doses and modes of application of FASt on plant height, tillers per hill, dry weight per hill, and leaf area index (**Table 1**). Significant differences were noticed among the treatments regarding plant height at 60 DAT. The treatment, which consisted of soil application of FASt at 35 kg/ha with RDF, registered the highest plant height (105.5 cm); however, it was found at par with treatment, which received RDF with 2 foliar applications of FASt at 0.50% at 25 and 45 DAT. Because foliar application of micronutrient significantly increased the plant height which might be attributed to the adequate supply of micronutrient, contributed to accelerate the enzymatic activity and auxin metabolism in plants [12]. While control plot, which received only RDF, recorded the lowest plant height (82.1 cm) among all the treatments. Similar results were reported by [13].

Significant variation was found among different treatments in the case of number of tillers per hill due to different levels of FASt at 60 DAT. The minimum number of tillers (7.9/hill) occurred under controlled plot due to the non-availability of micronutrient, where only RDF was given. However, soil application of FASt at 15 kg/ha with RDF treatment marginally increases the number of tillers. The treatment, which received soil application of FASt at 35 kg/ha with RDF bears maximum tillers (10.4/hill) and proved significantly superior over all the treatments. This might be due to improved metabolic activity with micronutrients that enhanced the floral primordia development in many tillers. [14] also made similar observations.

FASt nutrition significantly influenced the dry matter production of rice at 60 DAT. The controlled plot received only RDF, producing the least amount of dry matter (42.8 g/hill). However, the soil application of FASt at 35 kg/ha with RDF produced the maximum amount of dry matter production (54.8 g/hill), and it was outperformed among all the treatments, and it was at par with the foliar application of 2 sprays of 0.50% FASt at 25 and 45 DAT along with the RDF. The enhanced availability of nutrients, especially iron, might have led to a better accumulation of photosynthates in the form of dry matter. Application of sufficient amount of NPK nutrients along with ferrous sulphate could have enhanced the photosynthetic activity of the crop and ultimately the dry matter production. Our results closely conform to those of [15].

The leaf area index (LAI) at 60 DAT was significantly influenced by different treatments. The treatment, which consisted of soil application of FASt at 35 kg/ha with RDF, recorded the maximum LAI (4.02) and outperformed all the treatments. However, it was found at par with treatment which received RDF with 2 foliar applications of FASt at 0.50% at 25 and 45 DAT. While control plots recorded a minimum LAI (3.72), supplemented with RDF only due to absence of micronutrients (FASt). Our results confirm the findings of [16, 17].

Table 1. Effect of different doses and modes of application of FASt on growth parameters of rice at 60 DAT

Treatments	Plant height (cm)	Tillers/hill	dry weight/hill (g)	Leaf area index
RDF- Recommended dose of fertilizer	82.1	7.9	42.8	3.72
RDF + FASt @ 15kg/ha for soil application	86.8	8.6	43.7	3.82
RDF + FASt @ 25kg/ha for soil application	95.4	9.7	48.8	3.89
RDF + FASt @ 35kg/ha for soil application	105.5	10.4	54.8	4.02
RDF + 2 Spray of FASt 0.25% at 25 and 45 DAT	100.8	9.2	47.6	3.91
RDF + 2 Spray of FASt 0.50% at 25 and 45 DAT	103.3	9.4	50.2	3.94
RDF + 1 Spray of FASt 0.25% at 25 DAT	99.8	8.6	43.5	3.83
RDF + 1 Spray of FASt 0.50% at 25 DAT	100.2	8.8	45.4	3.87
CD (P=0.05)	4.34	0.42	5.51	0.05

3.2 Yield attributes and grain yield

Effective tillers per hill, grains per panicle, grain yield, and harvest index were affected by different doses and modes of application of ferrous ammonium sulfate (**Table 2**). The number of effective tillers per hill was found to increase significantly with an increase in the levels of FASt. Treatment having RDF application only recorded a minimum number of effective tillers (7.0/hill), which were increased in plots getting either soil or foliar application of FASt. However, soil application of FASt at 35kg/ha with RDF recorded maximum effective tillers (10.1/hill). It proved significantly superior over all the doses of FASt because FASt increases plants nutrient uptake capacity and makes them macronutrients available through the chelation process. Also iron reduces chlorosis in plant and induces the photosynthetic process which result in more tillers. Similar results were noted by [18].

The number of grains per panicle was significantly affected by different levels of FASt. The highest number of grains per panicle was noticed in soil application of FASt at 35 kg/ha with RDF treatment (178), followed by RDF + 2 Spray of FASt 0.50% at 25 and 45 DAT. These might be due to better translocation of accumulated photosynthates to the sink because iron help in the photosynthesis process. However, the lowest number of grains per panicle was found in the controlled plot, which is applied with RDF only (141). These results might be due to better translocation of accumulated photosynthates to the sink because iron help in the photosynthesis process. These results follow the findings of [19, 20].

There was a positive response in attaining increased grain yield of rice with different FASt graded levels. Maximum grain yield (5188 kg/ha) was recorded under soil application of FASt at 35kg/ha with RDF and proved significantly superior over the rest of the treatments. Moreover, the soil application of 25 kg FASt with RDF and 2 sprays of 0.50% of FASt at 25 and 45 DAT with RDF proved statistically equally good for grain yield. It may be due to better improvement in growth and yield parameters through adequate availability of primary and micronutrients in soil, which favorably influenced physiological processes and the build-up of photosynthates. While the lowest grain yield (3269 kg/ha) was recorded in treatment, which consisted of RDF only due to non-availability of micronutrient, resulting in poor growth parameters and yield attributing traits and finally grain yield was reduced. This result was conformity with those of [21, 22].

The harvest index of rice was significantly influenced by micronutrient management practices to a considerable extent. The lowest harvest index was recorded at a controlled plot consisting of RDF only (33.33%), and the highest harvest index associated with soil application of FASt at 35 kg/ha with RDF (38.85%) indicated the optimum vegetative growth and better source-sink relationship [23].

Table 2. Effect of different doses and modes of application of FASt on yield attributes and yield of rice

Treatments	Effective tillers/hill	Grains/panicle	Grain yield (kg/ha)	Harvest index
RDF- Recommended dose of fertilizer	7.0	141	3269	33.33
RDF + FASt @ 15kg/ha for soil application	8.4	152	4381	38.01
RDF + FASt @ 25kg/ha for soil application	8.8	164	4632	38.66
RDF + FASt @ 35kg/ha for soil application	10.1	178	5188	38.85
RDF + 2 Spray of FASt 0.25% at 25 and 45 DAT	8.6	163	4451	38.04
RDF + 2 Spray of FASt 0.50% at 25 and 45 DAT	8.8	165	4620	38.54
RDF + 1 Spray of FASt 0.25% at 25 DAT	8.3	154	4322	37.88
RDF + 1 Spray of FASt 0.50% at 25 DAT	8.5	158	4390	37.68
CD (P=0.05)	0.23	6.53	254.04	-

The optimal dose and time of ferrous ammonium sulfate fertilization for the cultivation of rice and other crops in the tropics can vary widely according to weather conditions [24, 25, 26]; and soil [27, 28]. Based on research and field tests carried out more than ten years ago, the appropriate fertilization strategies were established for conventional rice plantings currently used in countries with a tropical climate, as well as in other crops such as corn [29], tomato [30], potato [31], Onion [32] and bananas [33, 34, 35].

4. CONCLUSION

It was concluded that soil application of ferrous ammonium sulfate (FASt) at 35 kg/ha with a recommended dose of fertilizer (RDF) was found suitable for enhancing the growth and grain yield of rice with a higher value of harvest index.

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