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Effect on foliar nutrition of micro nutrients on growth attributes in transplanted rice (*Oryza sativa* L.)

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Abstract
During the samba season (September, 2022 - February, 2023), a field experiment was carried out at Annamalai University Experimental Farm, Department of Agronomy, to study the influence of foliar application of micro nutrients on growth parameters of transplanted rice. BPT 5204, a medium-duration rice variety, is chosen for the investigation. Eight treatments spread across three replications comprised the Randomized Block Design (RBD) layout of the field experiment. The treatments included various nutrient management techniques, such as 100% RDF (T_1), 100% RDF + foliar $ZnSO_4$ application at 0.5% (T_2), 100% RDF + foliar Borax application at 0.25% (T_3), and 100% RDF + foliar silicon application at 1% (T_4),100% RDF + $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1% (T_5), 100% RDF + $ZnSO_4$ @ 0.5% + Silicon @ 1% (T_6), 100% RDF + Borax @ 0.25% + Silicon @ 1% (T_7) and 100% RDF + $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1% (T_8). The application of the 100% recommended dosage of fertilizer plus foliar application of $ZnSO_4$ @ 0.5% + borax @ 0.25% + silicon @ 1% can be concluded based on the experimental results (T_8) remarkably boost the productivity and profitability of rice. Hence this treatment was considered to be the most efficient way to enhance the yield of transplanted rice.

Keywords: Rice, foliar nutrition, $ZnSO_4$, borax and silicon

Introduction
Rice (*Oryza sativa* L.) is the most significant cereal crop in the world and a staple food for over half of world population. Of all the grains produced, rice accounts for 42% and cereals for 45% of production. As per Sekhara and Devarajulu (2019) [11], the majority of India's farming population is employed by the paddy crop. The world produces 514.6 million tonnes of rice annually with a productivity of 4.60 t ha^{-1} on an area of 166.91 million hectares. As per USDA (2022) [16] South East Asia's rice productivity is 4.41 t ha^{-1}. India comes in second place to China in terms of both production and consumption of rice. With an annual production of 130.29 Mt and a productivity of 2.80 t ha^{-1}, rice is grown on 46.38 million ha in India and 3.6 t ha^{-1} of productivity and 8.07 Mt of production are achieved by cultivating rice on 2.21 million hectares in Tamil Nadu (DES, 2021) [2].

Micronutrients can be applied through a variety of techniques, including soil application, foliar application, seed priming, and fortification; however, foliar application is thought to offer greater advantages than other approaches. Foliar application is applied to established crop stands at various stages of crop growth. When micronutrients are applied to plants, their physiological processes are improved, which leads to increased growth and the production of dry matter. The most efficient way to apply nutrients to plants is through foliar application, which removes soil barriers and leaching losses that arise from applying fertilizers through soil (Fageria *et al*., 2015) [3]. Foliar nutrition application, which greatly increases the rice growth, and other yield attributes which ultimately results in higher yield (Saikh *et al*., 2022 and Tuiwong *et al*., 2022) [10, 15].

Zinc is considered the fourth major nutrient in India after nitrogen, phosphorus and potassium. Therefore, maintaining appropriate zinc transport to seeds, maintaining a sufficient amount of available zinc in soil solution, and increasing crop yield all depend on the application of zinc fertilizers. One of the components necessary for the growth and development of plants is boron (B). In addition to improving total chlorophyll content and plant height, Boron is primarily involved in cell wall biosynthesis and the structure and integrity of the plasma membrane (Songsriin *et al.*, 2023) [13]. The second most abundant element on Earth's surface, silicon (Si) is important for improving crop productivity and granting biotic and abiotic stress resistance (Aroubandi, 2017) [1]. With the aforementioned information in mind, the current study examined the impact of foliar nutrient application on transplanted rice.

Materials and Methods

During the Samba season (September, 2022 - February, 2023), a field experiment was carried out at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, to determine the impact of foliar nutrient application in transplanted rice. Using the medium duration variety BPT 5204, the field experiment was set up in a Randomized Block Design (RBD) with eight treatments spread across three replications. The treatments included the following: 100% RDF (T_1), 100% RDF + foliar application of $ZnSO_4$ @ 0.5% (T_2), 100% RDF + foliar application of Borax @ 0.25% (T_3), 100% RDF + foliar application of Silicon @ 1% (T_4), 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.25% (T_5), 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Silicon @ 1% (T_6), 100% RDF + foliar application of Borax @ 0.25% + Silicon @ 1% (T_7), and 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @% + Silicon @ 1% (T_8). Applying foliar spray at 25 and 45 DAT with a spray volume of 500 lit ha^{-1} using a hand-operated backpack sprayer, $ZnSO_4$ @ 2.5 kg ha^{-1}, Borax @ 1.25 kg ha^{-1}, and Silicon @ 5 kg ha^{-1} were carried out in accordance with the treatment schedule. Randomly chosen five representative plants were marked with a peg for periodic observations in each treatment plot. From the experimental field, random composite pre-sown soil samples were taken from 0 to 30 cm depth. Kg ha^{-1} is used to express values. Chopped and finely powdered were the oven-dried plant samples that were used to estimate the production of dry matter. In order to make statistical inferences for results that were significant, the critical difference was calculated at the 5% probability level.

Results and Discussion

Growth Parameters

The data regarding growth parameters recorded at the different growth stages of rice crop are discussed in table 1.

Application of 100% RDF + foliar $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1% (T_8) recorded a significantly higher plant height of 115.97 cm at harvest stage among the treatments. The control (T_1) plants had the lowest plant height, measuring 91.52 cm at rice harvest stages. The improvement in growth attributes may be the result of applying nutrients foliar at key stages to ensure optimal and consistent availability of NPK and micronutrients throughout the rice growth phase. Phosphorus, potassium, and nitrogen are associated with various aspects of plant growth, including increased photosynthetic activity, cell enlargement, carbohydrate synthesis, and solute translocation (Gewally *et al*., 2018) [4].

According to Meena *et al*. (2019) [8], the production of more long, erect leaves with a larger surface area was caused by the increased availability of mineral nutrients in the soil and the increased uptake of nutrients by the plant. This ultimately led to an increase in grow parameters. Furthermore, zinc application can be advantageous for cell elongation and division. This has been shown to increase net photosynthetic rate and chlorophyll content, which in turn affects plant height and leaf area index (LAI) (Sudha and Stalin, 2015) [14].

The application of 100% RDF + foliar application of ZnSo4 @ 0.5% + Borax @ 0.25% + Silicon @ 1% resulted in the highest number of tillers $hill^{-1}$ of 12.48 at maximum tillering stage (T_8). At the maximum tillering stage, T_1 (control) registered the lowest tillers $hill^{-1}$ of 7.11. This could be because zinc application influences chemical reactions like nucleotide synthesis, auxin metabolism, and enzyme activity of which have a positive impact on tiller production in plants (Soltani *et al*., 2020) [12]. Also, it could be due to the sustained availability of zinc and other micro nutrients that might have taken part in crop nourishment and enhanced the activity of meristematic cells and cell elongation, leading to better vegetative growth (Nandini *et al*., 2022) [9].

The application of 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1%, the highest dry matter production of 12586 kg ha^{-1} was achieved at harvest (T_8). The treatment T_1 (Control) produced the lowest dry matter of 9207 kg ha^{-1}. Applying 100% RDF along with foliar ZnSO4 at 0.5% Borax at 0.25% and Silicon at 1% (T_8) resulted in the highest LAI of 6.34 during the flowering stage. Micronutrients may increase the amount of leaf area on a plant, which in turn increases photosynthetic rate and prevents chlorophyll from being destroyed, ultimately leading to a higher DMP in rice. Additionally, silicon-induced leaf erectness can lead to increased photosynthesis, better water usage, decreased transpiration, and eventually an accumulation of more dry matter and an increase in leaf area, which could account for more DMP (Jinger *et al*., 2022) [6]. The increased photosynthetic and metabolic activity during the flowering stage, which causes an increase in various plant metabolic pathways responsible for cell division and elongation, may be the cause of the improvement in total dry matter with B application (Kumar *et al*., 2015) [7].

At flowering to harvest, the treatment of 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1% (T_8) resulted in the maximum CGR (table 1) of 4.63 g m^{-2} day^{-1}. The enhanced dry mater production and leaf area index following NPK and micronutrient application may be the cause of the increase in crop growth rate (CGR) similar findings reported with wader *et al*. (2013) [17]. Increased crop growth rates under micronutrient conditions may be attributed to zinc's significant contribution to photosynthesis, which increases leaf expansion and enhances plant growth when combined with other micronutrients (Jat *et al*., 2011) [5].

Table 1: Effect of foliar application of nutrients on growth parameters in transplanted rice

Treatments	Plant height at Harvest	Number of tillers m^{-2}	DMP at Harvest	CGR at 60-140 DAT	LAI
T_1 - 100% RDF	91.52	7.11	9207	3.38	4.16
T_2 - 100% RDF + foliar application of $ZnSO_4$ @ 0.5%.	103.54	9.61	10977	3.99	5.19
T_3 - 100% RDF + foliar application of Borax @ 0.25%	96.83	8.02	10064	3.69	4.62
T_4 - 100% RDF + foliar application of Silicon @ 1%.	98.28	8.45	10267	3.71	4.76
T_5 - 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.25%	109.31	10.98	11826	4.41	5.68
T_6 - 100% RDF + foliar application of Borax @ 0.25% + Silicon @ 1%	104.12	10.05	11169	4.07	5.32
T_7 - 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Silicon @ 1%	110.72	11.27	11955	4.46	5.87
T_8 - 100% RDF + foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.25% + Silicon @ 1%	115.97	12.48	12586	4.63	6.34
S. Ed±	2.30	0.25	289.62	0.12	0.12
CD (P=0.05)	4.89	0.54	614	0.26	0.25

Conclusion

According to the experimental findings, rice productivity and profitability are significantly increased by treatment T_8 (100% RDF + foliar application of $ZnSO_4$ at 0.5% + Borax at 0.25% + Silicon at 1%). Hence this practice is recommend to the farmers for getting higher productivity in transplanted rice.

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