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Consequences of nano N, P, K and $ZnSO_4$ fertilizers on growth and yield of rice production

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Abstract
The field experiment was carried out in the farmer's field, Vittukkatti village, Thiruthuraipoondi Taluk, Thiruvarur district, during June – October 2020 to assess the effect of Nano N, P, K and $ZnSO_4$ on rice production. The experiment was laid out in Randomized Block Design (RBD) with nine treatments *viz*., T_1-control,T_2-100% RDF (120: 40:40 N, P, K kg ha^{-1}), T_3-100% Nano N, P, K (25 kg ha^{-1}),T_4-75% RDF + 25% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application),T_5-75% RDF + 25% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application),T_6-50% RDF + 50% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1}(soil application),T_7-50% RDF + 50% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application),T_8-25% RDF + 75% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1}(Soil application),T_9-25% RDF + 75% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application)replicated thrice. The experiment results proved that the combined application of conventional and Nano N, P, K along with the different methods of $ZnSO_4$ application significantly influenced most of the growth and yield parameters of rice. Among the different treatments tried, application of 50% RDF + 50% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1}(T_6) was showed supremacy on improving growth components (plant height (95.2 cm), number of tiller $hill^{-1}$ (25), leaf area index (5.96), dry matter production (13893 kg ha^{-1}), crop growth rate (5.92)) and yield attributes (productive tillers (375), number of filled grains $panicle^{-1}$(127)). The lowest values of plant height (71.4cm) at harvest stage, productive tillers m^{-2} (176), number of filled grains $panicle^{-1}$ (98) were observed in control. Improved growth and yield parameters enhanced the yield of rice with the application of 50% RDF + 50% Nano N, P, K and $ZnSO_4$ soil application @ 25 kg ha^{-1}(T_6) with the higher grain yield of 7635 kg ha^{-1} and straw yield of 8609 kg ha^{-1}. It can be concluded that the continuous application of Nano and conventional fertilizers improved the plant growth and yield of rice significantly.

Keywords: conventional, foliar application, nano fertilizers and $znso_4$

Introduction
Rice (*Oryza sativa* L.) is the most important staple food for more than half of the world's population. It is the most important crop concerning nutrition and caloric intake. India is the second-largest producer of rice after China and being the stable food, rice plays a vital role in India's economy occupying a central position in shaping the agricultural policy (Dangwal *et al*., 2010) [5]. In Tamilnadu rice is grown in an area of 18.04 lakh hectares with a production of 63.08 lakh metric tonnes and an average productivity of 2.8 tonnes ha^{-1} (USDA report. 2020) [18].

The plants require more nutrients during growth stages to enhance their growth, productivity and quality especially after the introduction of high yielding and fertilizers responsive varieties (Ghasemi *et al*. 2017) [7]. These nutrients are provided as mineral fertilizers prepared in an ideal concentration of macro and micronutrients. To providing accessible macronutrients such as nitrogen, phosphorus, potassium and micronutrients to meet the requirement of the plant large quantities of mineral fertilizer to be sufficient for its growth development and grain production. However, fertilizers are the main input to increase agriculture production and productivity of the soil. Plants require a certain amount of nutrients in a specific form which should be added in time for their growth and development (Sharma *et al*., 2017). The use of conventional fertilizers causes major environmental problems such as heavy metal accumulation in soil and plant systems (Abdel *et al*. 2017) [1] where, Nano fertilizers can be used in a significant way to supply nutrients to crop, compared to conventional fertilizers, also Nano fertilizers minimizes nutrient loss through leaching with improves fertilizer use efficiency (Subbaro *et al*. 2013). Further, Nano fertilizers provide major nutrients to crops as requires in a phased manner as it contains (Manikandan and Subramanian. 2016) [9]. Very little information exists on the application of zinc fertilizers in the form of $ZnSO_4$ applied to soil and foliar application of these materials on rice crops under field conditions. Realizing the importance of zinc in plant growth and development along with NPK in a different form the current experiment was carried out to study the effect of Nano N, P, K and $ZnSO_4$ on rice growth and yield by reducing the usage of conventional fertilizers.

Materials and method
The field experiment was carried out in a farmer's field at Vittukatti village, Thiruthuraipoondi Taluk, Thiruvarur District, Tamil Nadu during 2020, to investigate the response of Nano N, P, K and $ZnSO_4$ application on rice production. The experiment field is geographically situated at 10°33′ North Latitude and 79°37′ East Longitude and an altitude of +6 m above mean sea level. The experiment farm is characterized by a tropical climate with a mean annual rainfall of 323.1 mm. The soils of the experiment field were

clay loam in texture. The available nutrient status (N, P, K) of the soil was low, medium and high respectively. The experiment was conducted during the kuruvai season (July-Oct 2020), with a short duration rice variety CO-51 as the test crop. The experiment was laid out in Randomized Block Design (RBD) with 9 treatments combination, replicated thrice and experimental plots were laid out with dimension as gross plot area (5.1 m × 4 m) and net plot area (4.5 m ×3.6 m). The treatments *viz*., T_1-control,T_2-100% RDF (120: 40:40 N, P, K kg ha^{-1}), T_3-100% Nano N, P, K (25 kg ha^{-1}),T_4-75% RDF + 25% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application),T_5-75% RDF + 25% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application),T_6-50% RDF + 50% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1}(soil application),T_7-50% RDF + 50% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application),T_8-25% RDF + 75% Nano N, P, K + $ZnSO_4$ @ 25 kg ha^{-1}(Soil application),T_9-25% RDF + 75% Nano N, P, K + $ZnSO_4$ @ 0.5% (foliar application). 21 days old seedlings were transplanted to the main field as per the transplanting method with the spacing of 10×15 cm with 3 seedlings per hill at 2cm depth. The recommended dose of nutrients 120:40:40 N, P_2O_5, K_2O kg ha^{-1} was applied through both conventional fertilizers (urea, DAP, and MOP) and granular forms of Nano N, P, K fertilizers for the experiment under irrigated conditions. The appropriate amount of fertilizers (conventional and Nano fertilizers) was calculated and applied as per the treatment schedule. The $ZnSO_4$ at the rate of 25 kg ha^{-1} was applied as soil broadcasting (basal) and 0.5% foliar sprays as per the treatment schedule. Observations on growth and yield attributes were taken on five randomly selected peg marked plants in periodical intervals. The mean values were used for statistical analysis as suggested by Panse and Sukhatme (1978) [11].

Preparation of Nano fertilizers

Protein- Lacto Gluconate-based N, P, and K in Nano fertilizer were formulated with the Nano micronutrient technology of ICAR Govt. of India, and with the carrier material of nutritional mycelium derived from a probiotic fermentation process. Nano N, P, K contains multiple organic acids based chelated major nutrients (N, P_2O_5, K_2O) min (4-4-4%) along with amino acid @ 6.00%(min), organic carbon @ 10.00% & formulated with organic micronutrient/trace element vitamins and probiotic.

Results and Discussion

Growth attributes

All the growth attributes were significantly influenced by the combined application of conventional and Nano N, P, K with the soil and foliar application of $ZnSO_4$ fertilizers. The growth components *viz*., Plant height, LAI, number of tillers and DMP in various stages of rice growth was enhanced due to the combined application of conventional and Nano N, P, K fertilizers (Table 1). The maximum growth attributes were recorded in (T_6). Among the different treatments 50% of RDF + 50 % of Nano N, P, K + soil application of $ZnSO_4$@ 25 kg ha^{-1} (T_6) significantly recorded higher growth attributes *viz*., plant height of 51.3, 78.5 and 95.2 cm at tillering, flowering and harvest stage respectively, LAI of 5.96 at flowering stage, number of tillers $hills^{-1}$ of 25, DMP of 13893 kg ha^{-1} at harvest stage of the crop and Crop growth rate of 5.92 gm^{-2} day^{-1}. This fact indicates that the combined application of conventional and Nano fertilizer encourages the plant to absorb and utilize nutrients efficiently. It may create a continuous nutritional balance for the different growth stages of the rice plant especially Nanomaterial which stimulates crop growth, improve the soil environment and promote crop growth metabolism. The increase in plant height by Nano fertilizer is due to its physiological role in stimulating porphyrin molecules present in important metabolic compounds such as chlorophyll and cytochrome pigments necessary for photosynthesis and respiration as well as coenzymes that activate phosphorous which are essential for the function of many enzymes and the production of amino acids used in protein synthesis. Besides, zinc acts as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin, when is applied as soil application compares to foliar spray, which produces more cells and dry matter that in turn will be stored in seeds as a sink. Similar results were obtained by Al-juthery and Saadoun (2019) [2], Rop *et al*. (2019) [13], Mahmoud and Swaefy (2020) [8].

The increase in LAI due to early and better availability of macro and micronutrients to the meristic tissues which in turn increasing the number of leaves and the total leaf area, which was facilitated by Nano N, P, K and $ZnSO_4$ application in submerged conditions efficiently compared to conventional fertilizers application. Since conventional fertilizers were more liable to nutrient loss compared to Nano fertilizers. These results were corroborating with the findings of Nouraein (2019) [10]. The dry matter production depends upon the photosynthetic ability of the plant. Here the combined application of conventional fertilizers and Nano fertilizers along with $ZnSO_4$ soil application increase availability of nutrient to the plants which increases chlorophyll formation, keeping the leaves remains green for a long period which helps to actively participate in the photosynthesis which in turn increased the photosynthesis rate, dry matter production and improve overall growth of the plant. Similar results were reported by Sahayaraj *et al*. (2014) [14] and Qureshi *et al*. (2018) [12]. The least value of growth attributes *viz*., plant height, LAI, number of tillers $hill^{-1}$ and DMP in rice crop were observed in control (T_1) no fertilizer added treatment which might be due to less availability of nutrients in the soil. This fails to perform the same function as other combinations treatments done with the physiological process at right time.

Yield attributes and yield

The entire yield attributes and yields *viz*. productive tillers m^{-2}, number of filled grains $panicles^{-1}$, grain yield and straw yield as influenced by the integrated use of conventional and Nano fertilizers except for 1000-grain weight (g) were recorded (Table 2). Among the imposed treatments, 50% RDF + 50% Nano N, P, K and $ZnSO_4$ 25 kg ha^{-1} (T_6) recorded a significantly higher number of 375 productive tillers m^{-2} at harvest, number of 127 filled grains $panicle^{-1}$, maximum test weight of 16.72g (1000 seeds), grain yield of 7635 kg ha^{-1} and straw yield of 8609 kg ha^{-1}. The higher grain yield and straw yield was obtained by the effective utilization of resources that increased the performance of the crop. These results conformed with the reports of Chowdhury *et al*., (2014) [4].

This might be due to the Nano-NPK promotes the plant, root as well as shoot efficiency to absorb and translocate the available macro and micronutrient from soil and thereby enhance the photosynthesis which in turn significantly

increased the grain yield by Nano NPK over conventional fertilizers alone applied treatment. Similar results were observed by (Wu, 2013) [19]. The increased yield attributes might be due to soil application of the $ZnSO_4$ which may enhance the role of Zn in the biosynthesis of Indole acetic acid (IAA), initiation of primordial reproductive parts and partitioning of photosynthates and enhanced the tiller production which might be manifested in superior yield attributes. Further, the increase in the number of productive tiller m^{-2} might be through adequate Zn supply which may positively increase the supply of other nutrients and stimulating the overall plant growth. Similar results were observed by Samreen *et al*. (2017) [15].

The influential role played by the Nano form of N, K and their longer duration availability to the crop especially in the later stages (reproductive stage) increased the yield. Further, the active role of Nanoparticles is integrated with other elements and act as a catalyst in increasing the enzymatic reactions due to their higher surface area. In addition to that, the higher yield is associated with the combined use of Nano N, P, K and conventional fertilizers along with basal organic manures. This increased the availability and uptake of macro and micronutrients. Besides, the application of Zn and its positive interaction with other macronutrients which induces biosynthesis of IAA, the activity of auxin and chlorophyll formation which may initiate the primordial for the reproductive part thus favoured the metabolic activities in a plant (EL-Ramady *et al*. 2018) which contributes the higher yield in rice. Present results are concomitant with those of Zahedi *et al.* (2020) [20] and Al-Khuzai *et al*. (2020) [3].

Conclusion

Based on present study results, new findings of different integrated conventional and Nano N, P, K two modes of $ZnSO_4$ application on growth and yield of rice. The application of 50% RDF +50% Nano N, P, K along with $ZnSO_4$ @ 25 kg ha^{-1} recorded higher growth, yield attributes and yield. From the enlightenment of the study, it can be concluded and recommended that application of 50% RDF +50% Nano N, P, K with $ZnSO_4$ (soil application) could be a viable option for enhancing the low land rice productivity without negative influences on plants and the environment.

Table 1: Effects of Nano N, P, K and $ZnSO_4$ on growth attributes of rice

Treatments	Plant height(cm)			No of tillers $hill^{-1}$	LAI	DMP (kg ha^{-1})			Crop growth rate ($g^{-2}day^{-1}$)
	Active tillering	Flowering stage	Harvesting stage			Active tillering	Flowering stage	Harvesting stage	
T1	31.0	55.8	71.4	10	3.08	5023	5695	6314	2.01
T2	34.6	61.5	77.5	14	3.40	6343	7427	8235	3.25
T3	38.4	64.4	80.3	16	3.86	6590	7828	8672	3.71
T4	46.5	72.7	89.6	20	5.43	7834	9456	10586	4.86
T5	41.8	67,7	84.4	18	4.87	7287	8682	9426	4.18
T6	51.3	78.5	95.2	25	5.96	8825	10801	13893	5.92
T7	43.6	69.8	86.6	19	5.05	7503	8975	9719	4.41
T8	49.0	75.2	92.5	23	5.73	8304	9978	12548	5.02
T9	42.0	68.3	85.3	18	4.95	7359	8873	9617	4.72
SEm±	1.07	1.12	1.23	0.62	0.09	110.2	166.3	181.8	-
CD(P=0.05)	2.27	2.38	2.62	1.33	0.20	233.4	352.6	385.4	-

T1 – control T2 - 100% RDF (120: 40:40 N, P, K kg ha-1) T3 - 100% Nano N, P, K (25 kg ha-1) T4 - 75% RDF + 25% Nano N, P, K + ZnSO4 @ 25 kg ha-1 (Soil application) T5 - 75% RDF + 25% Nano N, P, K + ZnSO4 @ 0.5% (foliar application) T6 - 50% RDF + 50% Nano N, P, K + ZnSO4 @ 25 kg ha-1(soil application) T7 - 50% RDF + 50% Nano N, P, K + ZnSO4 @ 0.5% (foliar application) T8 - 25% RDF + 75% Nano N, P, K + ZnSO4 @ 25 kg ha-1(Soil application) T9 - 25% RDF + 75% Nano N, P, K + ZnSO4 @ 0.5% (foliar application)

Table 2: Effects of Nano N, P, K and $ZnSO_4$ on yield attributes and yield of rice

Treatments	Number of productive tillers m-2	Number of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T1	176	98	16.41	2743	4576	37.46
T2	249	106	16.45	4425	6006	42.42
T3	268	109	16.48	4841	6328	43.35
T4	329	120	16.60	6273	7309	46.18
T5	298	115	16.51	5634	6629	45.94
T6	375	127	16.72	7635	8609	47.00
T7	312	117	16.58	5827	6759	46.29
T8	358	124	16.69	6935	7959	46.56
T9	309	116	16.53	5717	6627	46.31
SEm±	7.50	1.23	NS	103.1	113.8	-
CD (P=0.05)	15.91	2.62	NS	218.5	241.4	-

T1 – control T2 - 100% RDF (120: 40:40 N, P, K kg ha-1) T3 - 100% Nano N, P, K (25 kg ha-1) T4 - 75% RDF + 25% Nano N, P, K + ZnSO4 @ 25 kg ha-1 (Soil application) T5 - 75% RDF + 25% Nano N, P, K + ZnSO4 @ 0.5% (foliar application) T6 - 50% RDF + 50% Nano N, P, K + ZnSO4 @ 25 kg ha-1(soil application) T7 - 50% RDF + 50% Nano N, P, K + ZnSO4 @ 0.5% (foliar application) T8 - 25% RDF + 75% Nano N, P, K + ZnSO4 @ 25 kg ha-1(Soil application) T9 - 25% RDF + 75% Nano N, P, K + ZnSO4 @ 0.5% (foliar application)

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