"The impact of foliar application of Nano-fertilizers on the productivity and health of the soil in rice transplants (Oryza sativa L.)"

ABSTRACT:

During the 2019–20 Kharif season, a field experiment was conducted at the Acharya Narendra Deva University of Agriculture & Technology's Main Experimental Station in Kumarganj, Ayodhya (U.P.). Six treatments were used in the experiment. T_0 is the control, T_1 is 100% NPK & 100% Zinc application (RDF), T_2 is 50% N; 100% P & K + 2 spray of Nano Nitrogen, T_3 is 0% Zn, 100%NPK+2 spray of Nano Zinc, T_4 is 50% N & 0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn, and T_5 is 50% N & 0% Zn; 100% P & K + 2spray of Nano N mixed with Nano Zn & Nano Cu in a Randomized Block Design (RBD) with 4 replications. The results of the experiments indicated that T_5: 50% N and 0% Zn; 100% P & K + 2 sprays of Nano N combined with Nano Zn & Nano Cu produced the highest grain production. This yield was comparable to T_4: 50% N & 0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn and T_3: 0% Zn, 100% NPK + 2 spray of Nano Zn, T_5: 50% N and 0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn & Nano Cu yielded the greatest gross return (Rs. 119841ha-1), net return (Rs. 64711ha-1), and benefit-cost ratio (2.17) as well. In central Uttar Pradesh, the maximum concentrations of nitrogen (%), phosphorus (%), potassium (%), copper (%), and zinc (ppm) were found in grain and straw under T_5: 50% N & 0% Zn; 100% P & K + 2 sprays of Nano N mixed with Nano Zn & Nano Cu.

Keywords: Nano-fertilizer, Foliar application, Soil health, Productivity, Economics.

INTRODUCTION:

Arguably one of the world's most important field crops, rice (Oryza sativa L.) is a staple diet for millions of people and is ranked second only to wheat. For approximately half of Asia's population, it is critical to supply calories. 60% of the world's population lives in Asia, where rice accounts for over 90% of worldwide production and consumption. As such, rice is important for diet and culture. First and primary, rice is grown on 43.79 million hectares of land in India, where it produces 112.91 million tonnes of total output with an average productivity of 2578 kg/ha (Singh et al., 2020). In the 2019-20 timeframe, worldwide rice output reached roughly 493.79 million metric tons. In May 2020, the United States Department of Agriculture (USDA) projected that global rice production for 2020–2021 would be 501.96 million metric tonnes, up from 493.79 million tonnes the year before. This 8.17 million tonnes predicted increase, or 1.65%, may indicate an increase in rice production worldwide. 90% of the world's yields of rice are produced and consumed in monsoonal Asia, making it a vital cereal crop mostly consumed in Asian countries. Because rice is so adaptable to different temperatures and extreme water conditions, it is a staple food in this region. India is the world's second-largest producer of rice, after China. Prior to this, 495.9 million tonnes of rice were produced worldwide in 2018–19. According to estimates, India will produce a record 117.47 million tonnes of rice in 2019–20, a significant rise of 9.67 million tonnes over the previous five-year average of 107.80 million tonnes [1]. By releasing nutrients when needed, the characteristics of nano-fertilizers or nanoencapsulated nutrients may be advantageous to crops. In order to control plant growth and improve target activity, they might also provide a regulated delivery of chemical fertilisers [2]. It has been observed that applying nanomaterials as fertiliser works well. According to Raliya and Tarafdar (2013), the most prominent application of nano-fertilizers in crop production is a very creative and successful way to increase agricultural output [9]. Nano-fertilizers offer a new method of releasing nutrients into the soil gradually and under control as an alternative to traditional fertiliser applications, reducing eutrophication and water pollution [7]. The judicious application of nano-fertilizers in agricultural techniques enhances crop quality and increases soil compound efficacy, hence diminishing the requirement for chemical fertilisers. By responding to biological demands and environmental conditions, nano-structured fertilisers are made to increase nutrient efficiency through targeted delivery and controlled release. Research indicates that the use of nano-fertilizers in agricultural production only needs a little amount per acre, which makes this technique safe for the environment and economically viable for all living things [12].

MATERIALS AND METHODS:

The research was carried out in the kharif season of 2019-20 at the Main Experimental Station of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) alluvial soil. A sandy loam with slight calcareous properties, the soil in the experimental plot had a pH of 7.7, electrical conductivity of 0.36 dS m-1, permanent wilting point of 6.3%, field capacity of 18.4%, maximum water holding capacity of 29.5%, bulk density of 1.46 Mg m-3, particle density of 2.56 Mg m-3, and porosity of 42.9%. It also contained 16.3 kg/ha of available P2O5 and 154.7 kg/ha of available K2O. The experiment was conducted using a randomized block design with 4 replications, including different treatments. The fertilizers utilized were Urea, DAP, Muriate of Potash (MOP), Zn, and Nano nitrogen. While the amount of rainfall received during the crop period was 69.2 mm, compared to an average annual rainfall of approximately 800 mm, the accessible moisture at sowing time up to 100 cm soil profile was 282.5 mm. Suggested practice bundles were implemented in various interventions. To assess the soil moisture content and growth parameters, samples were taken at regular monthly intervals from soil depths of 0–25, 25–50, 50–75, and 75–100 cm using a gravimetric method. Three plants were chosen at random for each plot until the harvest. A statistical analysis was performed on the yield and growth attribute data [3]. Different treatments apply recommended procedures and fertiliser dosages.

RESULT AND DISCUSSION:

1. **Yield and Economics:**

- The highest grain yield was achieved with T_5, which consisted of 50% N and 0% Zn, 100% P and K, and two sprays of Nano N mixed with Nano Zn and Nano Cu. This was comparable to the yield from T_4, which had the same composition as T_5, and T_3, which had 0% Zn, 100% NPK, and two sprays of Nano Zinc. The lowest grain yield was observed in T_0 (Control). Similar findings were reported [4, 13].
- Straw yield and biological yield were recorded as highest T_5: 50 % N & 0% Zn; 100 %

P&K+2sprayofNanoNmixedwith Nano Zn& Nano Cu which was significant with treatment T_4: 50% N & 0 % Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn and T_3: 0 % Zn, 100% NPK + 2 spray of Nano Zinc. The lowest straw yield and biological yield were registered under T0 (Control). Reported similar results [6, 13].

- The highest harvest index was recorded (%) with T_5: 50%N&0%Zn;100 %P &K + 2 sprays of Nano N mixed with Nano Zn & Nano Cu which was followed by (%) with T_4: 50% N & 0 % Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn. Similar results were ported [8].
- The highest gross return (Rs 119841 ha-1), net return (Rs. 64711 ha-1), and benefit-cost ratio (2.17) as well were obtained T_5: 50 % N & 0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn & Nano Cu highest for rice crop. Reported similar results [11].

2. Qualities:

- The nitrogen (%), phosphorus (%), potassium (%), copper (%) and zinc(ppm) content ingrain & straw are highest in grain & straw content was recorded under T_5: 50 % N &0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn & Nano Cu which was followed by treatment T_4: 50% N & 0 % Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn and lowest nitrogen, phosphorus, potassium, copper and zinc content in grain & straw in T_0 (Control) during investigation. A similar result was reported by [10]**.**
- Among the nitrogen, phosphorus, potassium, copper, and zinc uptake in grain & straw (kg ha^{-1}) are highest in grain & straw uptake (kg ha^{-1}) was recorded under T_5: 50 % N& 0% Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn & Nano Cu which was followed by treatment T_4: 50% N & 0 % Zn; 100% P & K + 2 spray of Nano N mixed with Nano Zn and lowest nitrogen, phosphorus, potassium, copper and zinc uptake in grain & straw (kg ha^{-1}) in T_0 (Control). A similar result was reported [5]**.**

CONCLUSION

The combination of T_5: 50% N and 0% Zn; 100% P and K + 2 sprays of nano N combined with nano Zn and nano Cu—produced the maximum grain yield. Similar to T_4: 50% N&0% Zn; 100% P&K + 2 spray of Nano N mixed with Nano Zn and T_3: 0% Zn, 100% NPK + 2 spray of Nano Zinc, this yield was also achieved. T_5:50%N&0%Zn; 100%P&K + 2 spray of Nano N mixed with Nano Zn & Cub allowed for the maximum gross return (Rs. 119841ha-1), net return (Rs. 64711ha-1), and benefit-cost ratio (Rs. 2.17), respectively. The grain and straw under treatment T_5 had the highest percentages of nitrogen (%), phosphorus (%), potassium (%), copper (%), and zinc (ppm): 50% N & 0% Zn; 100% P & K + 2 sprays of Nano N mixed with Nano Zn & Nano Cu.

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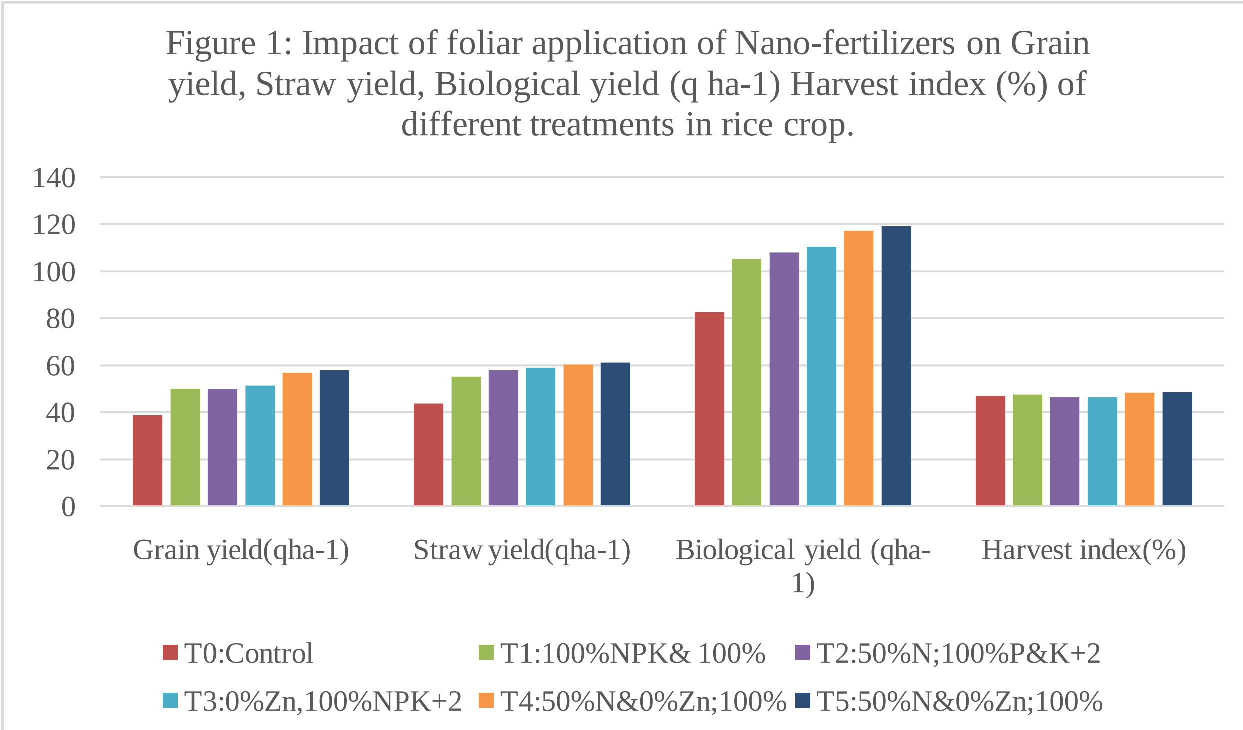

Fig. 01(A) Impact of foliar application of Nano-fertilizers on Grain yield, Straw yield, Biological yield (q ha-1) Harvest index (%) of different treatments in rice crop.

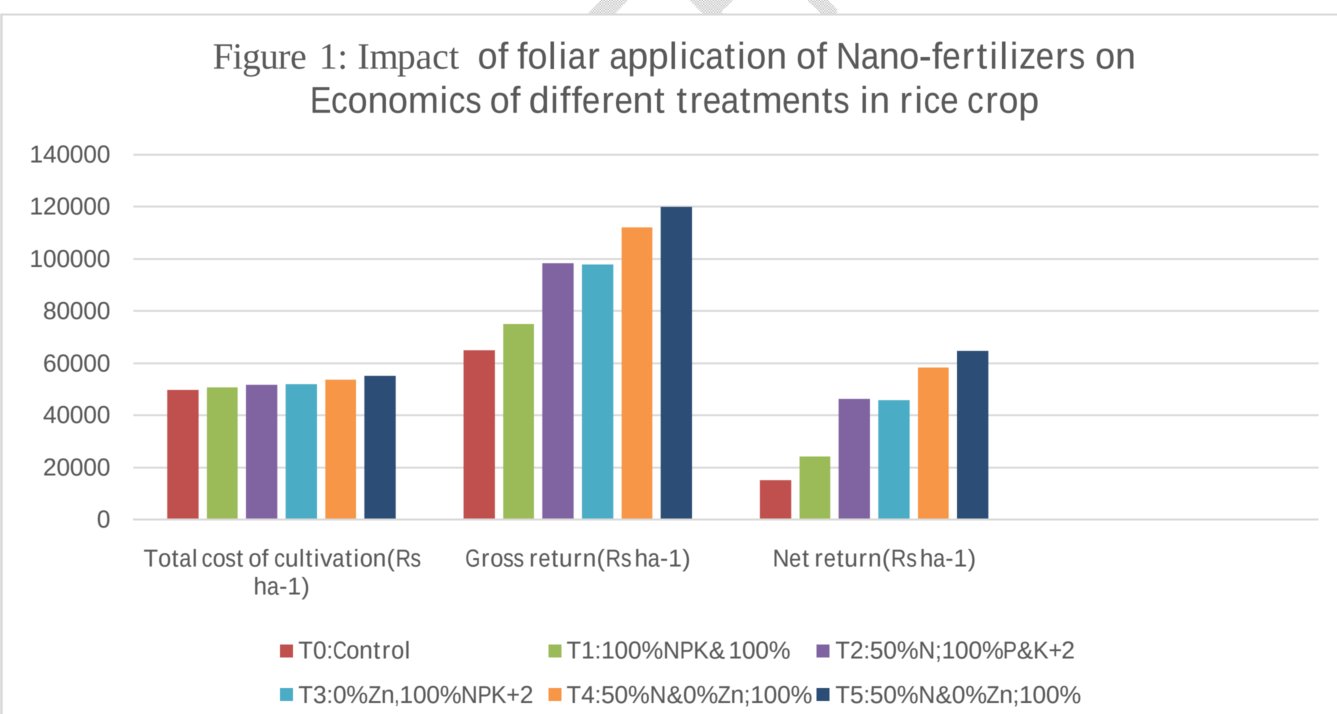

Fig.01 (B) Impact of foliar application of Nano-fertilizers on Economics of different treatments in rice crop.

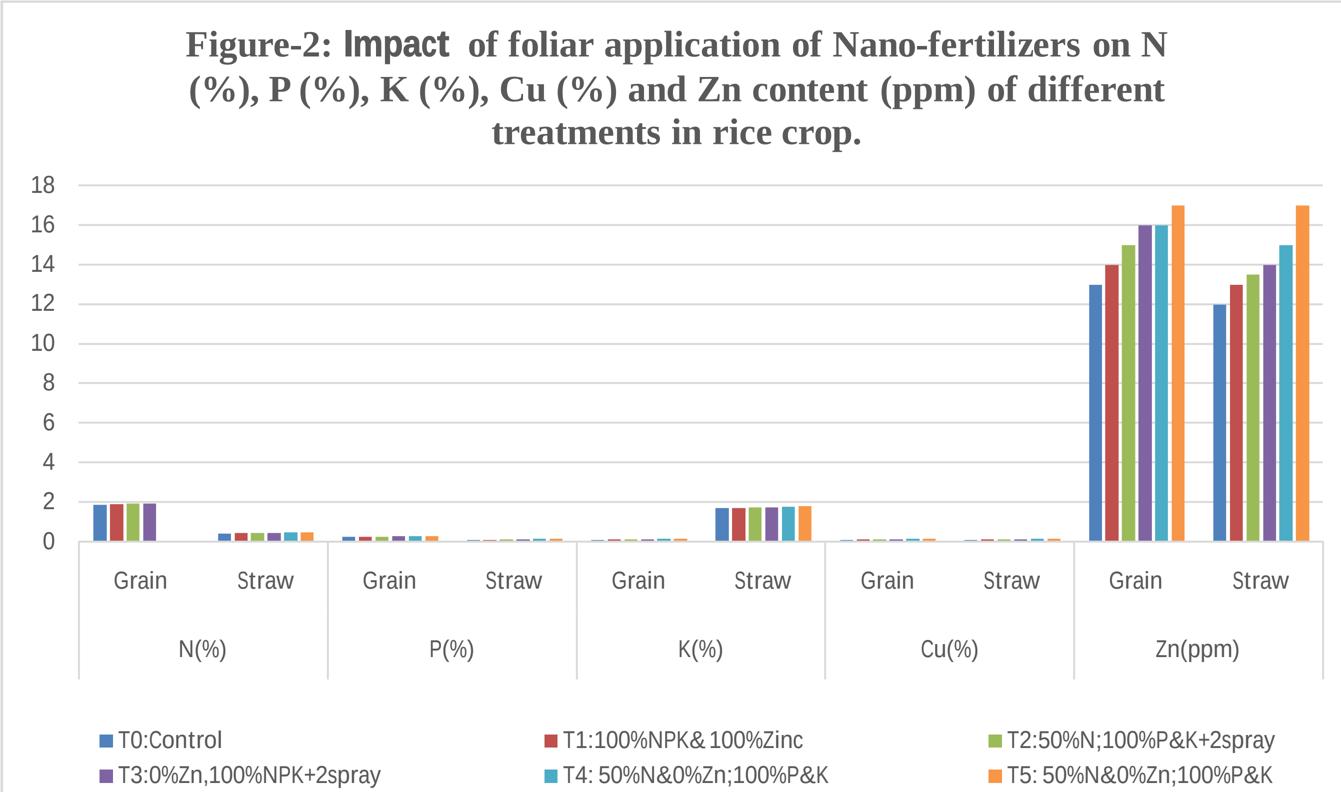

Fig. 02 Impact of foliar application of Nano-fertilizers on N (%), P (%), K (%), Cu (%) and Zn content (ppm) of different treatments in rice crop.

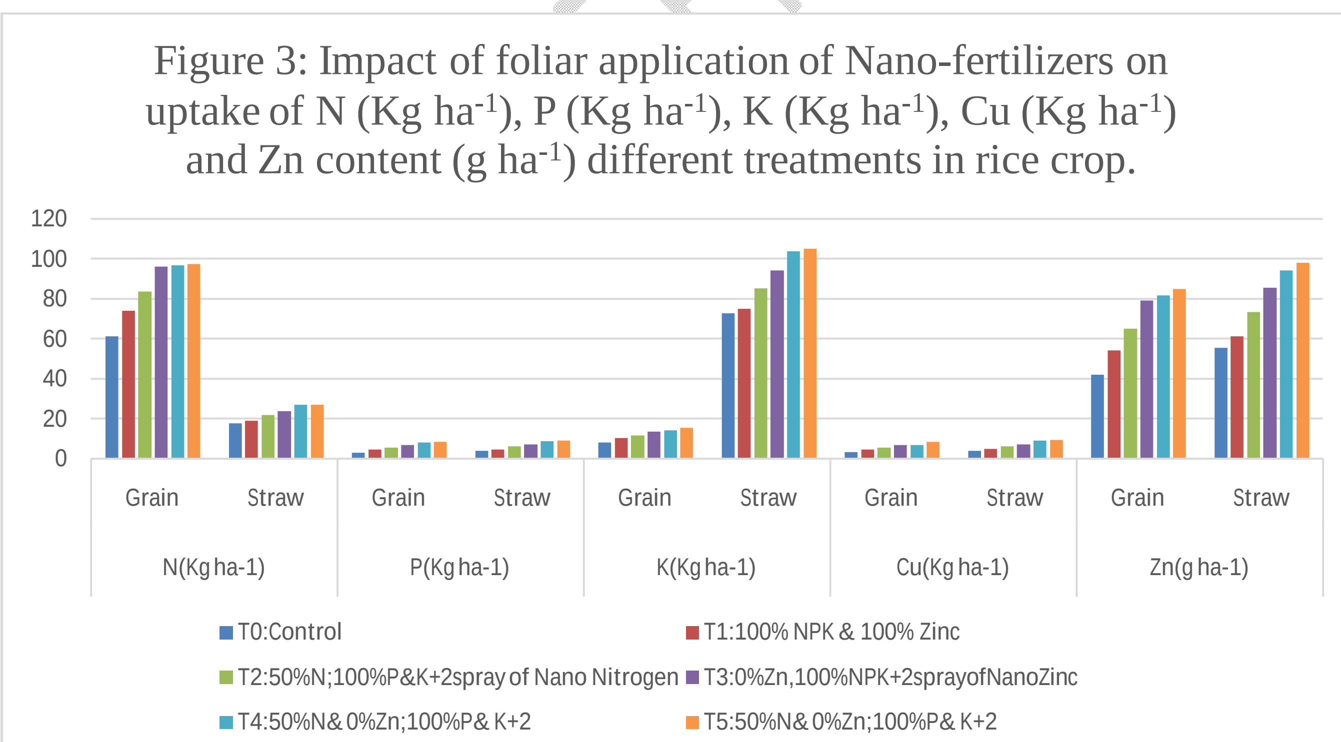

Fig. 03 Impact of foliar application of Nano-fertilizers on uptake of N (Kg ha^{-1}), P (Kg ha^{-1}), K (Kg ha^{-1}), Cu (Kg ha^{-1}) and Zn content (g ha^{-1}) different treatments in rice crop.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	Total cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_0: Control	38.94	43.78	82.72	47.07	49780	65010	15230	1.30
T_1:100% NPK &100% Zinc application (RDF)	49.95	55.31	105.26	47.45	50680	74967	24287	1.47
T_2:50% N;100% P&K+2 spray of Nano Nitrogen	50.12	57.87	107.99	46.41	51780	98205	46425	1.89
T_3:0% Zn,100% NPK+2 spray of Nano Zinc	51.28	59.07	110.35	46.47	51998	97850	45852	1.13
T_4:50% N&0% Zn;100% P&K+2 sprays of Nano N mixed with Nano Zn	56.76	60.43	117.19	48.43	53780	112098	58318	1.08
T_5:50%N&0%Zn;100% P & K + 2 sprays of Nano N mixed with Nano Zn &Nano Cu	57.82	61.12	118.94	48.61	55130	119841	64711	2.17
SEm±	1.34	1.54	2.15	1.98	-	-	-	-
CD(P=0.05)	3.76	2.09	4.43	3.90	-	-	-	-

Table 1: Impact of foliar application of Nano-fertilizers on Grain yield, Straw yield, Biological yield (q ha^{-1}) Harvest index (%), and Economics of different treatments in rice crop.

Treatments	N (%)		P (%)		K (%)		Cu (%)		Zn (ppm)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_0:Control	1.89	0.42	0.26	0.10	0.10	1.70	0.11	0.10	13	12.0
T_1:100%NPK& 100% Zinc application (RDF)	1.91	0.44	0.27	0.11	0.12	1.72	0.12	0.12	14	13.0
T_2: 50% N;100% P&K+2spray Of Nano Nitrogen	1.93	0.45	0.27	0.13	0.13	1.74	0.13	0.13	15	13.5
T_3:0% Zn,100% NPK+2 spray Of Nano Zinc	1.94	0.45	0.28	0.14	0.14	1.76	0.14	0.14	16	14.0
T_4: 50% N & 0% Zn;100%P&K+ 2 sprays of Nano N mixed with Nano Zn	1.96	0.47	0.29	0.15	0.15	1.78	0.15	0.15	16	15.0
T_5: 50% N & 0% Zn;100 P&K + 2 sprays of Nano N mixed	1.95	0.48	0.30	0.16	0.16	1.80	0.17	0.16	17	17.0

with Nano Zn & Nano Cu										
SEm±	0.32	0.38	0.046	0.35	0.031	0.22	0.025	0.07	1.25	1.18
CD(P=0.05)	NS	0.17	0.103	0.16	0.072	0.10	0.67	0.03	2.67	2.42

Table 2: Impact of foliar application of Nano-fertilizers on N (%), P (%), K (%), Cu (%), and Zn content (ppm) of different treatments in rice crop.

Treatments	N(Kg ha^{-1})		P(Kg ha^{-1})		K(Kg ha^{-1})		Cu(Kg ha^{-1})		Zn(g ha^{-1})	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
T_0: Control	61.51	18.05	3.25	4.29	8.46	73.06	3.58	4.29	42.32	55.77
T_1:100% NPK & 100% Zinc application (RDF)	74.37	19.26	4.67	4.81	10.51	75.30	4.67	5.25	54.51	61.29
T_2:50% N;100% P&K+ 2spray of Nano Nitrogen	83.83	22.07	5.65	6.37	11.72	85.36	5.65	6.37	65.16	73.59
T_3:0% Zn, 100% NPK + 2spray of Nano Zinc	96.32	24.12	6.95	7.50	13.90	94.33	6.95	7.50	79.44	85.76
T_4:50% N & 0% Zn; 100% P&K +2sprays of Nano N mixed with Nano Zn	97.10	27.16	8.20	8.86	14.38	104.14	7.20	9.25	82.04	94.51
T_5:50% N& 0% Zn;100% P&K+2sprays of Nano N mixed with Nano Zn & Nano Cu	97.73	27.27	8.51	9.25	15.53	105.16	8.51	9.45	85.20	98.37

SEm±	1.09	1.32	1.02	1.00	1.12	1.69	0.58	0.63	1.71	1.83
CD(P=0.05)	2.24	1.70	2.14	2.32	2.29	3.56	1.24	1.29	3.98	3.90

Table 3: Impact of foliar application of Nano-fertilizers on uptake of N (Kg ha^{-1}), P (Kg ha^{-1}), K (Kg ha^{-1}), Cu (Kg ha^{-1}) and Zn content (g ha^{-1}) different treatments in rice crop.