Strategies on Diminish the Greenhouse Gas Emission in Transplanted Rice

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Abstract - This study analyzed the influence of organic and inorganic fertiizers on greenhouse gas emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide(N2O), ensuing from farmer holding rice field during kharif 2025. The treatments consists of viz., T_1 – Farmer practices , T_2 - NPK (RDF), T_3 - RDF + $ZnSO_4$ @ 25 kg ha^{-1} , T_4 - RDF + Nano zinc (Granules @ 10 kg ha^{-1}),T_5 - RDF + Nano zinc (Granules @ 15 kg ha^{-1}),T_6 - RDF + Bio zinc (Granules @ 15 kg ha^{-1}),T_7 - RDF + Bio zinc (Granules @ 30 kg ha^{-1}),T_8 - RDF + Foliar spray of 0.5 % as $ZnSO_4$ at T.S and P.I.,T_9-RDF + Foliar spray of 1 ml L^{-1} as nano zinc at T.S and P.I. and T_{10}-RDF + Foliar spray of 1.5 ml L^{-1} as bio zinc at T.S and P.I.. The test crop was rice var. ADT 59. The results showed that the CO_2, CH_4 and N_2O emission rates in the application of RDF+ soil application of bio zinc @ 30 kg ha^{-1}. Similarly grain and straw yield was significantly enhanced on addition of different sources of zinc over control. The grain and straw yield were maximum (6070 and 7068 kg ha^{-1}) with application of RDF+ soil application of bio zinc @ 30 kg ha^{-1}and was on par with RDF + Foliar spray of 0.5 % $ZnSO_4$

***Key word*: Zinc, organics, rice, yield**

INTRODUCTION

The most serious problem finish humanity in this era is climate change, taken about by rising atmospheric greenhouse gas (GHG) emissions. A notable proportion of worldwide anthropogenic methane (CH_4) and nitrous oxide (N_2O) emissions comes from agriculture (Esmizade et al., 2010; Mikhaylov et al., 2020; Slingo and Slingo, 2024). Agricultural processes produce the majority of non-carbon dioxide (non-CO_2) emissions (84% N_2O and 47% CH_4), which also account for 10%–17% of all human GHG emissions (Beach et al., 2015; Bellarby et al., 2008; Frank et al., 2019; Linquist et al., 2018; Springmann and Freund, 2022). Agricultural soils alone account for 4.1% of total GHG emissions, and rice cultivation is responsible for 1.3% (Ritchie, 2020). Rice (*Oryza sativa* L.) is a vital food crop and the second most widely cultured cereal crop worldwide (Bodie et al., 2019). In Asia, rice is a critical and nutrient-dense staple food. Although China and India account for the majority of rice consumption, overall consumption has grown significantly, rising from 157 million tons in 1960 to 520 million tons in 2022 (USDA, 2023). By 2030, consumption is predicted to increase by an additional ~6% (Bin Rahman and Zhang, 2023). To happen the rising demand from the augmented increase in the human population, rice output must be raised by 40% by 2030, which may cause substantial ecological problems (IMF and UNCTAD, 2011). As a result, rice crop systems will need to be stable by producing higher grain output with possibly lower GHG emissions. Rice (*Oryza sativa L.*) is an important stable food crop among all the cereals. About 90 per cent of rice grown and consumed in South and South East Asia. In some parts of the world consumption of rice is a high as 990 g per person per day (Sharma et al., 2015). India ranks first in the world in terms of area of rice cultivation with 44.6 m ha and second in productivity of 2.96 t ha^{-1}. In Tamil Nadu has produced 79.14 lakh tones of rice from an 18.3 lakh hectares in 2014 -2015(Vaithilingam, 2015). Zinc is an essential element that plays many important roles in various physiological and metabolic processes in plant. This trace element plays vital function in structural molecules such as DNA and activates different metabolic and regulatory enzymes. It has been reported that nearly 925 proteins in humans and over 500 proteins in plant contain zinc (Graham, 2008). It also plays a role in photosynthesis, protein synthesis, cell division, maintaining integrity of the membrane structure (Marscher, 1995), resistance against the pathogen infection (Sarwar, 2011), and sexual reproduction through affecting production and shape of pollen and changes in the stigma. With this background the present experiment entitled influence of bio and nano zinc fertilization on growth and yield of rice.

MATERIALS AND METHODS

With a view to study the response of methane emission and rice yield to bio and nano zinc in rice soils, The field experiment was conducted to Padugai series (Vertic Ustropept) at the farmer's holding during the kuruvai season of year 2025. The experimental soil was clay loam in texture with pH 7.78, EC 0.84 dS m^{-1}, organic carbon 3.9 g kg^{-1} (low), low in $KMnO_4$-N 275 kg ha^{-1}, low in Olsen-P 10.4 kg ha^{-1}, high in NH_4OAc-K 294 kg ha^{-1} and low in available DTPA-Zn 0.68 mg kg^{-1}.The experiment was laid out in randomized block design. The treatments consists of eight treatments viz., T_1 – Farmer practices , T_2 - NPK (RDF), T_3 - RDF + $ZnSO_4$ @ 25 kg ha^{-1} , T_4 - RDF + Nano zinc (Granules @ 10 kg ha^{-1}),T_5 - RDF + Nano zinc (Granules @ 15 kg ha^{-1}),T_6 - RDF + Bio zinc (Granules @ 30 kg ha^{-1}),T_7 - RDF + Bio zinc (Granules @ 30 kg ha^{-1}),T_8 - RDF + Foliar spray of 0.5 % as $ZnSO_4$ at T.S and P.I.,T_9-RDF + Foliar spray of 1 ml L^{-1} as nano zinc at T.S and P.I. and T_{10}- RDF + Foliar spray of 1.5 ml L^{-1} as bio zinc at T.S and P.I. The recommended dose of 150:50:50 N, P_2O_5, K_2O ha^{-1} through urea, superphosphate and muriate of potash was added uniformly to all the plots. Nitrogen was applied in three split doses i.e., 50% as basal, 25% each at active tillering and 25% panicle initiation stages. The entire dose of P_2O_5 and K_2O were applied basally as per the treatment schedule. The test crop rice ADT 59. The zinc was applied through bio and nano zinc formulations.

RESULTS AND DISCUSSION

Methane and Nitrous oxide emission

Analysis of variance on greenhouse gas emissions (Fig. 1 and 2) indicated that the application of different sources and methods significantly reduced methane (CH_4) and nitrous oxide (N_2O) emissions at all growth stages compared to the control. At the tillering stage, CH_4 and N_2O emissions ranged from 7.22 to 12.99 and 4.11 to 11.23 mg m^{-2} day^{-1}, respectively; at the panicle initiation stage, from 11.78 to 17.24 and 7.23 to 14.32 mg m^{-2} day^{-1}; and at the harvest stage, from 5.22 to 11.23 and 5.14 to 12.11 mg m^{-2} day^{-1}, respectively. The lowest CH_4 and N_2O emissions across all stages were observed with RDF + soil application of bio-zinc @ 30 kg ha^{-1} (T7), which recorded 7.22 & 4.11 mg m^{-2} day^{-1} at tillering, 11.78 & 7.23 mg m^{-2} day^{-1} at panicle initiation, and 5.22 & 5.14 mg m^{-2} day^{-1} at harvest. This treatment was statistically on par with T8 and T9, followed significantly by T3, while the highest emissions were recorded under farmer practice. The reduction in CH_4 flux during the generative phase can be attributed to decreased activity of methanogenic bacteria under intermittent drying (aerobic conditions), which inhibits CH_4 production and enhances its oxidation (Conrad, 2007). Generally, CH_4 flux increases from the early planting stage until the early generative phase, then slightly declines before rising again after harvest (Setyanto et al., 2016). This decline is associated with reduced tiller number and lower photosynthetic activity, which limits assimilate supply for CH_4 formation (Ardiarini et al., 2020). After flowering, CH_4 emissions further decrease due to the decline in photosynthesis during seed development and the reduced availability of assimilates for methane production (Wihardjaka and Sarwoto, 2015). Similar findings have been reported earlier, where peak methane fluxes occurred during vegetative and early reproductive stages (about 25 DAS), followed by a decline during flowering and maturity phases (Chandrasekaran et al., 2022). Moreover, organic fertilizers provide labile carbon compounds that enhance denitrifying bacterial activity, thereby increasing N_2O emissions (Lazcano et al., 2021).

Rice yield

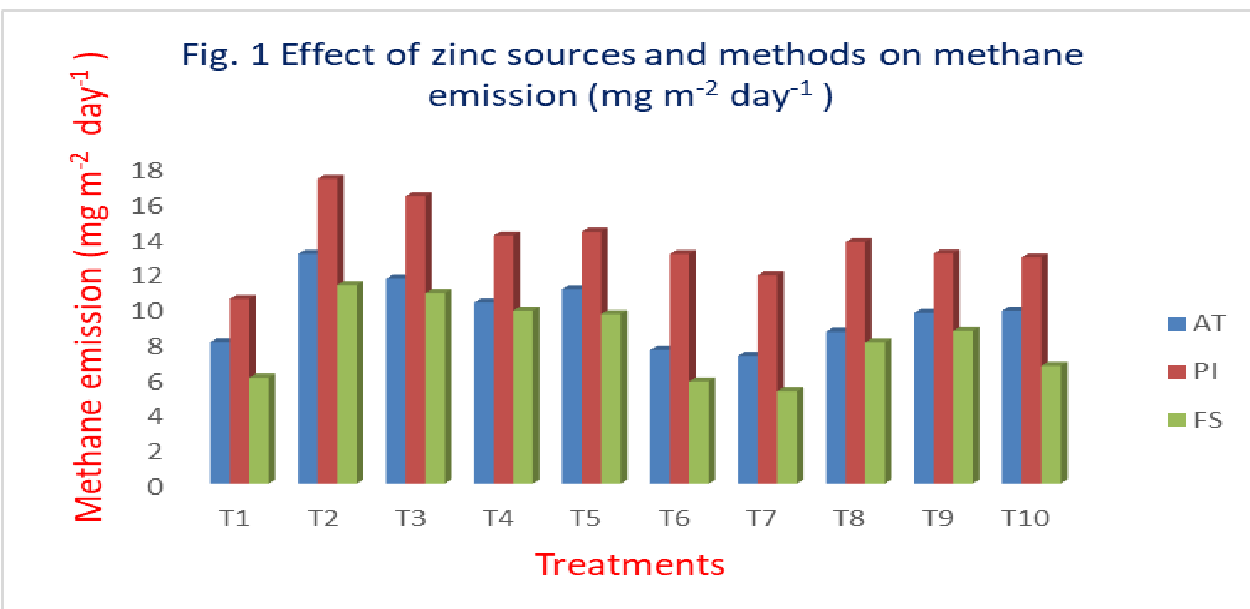
A significant improvement in both grain and straw yield of rice was observed with different sources and methods of zinc application compared to the control (Table 3). Grain yield ranged from 3319 to 6070 kg ha^{-1}, while straw yield ranged from 4032 to 7068 kg ha^{-1}. The maximum grain (6070 kg ha^{-1}) and straw yield (7068 kg ha^{-1}) were recorded with RDF + soil application of bio-zinc @ 30 kg ha^{-1} (T7), which was statistically on par with RDF + foliar spray of 0.5% $ZnSO_4$ (5522 kg ha^{-1}; T9). These treatments were significantly followed by T3, T10, and T6. The highest percentage increase in grain (45%) and straw yield (42%) was obtained with T7 over the control (T1). Conversely, the lowest yields were recorded in the treatment receiving RDF @ 150:50:50 kg ha^{-1}, followed by the control (3319 and 4032 kg ha^{-1}, respectively). The increase in grain yield with zinc application can be attributed to the enhancement of yield components. In the present study, the number of panicles m^{-2}, grains $panicle^{-1}$, panicle length, and 1000-grain weight increased with higher Zn levels, with the maximum values obtained under RDF + soil application of bio-zinc @ 30 kg ha^{-1}. This finding was further supported by strong linear relationships between grain yield and yield attributes: number of panicles m^{-2} ($Y = 3628 - 0.703x + 0.010x^2$, $R^2 = 0.99^{**}$), number of grains $panicle^{-1}$ ($Y = 4688 - 83.49x - 9.322x^2$, $R^2 = 0.99^{**}$), and panicle length ($Y = -353.6 + 393.6x - 4.473x^2$, $R^2 = 0.99^{**}$), indicating that 99% of the variation in grain yield was explained by these attributes. Similar increases in grain yield due to improvement in yield components with zinc application have also been reported by Muthukumararaja and Sriramachanderasehkar (2012) and Rahman et al. (2011).

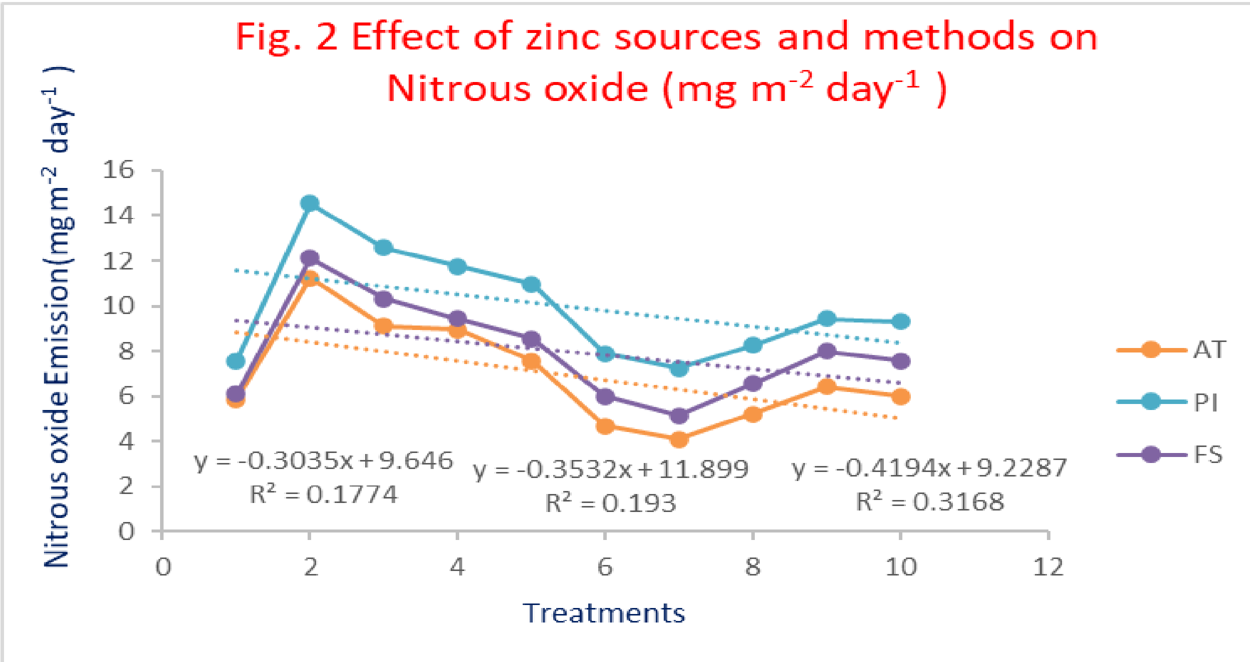
CONCLUSION

In conclusion, Bio zinc application to zinc deficient soil significantly increased grain yield of rice. Application of Bio zinc proved better over application of alone zinc sulphate ($ZnSO_4$) indicating the positive role of organic matter in increasing grain yield and reduce the greenhouse gas emission in transplanted rice soils.

Table 1 Effect of zinc sources and methods on grain and straw yield of rice (kg ha^{-1})

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1 – Absolute control	3319	4032
T_2 – NPK (RDF)	4483	5365
T_3 – RDF + Zn SO_4 (25 kg/ha)	5522	6572
T_4 –RDF + Nano Zinc (granules @ 10 kg /ha)	4657	5551
T_5 –RDF + Nano Zinc (granules @ 15 kg /ha)	4758	5708
T_6 – RDF + Bio zinc (granules @ 15 kg/ha)	5338	6377
T_7 – RDF + Bio zinc (granules @ 30 kg/ha)	6070	7068
T_8– RDF + Foliar spray of 0.5% Zn SO_4@ TS and PIS	5983	6980
T_9- RDF + Foliar spray of 0.1% Nano Zinc @ TS and PIS	5962	6909
T_{10}- RDF + Foliar spray of 0.15% Bio Zinc @ TS and PIS	5455	6459
SEd	131.17	106.23
CD (P = 0.05)	281.88	223.19





REFERENCE

[1] Abbas, G., G. Hassan, M.A., Ali, M. Aslam and Z. Abbas. 2010. Response of wheat to different doses of $ZnSO_4$ under Thal desert environment. Pak. J. Bot., 42(6): 4079-4085.

[2] Alloway, B.J. 2009. Soils factors associated with zinc deficiency in crops and humans. Environ. Geocehm. Hlth., 31(5): 537-548.

[3] Arunachalam, P., Kannan, P., Prabukumar, G and Govindaraj, M. 2013. Zinc deficiency in Indian soils with special focus to enrich zinc in peanut. African J. Agricultural research. 8(50): 6681 - 6688.

[4] Chandrasekaran D., Tabassum – Abbasi, T., and Abbsai,S. A.(2022). Assessment of methane emission and the factors that influence it, from three rice varieties commonly coutivated in the state of Puducherry. Atmosphere 13, 1811. Doi: 10.3390/ atmos 13111811

[5] Conrad, R (2007) Microbial ecology of methanogens and methanotrophs. adv Agro,96-1-63, doi 10.1016/S0065-2113 (07) 96005-8

[6] Lazcano, C., Zhu- Barker.X., and Decock, C(2021) Effectes of organic fertilizers on the soil microorganism responsible for N2O emission A review Microorganisms 9-1-18 doi: 10.3390/ microorganisms 9050983

[7] Caulfield L.E and R.E.Black .2004. Zinc deficiency, In M. Ezzati, et al., eds. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected major Risk Factors. World Health Organization, Geneva.

[8] Devarajan, R. and G. Ramanathan. 1995. Direct, residual and cumulative effect of applied zinc for rice in red soil. Madras Agric. J., 82(2): 102-103.

[9] Fageria, N.K., A.B. Das Santos and T. Cobucci. 2011. Zinc nutrition of lowland rice. Commun. Soil sci. Plant Ann. 42: 1719-1727.

[10] Flaig, W., N. Beutolspacher and E. Rietz. 1975. Chemical composition and physical chemical properties of humic substances. In: Soil components (J.E. Gieseking, ed.), Vol. 1, Springer-Verlag, Berlin, New York.

[11] Graham, R.D. 2008. Micronutrient deficiencies in crops and their global significance. In: micronutrient deficiencies in global crop production (Ed Alloway BJ). Springer. PP. 41 -61.

[12] Kandasamy, S and Prema, R.S. 2015. Methods of synthesis of nano paricles and its applications. Journal of Chemical and Pharmaceutical research. 7(3): 278-285.

[13] Khalivand Behrouzyar E, M. Yarnia, FR. khoii, M.Mogaddam and M.N. Safarzadeh vishkaii. 2012. The effect of methanol and some micro – macronutrients foliar application on Maize (Zea

mays L.,) maternal plant on some of morphophysiological characteristics in a subsequent generation. International journal of Agronomy and plant production. 3 (12): 618 -624.
[14] Marschner, H. 1995. Mineral nutrition of higher plants. 2nd ed. Academic press pub., New York (USA), pp: 559.
[15] Muthukumararaja, T. and M.V. Sriramachandrasekharan 2012. Critical limit of zinc for rice soils of
[16] Veeranam command area, Tamilnadu, India. ARPN J. Agrl. Biol. Sci. 7(1): 1-12.
[17] Obrador, A., J. Novillo and J.M. Alvarez. 2003. Mobility and availability to plants of two sources zinc applied for a calcareous soil. Soil Sci. Soc. Amer. J., 67: 564-572.
[18] Rahman, K.M.H., Md. Abdul Khan Chowdhury, F. Sharmeen and A. Sarkar. 2011. Effect of zinc and phosphorus on yield of *Oryza sativa* (cv. BR 11). Bang. Res. Pub. J., 5(4): 351-358.
[19] Sarwar, M. 2011. Effects of zinc fertilizers application on the incidence of rice stem borers (*Scirpophaga* sp.) (Lepidoptera: Pyralidae) in rice (*Oryza sativa*) crop. J. Cereals Oilseeds, 2(5): 61-65.
[20] Shanmugam, P.M. and R.Veeraputhiran. 2000. Effect of organic and inorganic N and zinc application on soil fertility and nutrient uptake of rabi rice. Madras Agric. J.,89(1-3): 90- 92.
[21] Sharma, B.D., Arora, H., Kumar, R and Nayyar, V.K. 2015.Relationships between soil characteristics and total DTPA –extractable Zn,Cu,Mn and Fe in Indo-Gangetic plains. Communication in soil science and plant analysis.35: 799 -818.
[22] Shehu, H.E. and G.Y. Jamala. 2010. Available Zn distribution, response and uptake of rice (*Oryza sativa* L.) to applied Zn along a Toposequence of Lake Gerio Fadama soils at Yola, North Eastern Nigeria. J. Amer. Sci., 6(11): 1013-1016.
[23] Shukla, A.K., Tiwari, P.K and Chandra Prakash. 2014. Micronutrients deficiencies vis-a- vis food and nutritional security of India. Indian J. Fertilizers. 10(12): 94-112.
[24] Vaithilingam, R. 2015. Policy Note – Department Of Agriculture, Government Of Tamil Nadu
[25] Welch R.M. 2008. Linkages between trace elemebts in food crops and human health. P. 41-61. In B.J. Alloway, ed. Micronutrient Deficienceies in Global crop Production. Springer Science.
[26] Yuvaraj, M and Subramanian, K.S. 2014. Fabrication of zinc nano fertilizer on growth parameter of rice. Trends in biosciences. 7(17): 2564-2565.