## Effect of zinc nutrition on economic productivity of rice (*Oryza sativa*) and soil biological properties

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Received: 21 December 2020; Accepted: 06 September 2021

**Keywords**: Dehydrogenases activities, Foliar spray, Grain yield, Soil Microbial biomass carbon

Rice (Oryza sativa L.) is the principal food crop for the populace in North Eastern Hill (NEH) region of India, however the region is deficit of 1.40 million tonnes of rice to feed its population (Babu et al. 2014 and Das et al. 2014). The rice productivity of the region  $\sim 49.5\%$ is less as compared to the average productivity of India (Das et al. 2014). Majority of the soils of NEH region is acidic in nature. The low zinc (Zn) availability is one of the serious abiotic stresses for rice production in NEH. Zn plays a pivotal role in various plant metabolic processes and enzyme synthesis. Rice is very sensitive to low Zn supply in submerged soils (Yadav et al. 2011). Zn deficiency is becoming serious threat to profitable rice production and maintains the live soil healthy (Yadav et al. 2011, Prasad et al. 2013). Although, lot of works has been done on effect of Zn nutrition on the productivity of rice, however research work is very meagre to assess the effect of Zn on soil biological properties. Furthermore, such kind of the study has not been conducted in acidic soils of NEH region of India especially in Manipur. Considering the above mentioned facts and with the hypothesis that Zn fertilization can improve the productivity and soil biological properties of transplanted rice, present investigation was undertaken with the objective to assess the effect of Zn nutrition on soil biological properties at different growing stages and productivity of transplanted rice.

A field experiment was conducted during *Kharif* 2019 at Research Farm of College of Agriculture, Central Agricultural University, Imphal, Manipur. The farm is situated at 24<sup>0</sup>45' N latitude and 93<sup>0</sup> 56' E longitude with an elevation of 790 m amsl. The Imphal receives about 1,320 mm of rain annually. The region has a large variation in temperature across the year. January is the coldest

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month while May is the hottest month. The minimum and maximum temperatures during the cropping year were 7.5 and 30.7°C, respectively. Total rainfall of 1168.3 mm was received during the experimental year. The maximum rainfall was received in September (253.7 mm) while the minimum rainfall was received in March (12.1 mm) during 2019–20. The relative humidity (RH) was in the range of 37.5–93.5% throughout the experimental year. In general, much fluctuation was not noticed in other weather parameters during the cropping season at the experimental site. The soil of the experimental site was silty clay in texture (sand 16.1%, silt 36.9% and clay 46.3%) with a pH of 5.09 (1:2.5 soil and water ratio). The soil had 1.09% initial organic carbon and 255 kg/ha alkaline permanganate oxidizable N which was low, 12.3 kg/ha available phosphorus (P) and 199.98 kg/ha 1 N ammonium acetate exchangeable K which were of medium type in soil fertility rating. The experiment was laid out in three times replicated Completely Randomized Block Design (CRBD). Fifteen treatment combinations of Zn, viz. Control,  $\rm T_1$  Zn @2.5 kg/ha,  $\rm T_2$  Zn @5 kg/ha,  $\rm T_3$ Zn @7.5 kg/ha, T<sub>4</sub> Zn @10 kg/ha, T<sub>5</sub> Zn @0.25% foliar spray (two times), T<sub>6</sub> Zn @0.5% foliar spray (two times),  $T_7 Zn @2.5 kg/ha + foliar spray of Zn@0.25\%$  (two times), T<sub>8</sub> Zn @2.5 kg/ha+ foliar spray of Zn@0.5% (two times),  $T_{o}$  Zn @5 kg/ha+ foliar spray of Zn @0.25% (two times),  $T_{10}$  Zn @5 kg/ha+ foliar of Zn @0.5% (two times),  $T_{11}$  Zn @7.5 kg/ha+ foliar spray of Zn @0.25% (two times), T<sub>12</sub> Zn @7.5 kg/ha+ foliar spray of Zn @0.5% (two times),  $T_{13}$ Zn @10 kg/ha + foliar spray of Zn @0.25% (two times) and  $T_{14}$  Zn @10 kg/ha+ foliar spray of Zn @0.5% (two times) were imposed to rice crops. The land was thoroughly prepared and well levelled with peripheral bunding. Puddling was done 2-3 times to minimize the percolation losses of water and to reduce the weed infestation. The field was demarcated into plots providing irrigation and drainage channels according to the layout plan. After proper puddling thirty-day old rice (CAUR-1) seedling were transplanted during first week of July at a spacing of 20 cm × 15 cm. The rice crop was fertilized with the recommended dose of N (60 kg/ha), P (40 kg/ha) and K (30 kg/ha). Half dose

Table 1 Effect of zinc application on yield attributes and yield of rice

Treatment	Productive tiller/ hill	Panicle length (cm)	Number of grains per panicle	Grain yield (t/ha)
Control	5.7	22.0	102.1	4.35
T <sub>1</sub> Zn @2.5 kg/ha	7.1	23.8	121.7	4.60
T <sub>2</sub> Zn @5 kg/ha	7.5	24.3	130.7	5.07
T <sub>3</sub> Zn @7.5 kg/ha	8.5	24.8	137.1	5.51
T <sub>4</sub> Zn @10 kg/ha	9.2	24.0	145.9	5.39
T <sub>5</sub> Zn @0.25% foliar spray	6.2	23.0	112.7	4.40
T <sub>6</sub> Zn @0.5% foliar spray	6.9	23.3	113.2	4.61
T <sub>7</sub> Zn @2.5 kg/ha + foliar spray of Zn @0.25%	7.2	24.3	137.7	4.67
T <sub>8</sub> Zn @2.5 kg/ha + foliar spray of Zn @0.5%	7.4	24.4	138.7	5.09
T <sub>9</sub> Zn @5 kg/ha + foliar spray of Zn @0.25%	8.9	24.3	141.1	5.16
T <sub>10</sub> Zn @5 kg/ha + foliar of Zn @0.5%	9.4	24.5	148.3	5.32
T <sub>11</sub> Zn @7.5 kg/ha + foliar spray of Zn @0.25%	9.6	24.6	160.0	5.59
T <sub>12</sub> Zn @7.5 kg/ha + foliar spray of Zn @0.5%	9.9	25.4	176.0	5.77
T <sub>13</sub> Zn @10 kg/ha + foliar spray of Zn @0.25%	9.1	25.1	150.1	5.58
T <sub>14</sub> Zn @10 kg/ha + foliar spray of Zn @0.5%	8.7	24.5	146.5	5.73
SEm ±	0.7	0.7	11.8	0.11
CD (P=0.05)	2.2	2.0	34.1	0.31

Foliar spray was done twice first at panicle initiation and second booting at stage.

of nitrogen and a full dose of phosphorus and potassium was applied as a basal at the time of the last puddling and remaining half dose of nitrogen was applied at 30 DAT (days after transplanting) (tillering stage) and 60 DAT (panicle initiation stage) in equal proportion. Zinc sulphate (ZnSO<sub>4</sub>. H<sub>2</sub>O) containing 21% Zinc (Zn) was used as a source of Zn fertilizer. The basal application of Zn was done at the time of transplanting as per the treatments. However, two sprays of Zn were done first at the panicle initiation stage and second at the booting stage as per the treatments. The nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP), and muriate of potash (MOP), respectively. Recommended agronomic package of practices were adopted for cultivation of rice. The crop was harvested in November. Yield attributing parameters and yield of rice was recorded as per the standard procedures. Similarly, standard protocols were followed for analysing the soil biological properties, viz. SMBC (Vance et al. 1987), dehydrogenases (Casida et al. 1964), and FDA activities (Green et al. 2006)) at different growth stages (tillering, panicle emergence and at harvest) of rice. The data related to each parameter were analyzed as per the procedure of analysis of variance (ANOVA) and significance of CRBD tested by the 'F' test (Gomez and Gomez 1984). Standard Error of Means (SEm±) and Critical Difference (CD) at 5% level of significance were worked out for each parameter.

Results revealed that the application of Zn had marked effect on number of active tillers per hills, panicle length (cm), grains per panicle and productivity of rice over control (Table 1). Among the Zn nutrition treatments, application of Zn @7.5 kg/ha + foliar spray Zn @0.5% recorded the

maximum number of productive tillers per hill (9.9), panicle length (25.4 cm), grains per panicle (176) and grain yield of rice (5.77 t/ha). Application of Zn @7.5 kg/ha + foliar spray of Zn @0.5% recorded 24.6% higher grain yield over control (no zinc nutrition). However, a slight reduction in rice grain yield was observed when 10 kg/ha was applied in soil along with the foliar spray of Zn @0.5% at panicle initiation and booting stage. Application of Zn might increase the plant nutrient availability throughout the crop growth period which promotes the various physiological activities. Higher grain yield due to combined application (soil and foliar) of Zn is attributed to involvement of Zn in many metallic enzymes in plant system, and auxin production, which enhances the carbohydrates synthesis and transport to the grain production site (Pedda Babu et al. 2007). These results are in agreement with the findings of Shivay (2015) and Kadam (2018). With regards to the soil biological properties, irrespective of the Zn treatments, soil microbial biomass carbon (SMBC) and soil enzymatic activities (DHA and FDA) increases with the advancement in crop growth stages and maximum value of SMBC (307.6 µg MBC/g soil), DHA (24.82 µg TPF g/soil/h) and FDA (58.93 µg FDA g/soil/h) under study was observed at panicle emergence stages thereafter reduction in theses parameters were noticed and minimum values of SMBC, DHA (Fig 1 & 2) and FDA were recorded at harvest stage of rice. Application of Zn in rice change the SMBC and enzymatic reactions (DHA and FDA) in soil at different growth stages of rice in 0-15 cm soil depth. Among the Zn nutrition treatment imposed to rice application of Zn @10 kg/ha + foliar spray of Zn @0.5% registered maximum

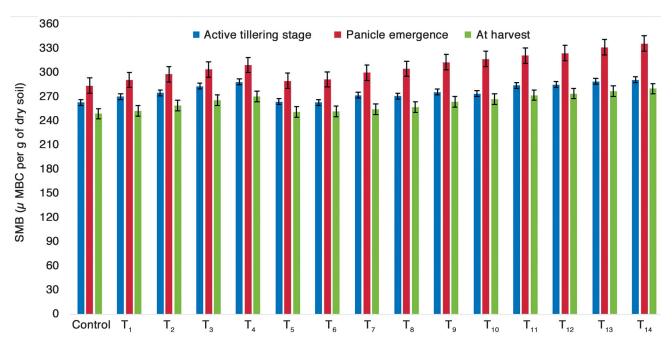


Fig 1 Effect of Zn nutrition on soil microbial biomass carbon (SMBC) at different stages of rice. Error bars indicate critical difference (CD) values at P=0.05. Treatment details are mentioned in materials and methods.

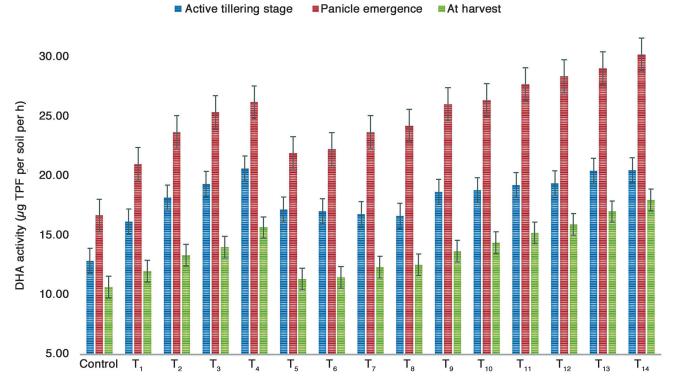


Fig 2 Effect of Zn nutrition on dehydrogenase (DHA) activities in soil at different stages of rice. Error bars indicate critical difference (CD) values at P=0.05. Treatment details are mentioned in materials and methods.

increment in SMBC, DHA and FDA activities at all the growth stages of rice, however it remains statistically at par with soil application of Zn @10 kg/ha at active tilling stage and with Zn @7.5 kg/ha + foliar spray of Zn @0.5% and Zn @10 kg /ha+ foliar spray of Zn @0.25% at panicle emergence and at harvest stage. These results are in close conformity with the findings of Ponnmani *et al.* (2019).

## SUMMARY

Based on our findings, it can be concluded that application of Zn in transplanted rice is essential to harvest profitable yield under acidic soils of NEH region of India. Combined application (soil and foliar) was more effective instead of soil or foliar application alone. Successive yield increment of rice was noticed up to the application of Zn

@7.5 kg/ha + foliar spray of Zn @0.5% at panicle initiation and booting stages. Thereafter productivity of rice slightly declined with increases of Zn doses in acidic soils. The application Zn @7.5 kg/ha + foliar spray of Zn @0.5% significantly improved yield attributing parameters of rice over control. Among the Zn nutrition treatments, application of Zn @7.5 kg/ha + foliar spray of Zn @0.5% registered 4.5% higher grain yield over its soil application. With regards to the soil biological properties successive increase of Zn doses improved the soil biological properties up to the application of Zn @10 kg/ha + foliar spray of Zn @0.5%. However, it remains statistically at par with Zn @7.5 kg/ha + foliar spray of Zn @0.5% at most of the growth stages of rice. Hence, application of Zn @7.5 kg/ha + foliar spray of Zn @0.5% at panicle initiation and booting stages is a profitable option for sustainable rice production in NEH, India besides sustaining the soil biological properties.

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