



Role of zinc in inducing resistance in rice to whitebacked planthopper (*Sogatella furcifera*) under field conditions

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Rice is the staple food for nearly half of the world's population. In India, the rice area is around 43.79 million ha with an annual production of 112.91 million MT (USDA 2017-18). Both biotic and abiotic stresses reduce the targeted yield as per its genetic potential. Insect pests are the major biotic stress to the rice production in India accounting for 31.1-86.0% yield loss (Gunathilagaraj and Kumar 1997).

Planthoppers especially the brown planthopper, whitebacked planthopper [*Sogatella furcifera* (Horvath)] and leaf hoppers are of economic concern in India (Atwal *et al.* 1967). Serious damage usually occurs during the early stage of plant growth with symptoms of hopperburn due to intensive sucking by the WBPH (Dale 1994). Unfortunately neither the insecticides are no longer fruitful nor there are resistant varieties developed in rice against this insect so far. Thus, the alternate approach is to manage this pest through induction of resistance in the crop plant through application of various micro-nutrients. Zinc is one such micro-nutrient which can induce defence mechanism in rice against the sucking pest (Rath and Misra 1998, Rath 2004, 2006). Keeping this in mind, field trials were conducted during *kharif* 2016, summer 2016-17 and *kharif* 2017 to evaluate the influence of zinc applied through various sources in inducing defence in rice against WBPH.

The rice variety TN 1 (susceptible) was grown in nursery bed in three different seasons following the local agronomic recommendations. In all the seasons, 21 days old seedlings were transplanted in plot sizes of (5 × 4) m² each with the spacing of 15 cm × 10 cm. A total of nine treatments including a control were allocated randomly following randomized block design (RBD) with three replications in all the test seasons. Various Zn treatments taken were, T₁: ZnSO₄ basal (25 kg/ha), T₂: Zn EDTA basal (40 kg/ha), T₃: ZnSO₄ foliar spray (0.5 %) (30 and 45 DAT), T₄: Zn EDTA foliar spray (0.8%) (30 and 45 DAT), T₅: T₁ + T₃, T₆: T₂ + T₄, T₇: T₁ + T₄, T₈: T₂ + T₃ and T₉: control. The

experimental field remained same in all the three seasons of study. Transplanting operations were undertaken following recommended agronomic practices with a fertilizer dose of 80-40-40 kg N, P₂O₅ and K₂O per ha. Observation on WBPH population was recorded from 10 randomly selected hills per plot at 40, 50, 60, 70 and 80 DAT in all seasons and the data was subjected to necessary transformation. Grain yield per plot was also recorded from each plot leaving two border rows and converted to q/ha and all the data were analysed as per RBD procedure (Gomez and Gomez 1984).

It can be observed from the (Table 1) that, over three seasons at 60 DAT (81 days-crop age) there was peak activity of WBPH. The data on the incidence of WBPH during *kharif* 2016 revealed that at 60 DAT, the control treatment registered 44.66 insect/hill, which was significantly higher from rest of the treatments. The treatment T₆ supported lowest WBPH (19.67/hill) which remained at par with T₇ (23.43 insects/hill) and T₂ (27.72 nymphs/hill). During Summer 2016-17, at 60 DAT, T₆ had 5.24 insect/hill, which was at par with T₇, T₈, T₅, T₄ and T₃. The treatment T₁ and T₂ had relatively higher WBPH population (8.19-8.37/hill). During *kharif* 2017, at 60 DAT, the treatment T₆ exhibited its superiority over rest of the treatments by supporting least numbers of WBPH/hill (9.21) that remained statistically at par with T₇ (10.53), T₈ (10.98), T₅ (11.22), T₃ (11.92) and T₄ (12.85 insects/hill). At this stage, the control treatment supported highest number of WBPH/hill (24.18) and remained significantly different from all other treatment.

The pooled data of WBPH population (Table 2) revealed that, at 60 DAT, T₆ supporting an average of 11.37 insects/hill was found equally effective to T₇ (13.23 insects/hill) in containing the WBPH as compared to rest of the treatments and the control (27.66 insects/hill).

During *kharif*, 2016, the grain yield was highest in T₇ (36.70 q/ha), which was at par with T₈, T₆ and T₅ in which the yield ranged from 34.56-36.50 q/ha (Table 2). During summer 2016-17, T₆ produced highest grain yield (42.51 q/ha), which was at par with only T₇ (40.15 q/ha). In *kharif* 2017, T₆ resulted in highest grain yield (39.90 q/ha), which remained at par with the same T₇ (39.15 q/ha). Pooled mean revealed that, T₆ produced highest mean grain

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Table 1 Effect of zinc on the incidence of WBPH in rice during 2016-17

Treatment	Mean WBPH population (numbers/hill)																
	Kharif 2016							Summer 2016-17							Kharif 2017		
	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT		
T ₁ : ZnSO ₄ basal (25 kg/ha)	3.20 (1.91) ^b	13.93 (3.79) ^b	28.24 (5.36) ^{bc}	17.90 (4.28) ^{bc}	8.90 (3.06) ^b	0.90 (1.18) ^b	4.70 (2.28) ^b	8.19 (2.95) ^b	5.94 (2.53) ^b	0.89 (1.17) ^{cd}	6.08 (2.56) ^{ab}	13.80 (3.77) ^b	14.21 (3.82) ^{bc}	6.02 (2.54) ^b	2.05 (1.59) ^{bc}		
T ₂ :ZnEDTA basal (40 kg/ha)	3.43 (1.98) ^b	14.57 (3.88) ^b	27.72 (5.30) ^{bc}	20.26 (4.50) ^{ab}	9.26 (3.10) ^b	0.95 (1.20) ^b	4.77 (2.28) ^b	8.37 (2.97) ^b	5.97 (2.53) ^b	1.14 (1.27) ^{bc}	6.21 (2.58) ^{ab}	12.99 (3.66) ^b	16.44 (4.11) ^b	5.13 (2.37) ^{bc}	2.11 (1.59) ^{bc}		
T ₃ : ZnSO ₄ FS (0.5%) (30 & 45 DAT)	3.13 (1.90) ^b	13.26 (3.71) ^b	33.93 (5.84) ^b	17.06 (4.16) ^{bc}	8.06 (2.88) ^{bc}	0.86 (1.17) ^b	4.56 (2.25) ^b	7.46 (2.82) ^{bc}	4.85 (2.30) ^{bc}	1.57 (1.43) ^b	5.36 (2.38) ^{bc}	10.76 (3.35) ^{bc}	11.92 (3.52) ^{bcd}	4.95 (2.33) ^{bc}	2.20 (1.63) ^b		
T ₄ : Zn EDTA FS (0.8%) (30 & 45 DAT)	2.93 (1.81) ^b	13.20 (3.69) ^b	33.00 (5.72) ^b	15.56 (4.00) ^{bc}	6.56 (2.66) ^{bcd}	0.80 (1.14) ^b	4.52 (2.23) ^b	7.19 (2.76) ^{bc}	4.27 (2.18) ^{bc}	0.45 (0.97) ^{de}	5.11 (2.33) ^{bc}	10.15 (3.26) ^{bcd}	12.85 (3.65) ^{bcd}	4.63 (2.25) ^{bcd}	1.13 (1.28) ^{cd}		
T ₅ : T ₁ + T ₃	2.76 (1.79) ^b	11.46 (3.46) ^{bc}	31.60 (5.64) ^{bc}	15.23 (3.93) ^{bc}	5.93 (2.52) ^{bcd}	0.78 (1.13) ^b	4.21 (2.16) ^b	6.84 (2.70) ^{bc}	4.10 (2.14) ^{bc}	1.11 (1.27) ^{bc}	4.01 (2.10) ^{bcd}	8.53 (3.00) ^{cd}	11.22 (3.41) ^{bcd}	3.61 (2.02) ^{cde}	1.21 (1.30) ^{cd}		
T ₆ : T ₂ + T ₄	2.26 (1.66) ^b	7.12 (2.76) ^d	19.67 (4.48) ^d	12.53 (3.61) ^c	3.53 (2.00) ^d	0.74 (1.11) ^b	3.38 (1.97) ^b	5.24 (2.34) ^c	2.97 (1.86) ^c	1.02 (1.23) ^{bc}	2.23 (1.63) ^d	5.68 (2.47) ^e	9.21 (3.09) ^d	2.15 (1.61) ^e	0.70 (1.09) ^d		
T ₇ : T ₁ + T ₄	2.40 (1.67) ^b	8.70 (2.99) ^{cd}	23.43 (4.88) ^{cd}	13.60 (3.74) ^{bc}	4.60 (2.25) ^{cd}	0.76 (1.12) ^b	3.75 (2.06) ^b	5.73 (2.49) ^{bc}	3.81 (2.07) ^{bc}	0.17 (0.82) ^e	2.98 (1.80) ^{cd}	6.09 (2.55) ^e	10.53 (3.31) ^{cd}	2.93 (1.84) ^{de}	1.32 (1.35) ^{bcd}		
T ₈ : T ₂ + T ₃	2.41 (1.70) ^b	8.90 (3.05) ^{cd}	29.86 (5.48) ^{bc}	14.13 (3.81) ^{bc}	5.13 (2.35) ^{cd}	0.76 (1.12) ^b	3.94 (2.10) ^b	6.40 (2.61) ^{bc}	3.99 (2.09) ^{bc}	1.01 (1.23) ^{bc}	3.46 (1.98) ^{bcd}	6.89 (2.72) ^{de}	10.98 (3.38) ^{cd}	4.14 (2.15) ^{bcd}	1.55 (1.42) ^{bc}		
T ₉ : Control	5.96 (2.54) ^a	26.13 (5.16) ^a	44.66 (6.72) ^a	32.06 (5.68) ^a	14.06 (3.80) ^a	2.76 (1.80) ^a	9.20 (3.08) ^a	14.13 (3.81) ^a	9.71 (3.19) ^a	5.47 (2.44) ^a	9.41 (3.13) ^a	19.73 (4.48) ^a	24.18 (4.93) ^a	9.52 (3.16) ^a	4.73 (2.28) ^a		
SE _m (±)	0.128	0.178	0.277	0.256	0.220	0.057	0.135	0.187	0.161	0.066	0.203	0.195	0.241	0.143	0.104		
CD (5%)	(0.38)	(0.53)	(0.83)	(0.77)	(0.66)	(0.17)	(0.40)	(0.56)	(0.48)	(0.20)	(0.61)	(0.58)	(0.72)	(0.43)	(0.31)		

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values, FS- foliar spray, DAT- days after transplanting. Means followed by the same letter are not significantly different from each other.

Table 2 Effect of zinc on the incidence of WBPH and grain yield in rice during 2016-17 (pooled)

Treatment	Pooled mean WBPH population (numbers/hill)						Grain yield (q/ha)			
	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	Overall mean	Kharif, 2016	Summer, 2016-17	Kharif, 2017	Pooled mean
T ₁ : ZnSO ₄ basal (25 kg/ha)	3.39 (1.88) ^{bc}	10.81 (3.28) ^b	16.88 (4.04) ^b	9.95 (3.12) ^b	3.95 (1.94) ^{bc}	9.00	28.10 ^{cd}	29.30 ^{ef}	27.90 ^{de}	28.43 ^d
T ₂ : ZnEDTA basal (40 kg/ha)	3.53 (1.92) ^b	10.78 (3.28) ^b	17.51 (4.13) ^b	10.45 (3.13) ^b	4.17 (1.99) ^b	9.29	28.59 ^{cd}	26.64 ^f	28.61 ^{cd}	27.95 ^d
T ₃ : ZnSO ₄ FS (0.5%) (30 & 45 DAT)	3.12 (1.81) ^{bcd}	9.53 (3.10) ^{bc}	17.77 (4.06) ^b	8.95 (2.93) ^{bc}	3.94 (1.98) ^b	8.66	31.40 ^{bc}	30.50 ^{def}	32.10 ^{bc}	31.33 ^c
T ₄ : Zn EDTA FS (0.8%) (30 & 45 DAT)	2.95 (1.76) ^{bcd}	9.29 (3.06) ^{bc}	17.68 (4.04) ^b	8.15 (2.81) ^{cd}	2.71 (1.63) ^{de}	8.16	30.80 ^{bc}	32.34 ^{de}	32.75 ^b	31.96 ^c
T ₅ : T ₁ + T ₃	2.52 (1.67) ^{cdef}	8.07 (2.87) ^{cd}	16.55 (3.92) ^{bc}	7.65 (2.70) ^{cd}	2.75 (1.70) ^{cd}	7.51	34.56 ^{ab}	34.12 ^{cd}	34.49 ^b	34.39 ^b
T ₆ : T ₂ + T ₄	1.74 (1.47) ^f	5.39 (2.40) ^e	11.37 (3.30) ^d	5.88 (2.36) ^f	1.75 (1.44) ^e	5.23	35.80 ^{ab}	42.51 ^a	39.90 ^a	39.40 ^a
T ₇ : T ₁ + T ₄	2.05 (1.53) ^{ef}	6.18 (2.53) ^e	13.23 (3.56) ^{cd}	6.78 (2.55) ^{def}	2.03 (1.47) ^{de}	6.05	36.70 ^a	40.15 ^{ab}	39.15 ^a	38.67 ^a
T ₈ : T ₂ + T ₃	2.21 (1.60) ^{def}	6.58 (2.62) ^{de}	15.75 (3.83) ^{bc}	7.42 (2.68) ^{cde}	2.56 (1.67) ^{de}	6.90	36.50 ^a	37.55 ^{bc}	33.60 ^b	35.88 ^b
T ₉ : Control	6.04 (2.49) ^a	18.35 (4.24) ^a	27.66 (5.15) ^a	17.09 (3.73) ^a	8.09 (2.84) ^a	15.45	24.83 ^d	21.45 ^g	23.92 ^e	23.40 ^e
Mean	1.79	3.04	4.00	2.92	1.85	-	31.92	32.73	32.49	32.38
SE _m (±)	0.086	0.099	0.135	0.106	0.084	-	1.676	1.369	1.316	0.804
CD (5%)	(0.24)	(0.30)	(0.38)	(0.30)	(0.25)	-	(5.02)	(4.11)	(3.95)	(2.41)

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values, Fs-foliar spray. Means followed by the same letter are not significantly different from each other.

yield of 39.40 q/ha. The grain yield was nearly 68% higher in T₆ as compared to control, while, T₇ accounted for 65% yield advantage over control. Hence, it can be inferred that, Zn had a positive role in enhancing the grain yield. Sudha and Stalin (2015) have reported that the application of zinc significantly increased the grain yield in rice due to increase in number of productive tillers/m² and number of filled grains per panicle. Prakash *et al.* (2017) have also observed a similar phenomenon.

Application of zinc to the rice crop was instrumental in curbing the WBPH population as compared to control in all the test seasons. Among various treatments, T₆ was the best treatment that could reduce WBPH number by 66.15% which was outstanding. Closely followed by T₆, the treatment T₇ caused 60.84% elimination of the target pest. Earlier workers like Panda (1976), Padhee and Mishra (1993) have also studied the induced defence effect of Zn against yellow stem borer and leaf folder in rice respectively. Hence, our finding derives ample support from the above findings. However, the field observation should be substantiated with further study of mechanism of induced resistance.

SUMMARY

The study on influence of Zn applied in forms of

fertilizer formulations was carried out against whitebacked planthopper (WBPH) [*Sogatella furcifera* (Horvath)] infesting rice under field conditions during *kharif* 2016, summer 2016-17 and *kharif* 2017 in the Central Research Farm, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. It was revealed that application of zinc to rice crop was instrumental in curbing the WBPH population. Basal application of Zn EDTA @ 40 kg/ha along with its foliar spray @ 0.8%, twice at 30 and 45 days after transplanting (DAT) (T₆) was the best treatment in reducing the number of WBPH population over seasons as well as in increasing the grain yield. The next better treatment was T₇ (ZnSO₄ basal @ 25 kg/ha + Zn EDTA foliar spray @ 0.8% twice at 30 and 45 DAT) which also reduced the WBPH population substantially. From the entire study, it was inferred that reduction in WBPH population in various Zn supplementations as compared to control may be attributed to influence of Zn on rice plant physiology. Uptake of zinc definitely altered the nutritional status of rice plant as a result of which the population build up of WBPH on rice was minimized.

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