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Non-preference mechanism of induced resistance in rice to white backed plant hopper through application of zinc

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Abstract
Influence of zinc in form of its sulphatic and EDTA formulations, applied as basal or foliar spray alone or in various combinations, against the white backed plant hopper (WBPH), *Sogatella furcifera* (Horvath), a major insect pest on rice, was studied under caged condition during *Kharif*, 2017 in the Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. It was observed that, basal application of Zn EDTA @ 40 kg/ha along with its foliar spray @ 0.8%, twice at 30 and 45 days after transplanting affected the nymphal and adult alightment as well as decreased the total number of eggs laid by the female and percent hatching of eggs. Zinc exercised a possible induced non-preference mechanism of resistance in rice to WBPH.

Keywords: Rice, $ZnSO_4$, Zn EDTA, white backed plant hopper

1. Introduction

Rice is cultivated in the most diverse ecosystems of tropical and sub-tropical parts of the world. But, there has been a serious decline in rice productivity in India because of infestation by a number of insect pests. By regular monitoring of rice field, farmers can manage this pest effectively by need based application of recommended insecticides [1]. However, adoption of intensive agricultural technology resulted in a high level of pest infestation in rice. Hence, cultivation of resistant varieties is an environmentally sound approach for insect pest management [2]. It has been reported that cultivation of brown plant hopper resistant varieties has compounded WBPH problem in rice, for which it has emerged as one of the major pests of rice [3]. Keeping in view the restoration of environmental quality, induction of resistance through the application of zinc fertilizer in rice to control a number of rice pest has already been studied by many workers. Induced resistance has tremendous potential in plants' defense mechanism. Biotic and abiotic elicitors trigger a cascade of pathways favouring production of a number of defensive chemicals which check the further invasion of the pest. Zinc is one such micronutrient which is reported to produce induced defense mechanism in rice against the sucking pests [4, 5]. Application of zinc triggers the formation of various secondary metabolites along with several antioxidative enzymes, which is helpful in inducing resistance against the insect.

Keeping this in view, a pot culture experiment was conducted to study the effect of Zn applied as fertilizers at various dosages on the white backed plant hopper infesting rice.

2. Materials and methods

Various non-preference mechanism studies were undertaken in the green house of the Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. Susceptible rice variety TN 1 was used as the test variety. Twenty day old seedlings of healthy TN 1 rice variety were used in various experiments as detailed hereunder:

2.1 Nymphal alightment

In this study nine different treatments (Table 1) were imposed, each facing three replications. Twenty day old seedlings of the test variety were transplanted in each pot (10 kg capacity) @ 2 seedlings/pot. Before planting all the basal application of zinc fertilizers were applied and the seedlings were kept covered by Mylar cages.

Watering was ensured to prevent the seedlings from wilting. Care was taken to disallow entry of any predator into the Mylar cages. Foliar spraying of the fertilizers was undertaken at 30 and 45 days after transplanting (DAT) in respective treatments (Table 1) after removing the Mylar cages. The treated plants were again caged after spraying. At 46 DAT, all the pots with different treatments were arranged in a circular fashion and simultaneously confined under a mosquito net as one experimental unit and at the center of the circle, pot with untreated TN 1 plants was kept. Nearly 300 nymphs of WBPH (mixture of 2nd and 3rd instar) collected from the insect rearing house were released on the central pot. Observation on nymphal settlement on different treatments was recorded at 6, 24, 48 and 72 hours after release. After each observation, the seedlings were disturbed to facilitate fresh orientation. The data on nymphal orientation and settling at different hours of observation were recorded and expressed in percent alightment [6].

2.2 Adult (female WBPH) alightment

In this experiment, the exact set up was placed as described in the nymphal alightment study. Nearly 100 female adults of WBPH collected from the insect rearing house were released on the central pot. Observation on female adult settlement on different treatments was recorded at 6, 24, 48 and 72 hours after release. The data on female adult orientation and settling at different hours of observation were recorded and expressed in percent adult alightment [6].

2.3 Oviposition study

In this study also nine different treatments (Table 1) were imposed, each facing five replications. Twenty day old seedlings of the test variety were transplanted in each pot (10 kg capacity) @ 2 seedlings/pot. All the basal application of zinc fertilizers was applied before planting and the seedlings were kept covered by Mylar cages. Moisture content was ensured to prevent the seedlings from wilting by need based watering. Care was taken to prevent entry of any predator into the cages. Foliar spraying of the fertilizers was undertaken at 30 and 45 DAT in respective treatment (Table 1). One day old adult female was released @ 1 gravid female into each pot at 46 DAT. After 7 days of release, the surviving females were removed from the pot. The potted plants were continuously observed to note the emergence of nymphs. The number of emerging nymphs was noted from each pot every day and transferred to rearing cage. This observation was continued till no nymphal emergence was observed. Then the plants were dissected and observed under a binocular research microscope attached to computer and searched for number of unhatched eggs. Thus, with respect to each treatment, the number of nymphs emerged from a pot and the number of unhatched eggs found from that pot accounted for the total number of eggs laid by the female. Thus, the total fecundity and unhatched eggs were recorded, treatmentwise. Unhatched eggs were expressed as percentage of total, which is sum of number of nymphs counted and the number of unhatched eggs [6].

$$\%\ \text{Unhatched eggs} = \frac{\text{Number of unhatched eggs}}{(\text{Number of nymphs} + \text{Number of unhatched eggs})} \times 100$$

2.4 Statistical analysis

The data thus, generated in various experiment were analysed as per Completely Randomized Block Design (CRBD) procedure [7].

3. Results

The data on nymphal alightment has been presented in Table 1. From this table, it was clearly indicated that the test insect could discriminate between various treatments and control, as more percent of nymphs were alighted on control plants (10.32%), which was significantly different from rest of the treatments. The treatment T_6 invited only 4.02% nymphs being at par with T_7 (4.32%). Other better treatment was T_8 (5.14%), which remained at par with T_5 (5.21%). After 24 hours, there was a slight change in the preference. In all the treatments, the percent nymphal alightment was more and the control invited 13.25% nymphs to orient on. At 48 hours after release, there was also increase in percent nymphal alightment in all the treatments and after 72 hours, the control treatment invited maximum 19.75% nymphs to alight on. The treatment T_6 invited least percent nymph (6.07), which was significantly not different from T_7 (6.62%). Rest other treatments allowed 7.32 to 9.53% nymphs to orient on various treated plants. As regards to mean performance, it can be observed that, the control pot, while invited nearly 15% of the nymphs towards them, at that time the other plants of different treatments invited nearly half of the nymphs of control treatment.

It is evident from the adult alightment study (Table 1), that significant variation between the treatments existed at different post release periods. At 6 hours after release, the control plot invited 13.06% adult as against 5.13% in T_6 to 9.73% orientation in T_2. The treatment T_6 that attracted 5.13% of the adult was statistically superior to rest of the treatments. More or less a same trend was witnessed at 24 hours after release, in which the same treatment T_6 invited only 5.85% adults, which was statistically different from other treatments. A similar orientation pattern was too noticed after 48 hours of release in different treatment. After 72 hours of release, it was observed that 18.23% adults were oriented towards the control plants, whereas, T_6 and T_7 attracted nearly 60% less adult as compared to control. Though the treatment T_1, T_2, T_3, T_4 didn't vary among themselves yet, basal application of treatments invited more adult orientation than foliar spray treatments. It was indicated in the table that the control pot attracted a mean of 15.64% adult towards them while, in rest of the treatments, the rate of orientation varied from 6.05 in T_6 to 10.65 in T_2. It was very clear that all the treatments were definitely superior to control treatment.

The data on the rate of oviposition and percent unhatching of eggs has been presented in Table 2. It was quite interesting to note that while, the average number of eggs laid in control was 86.2, at that time the treatment T_6 and T_7 could allow the adult females to lay 34.40 and 38.70 eggs, respectively. Though, there was a slight increase in rate of oviposition in other treatments, yet, it was clearly observed that all the treatment tested definitely accounted for less egg laying as compared to control. Hence, the role of zinc for the reduction in rate of oviposition by the female WBPH cannot be ruled out. With respect to percent unhatched eggs, there was no much variation between the treatments but least percent of unhatched eggs were recorded from control treatment. It was also observed that the treatment T_6 didn't allow 31.68% egg to hatch.

Table 1: Effect of zinc on WBPH nymphal and adults (female) alightment on rice

Treatments	Nymphal alightment at different hours after release* (%)					Adults (female) alightment at different hours after release* (%)				
	6 hour	24 hour	48 hour	72 hour	Mean	6 hour	24 hour	48 hour	72 hour	Mean
T_1: $ZnSO_4$ basal (25kg/ha)	7.68	8.11	8.16	8.25	8.05	9.38	10.09	11.15	11.21	10.46
T_2: Zn EDTA basal (40 kg/ha)	7.96	8.23	9.32	9.53	8.76	9.73	10.53	11.03	11.32	10.65
T_3: $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	6.33	7.59	8.21	8.47	7.65	8.25	9.27	9.76	10.12	9.35
T_4: Zn EDTA Foliar spray @ 0.8% (8g/l of water) twice at 30 and 45 DAT	6.15	7.36	8.67	8.72	7.73	8.17	9.02	9.59	10.19	9.24
T_5: $ZnSO_4$ basal (25kg/ha) + $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	5.21	6.91	7.24	7.44	6.70	7.32	8.13	8.38	8.95	8.20
T_6: Zn EDTA basal (40 kg/ha)+ Zn EDTA Foliar spray@ 0.8% (8 g/l of water)twice at 30 and 45 DAT	4.02	5.33	6.02	6.07	5.36	5.13	5.85	6.12	7.10	6.05
T_7: $ZnSO_4$ basal(25kg/ha)+ Zn EDTA Foliar spray @ 0.8% (8 g/l of water) twice at 30 and 45 DAT	4.32	5.48	6.46	6.62	5.72	6.51	7.04	7.32	7.16	7.01
T_8: Zn EDTA basal (40 kg/ha) + $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	5.14	6.03	7.11	7.32	6.40	7.09	7.88	8.42	8.09	7.87
T_9: Control	10.32	13.25	15.89	19.75	14.80	13.06	14.01	17.26	18.23	15.64
$SE_m(\pm)$	0.282	0.276	0.311	0.379	-	0.251	0.228	0.247	0.481	-
C.D.(0.05)	0.84	0.83	0.93	1.14	-	0.75	0.68	0.74	1.44	-

*Mean of three replications

Table 2: Effect of zinc on oviposition by WBPH females on rice

Treatments	Number of eggs laid*	Unhatched eggs* (%)
T_1: $ZnSO_4$ basal (25kg/ha)	61.20	22.30
T_2: Zn EDTA basal (40 kg/ha)	59.60	22.10
T_3: $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	58.90	23.20
T_4: Zn EDTA Foliar spray @ 0.8% (8g/l of water) twice at 30 and 45 DAT	55.50	23.60
T_5: $ZnSO_4$ basal (25kg/ha) + $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	46.80	25.90
T_6: Zn EDTA basal (40 kg/ha)+ Zn EDTA Foliar spray@ 0.8% (8 g/l of water)twice at 30 and 45 DAT	34.40	31.68
T_7: $ZnSO_4$ basal(25kg/ha)+ Zn EDTA Foliar spray @ 0.8% (8 g/l of water) twice at 30 and 45 DAT	38.70	28.35
T_8: Zn EDTA basal (40 kg/ha) + $ZnSO_4$ foliar spray @ 0.5% (5g/l of water) twice at 30 and 45 DAT	45.40	26.77
T_9: Control	86.20	8.80
$SE_m(\pm)$	0.542	0.303
C.D.(0.05)	1.56	0.87

*Mean of five replications

4. Discussion

Non-preference is one of the main mechanisms of host plant resistance [8], which is helpful to ascertain the relative resistance level of a test variety to a particular insect pest [9]. In the present study, we observed that, application of zinc at different doses produced a clear cut nymphal orientation preference at 72 hours after release. The treatment T_6 caused 6.07% nymphal alightment on the treated plants as compared to control. Thus, zinc must have induced the production of some secondary metabolites in the treated TN 1 plants as a result of which the nymphal preference in T_6 was very less than the control and other treatments. The treatment T_7 also exhibited a similar response lying at par with T_6. Less number of BPH as well as WBPH populations per hill under caged condition due to Zn application in rice was also observed by earlier worker [10]. Similarly, higher preference of WBPH adult towards untreated control as compared to Zn treated plants, as has been witnessed in the present study also has been documented [11]. Hence, the present finding aims at a possible induced non-preference mechanism of resistance in rice plants treated with Zn.

As regards to rate of oviposition, we also evidenced that the female WBPH preferred untreated plant to oviposit more because of the suitable ovipositional environment inside the plant tissue. Reduced number of egg laying by WBPH female in T_6, T_7, T_8 and T_4 clearly demonstrated zinc induced impairment at the tissue level. Thus, zinc must have brought out some physiological imbalance within the plant system, as a result of which the adult female laid fewer number of eggs (nearly two and half time less) as compared to untreated plant. Though, we could not come across any literature to substantiate our finding, many scientists have studied lower oviposition on resistance variety than on susceptible variety by brown plant hopper females [12, 13, 14]. Hence, decrease in the rate of oviposition as evidenced, particularly in T_6 and T_7 gives an impression that definitely some resistance has been afforded by the Zn treated plants to adult females of WBPH, which needs further confirmation through antibiosis and biochemical analysis study.

5. Conclusion

It can be concluded from the entire study that application of Zn in various forms either to soil or plants has caused uptake of zinc by the rice plants which ultimately might have brought a physiological change in the treated rice plants. As a result of which there was reduced nymphal and female adult attraction to treated plants as compared to control. It was evidenced that the treatment T_6 (basal application of Zn EDTA @ 40 kg/ha along with its foliar spray @ 0.8%, twice at 30 and 45 days after transplanting) was the most superior treatment in enhancing the level of non-preference in the treated rice plants as compared to untreated plants.

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