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Field evaluation of synthetic elicitors as attractants to predators of rice brown planthopper, *Nilaparvata lugens* (Stal.) (Delphacidae: Homoptera)

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Abstract
In the present study at Madurai during 2015 – 16, efficacy of synthetic elicitors was evaluated as attractant to predators of brown planthopper, *Nilaparvata lugens* (Stal.) under field conditions. Significantly greater numbers of predators were attracted to Linalool and 2,4-D treated plants resulting in reduction in population load of BPH than buffer and control. Among all the evaluated treatments, Linalool @ 10 mM harboured maximum number of 19.21 mirids/5 hills and 13.32 coccinellids/5 hills over the study period as compared to 13.66 mirids/5 hills, and 8.34 coccinellids/5 hills in control. Thus, Linalool@ 10 mM recorded 1.88 and 1.95 fold increase in population of mirids and coccinellids and 1.70 fold decrease in BPH population as compared to control. By testing the field efficacy of synthetic elicitors as attractants to predators of *N. lugens*, they can be used as potential semiochemicals for the sustainable management of brown planthopper on rice. Hence the present study evaluates the potentiality of four different synthetic elicitors at three various concentrations as attractants to predators of *N. lugens*.

Keywords: Brown planthopper, *N. lugens*, Predators, Rice, Synthetic elicitors

1. Introduction

Rice is the staple food for a large part of the world's human population, especially in East, South and Southeast Asia, making it the second most consumed cereal grain. Among the rice growing countries, India has the largest area under rice crop and ranked second in production next to China. Rice alone contributed 43 per cent of the total food grain production and 46 per cent of total cereal production of the country. In India, rice is grown over an area of 43.97 million hectares with a production of 104.32 million tonnes [2]. In India, about 300 species of insect pests have been reported to devastate rice crop, out of which 20 have been found to be the major pests causing 21 to 51 per cent yield loss [3]. Among the several insect pests of rice, the rice hoppers namely brown planthopper (BPH), *Nilaparvata lugens* (Stal.); white backed planthopper (WBPH), *Sogatella furcifera* (Horvath) and green leafhopper (GLH), *Nephotettix virescens* (Distant) are considered as "Green revolution introduced pests". BPH is a major insect pest which severely damage the rice crop successively every year, in most of the Asian countries. The extent of yield loss due to BPH ranged from 1 to 33 per cent in India [8]. Rice brown planthopper damaged the plants directly by sucking the plant sap as well as oviposited in plant tissues, thereby resulted in plant wilting or hopper burn [10]. Damage was also caused indirectly by transmitting plant viral diseases like grassy stunt and wilted stunt viruses [6].

In recent years, BPH invasion has intensified across Asia and led to heavy yield losses in rice. Factors that intensified the BPH infestations are injudicious use of inorganic nitrogenous fertilizers, insecticides that caused pest resurgence, elimination of natural enemies, development of insecticide resistance and lack of integration of different pest management tactics. Major emphasis is given on integrated management approaches in the present context of environmental safety. Management of brown planthopper using semiochemicals is gaining importance due to their target specificity and environmental safety.

Plants responded to herbivore inflicted injury/attack and tailored their induced direct and indirect defences accordingly. Chemical defences that target the herbivore directly resulted in herbivore death or retarded development, whereas indirect defences increased herbivore mortality through the recruitment of parasitoids and predators with volatile signals. Synthetic elicitors can induce plant immune responses and are structurally distinct from natural plant defense inducers such as general or race-specific elicitors or endogenous plant defense signalling molecules. Synthetic elicitors trigger defense reactions by mimicking interactions of natural elicitors or defense signalling molecules with their respective cognate plant receptors or by interfering with other defense signalling components [11]. Alternatively to the use of elicitor lures, plants can be treated with an exogenous elicitor in the field to induce production and emissions of their own blend of volatiles, and as a result attract natural enemies [7]. The elicitors are currently the best option to enhance the attractiveness of cultivated plants to biological control agents [9].

Synthetic chemical elicitors of plant defense have been touted as a powerful means for sustainable crop protection. Yet, they have never been successfully applied to control insect pests in the field [12]. Keeping this in view, the present study was carried out to evaluate the efficacy of four different synthetic elicitors as attractants to predators of rice brown planthopper under field conditions. Thus by testing the field efficacy of synthetic elicitors as attractants to predators of rice brown planthopper, they can be used as a potential semiochemical for the sustainable management of *N. lugens* on rice.

2. Materials and Methods

The experiment was conducted in farmer's field under the supervision of Department of Entomology, Agriculture College and Research Institute, Madurai, Tamil Nadu, India during 2015 - 2016.

2.1 Field study

Four synthetic elicitors, Indole, 2,4-D, Linalool and Benzothiadiazole (BTH) were tested at three different dosages (1, 10 and 100 mM). The treatments were compared with buffer and control and were replicated thrice. Size of each plot was 5x 4 m^2. Five plants per treatment were selected and labelled. Each selected plant was individually damaged with a needle on rice leaves with 200 pricks and then the damage site was treated by applying 40 µl of each Indole, 2,4-D, Linalool and Benzothiadiazole (BTH) at different dosages (50 mM sodium phosphate buffer titrated with 1 M citric acid until pH 8, including 0.01% Tween). In buffer treatment sodium phosphate buffer was treated @ 40 µl of 50 mM solution whereas the control plants were kept non-manipulated without application. In each treatment, population of *N. lugens* and its predators were recorded before application as well as on 1, 3, 5 and 7 days after the application (DAA) of elicitors.

2.2 Statistical analysis

The field experiment was designed under Randomized Block Design (RBD). The means for the population counts were separated by Duncan's Multiple Range Test (DMRT). The statistical analysis was performed by AGRES. Two way analysis of variance (ANOVA) was conducted on the population counts to test the level of significance of the difference in response between the treatments under field conditions.

3. Results and Discussion

3.1 BPH population: The mean BPH population recorded after the application of elicitors ranged from 62.33 to 106.22 nos./5 hills over the study period. The mean BPH population was lowest in Linalool @ 10mM (62.33 nos./5 hills) and it was significantly different from other treatments. It was followed by 2,4-D @ 10 mM (68.33 nos./5 hill) and Linalool @ 100mM (73.59 nos./ 5 hills). A mean BPH population of 105.33 nos./5 hills was recorded in buffer @ 50mM whereas the control had maximum population of 106.22 nos./5 hills and both were on par with each other. The BPH population in Linalool @ 10mM was 1.50 times lesser as compared to the pre-count and 1.70 times lesser compared to the control. BPH population recorded at 1 DAA of elicitors increased in all the treatments as compared to pre-count and then the population started declining from 3 DAA. At 5 DAA of the elicitors the BPH population was minimum of 73.02 nos./5 hills followed by 7 DAA with 74.50 nos./5 hills. Linalool @ 10mM, at 5 and 7 DAA recorded the minimum BPH population of 47.87 and 48.23 nos./5 hills, respectively and both were on par with each other and were significantly different from all other evaluated treatments. The next best treatments were Linalool @ 10mM at 3 DAA (50.66 nos./5 hills) and 2,4-D @ 10mM at 5 DAA (51.23 nos./5 hills) and both were on par with each other (Table 1). The BPH population in the control ranged from 101.34 to 110.65 nos./5 hills, while in the buffer it ranged between 102.11 and 108.47 nos./5 hills. Linalool @ 10mM at 5 and 7 DAA, had nearly 2.31 and 2.29 times lesser BPH population compared to the control (Table 1). The results are in agreement with the findings of Kawasumi [4], who reported that synthetic chemical elicitors can be used to control pests by eliciting plant defense and are also powerful tools to elucidate the mechanisms behind plant defense responses. Similarly, Zhaojun Xin [12] reported 2,4-D as a potent elicitor, highly attractive to the brown planthopper, *N. lugens* and after its application in a field experiment turned rice plants into living traps for *N. lugens* by attracting parasitoids.

3.2 Mirid bug population

The mirid bug population ranged from 14.36 to 19.21 nos./5 hills during the study period after the application of elicitors, whereas the buffer and control had 12.40 and 13.66 nos./5 hills. Linalool @ 10mM recorded the maximum mirid population of 19.21 nos./5 hills followed by 2,4-D @ 10mM and 2,4-D @100mM with a mean population of 17.77 and 16.94 nos./ 5 hills, respectively. The mean mirid bug population was approximately 1.57 and 1.41times higher in Linalool @ 10mM than the pre-count and control, respectively. Mirid bug population after the application of elicitors increased in all the treatments as compared to pre-count. The mirid bug population was maximum at 7 DAA of elicitors (18.67 nos./5 hills) followed by 5 DAA (16.74 nos./5 hills). As the days progressed after the application of elicitors the mirid population showed an increasing trend. Maximum mirid bug population was observed in Linalool @ 10mM at 7 DAA (23.13 nos./5 hills) and 2,4-D @ 10mM at 7 DAA (22.95 nos./5 hills) and both were on par with each other and were significantly different from all other treated treatments. The efficacy of the elicitors in their decreasing order of merit was Linalool @ 10mM at 5 DAA (21.87 nos./5 hills), Benzothiadiazole @10mM at 7 DAA (19.88 nos./ 5 hills), Indole @ 1mM at 7 DAA (19.84 nos./5 hills), 2,4-D @100mM at 7 DAA (19.65 nos./5 hills) and Benzothiadiazole @ 100mM at 7 DAA (19.45 nos./5 hills) and 2,4-D @ 10 mM at 5 DAA (19.57 nos./5 hills). The best treatment Linalool @ 10mM at 7 DAA attracted 1.88 times more mirids when compared to the control (Table 2). Similar results are also reported by Lou [5], who studied the impact of rice genotypes on the predation rates of the predator, *Cyrtorhinus lividipennis* Reuter, for eggs of the rice brown planthopper (BPH), *N. lugens* (Stal.), and their relation to the rice volatiles in a two-choice test. The results of predation rates showed that rice volatiles played an important role in the foraging behaviour of *C. lividipennis*.

3.3 Coccinellid population

The mean coccinellid population ranged from 9.75 to 13.32 nos./5 hills after the application of elicitors. The maximum mean population was found in Linalool @ 10mM (13.32 nos./5 hills) and it was significantly different from all other evaluated treatments. It was followed by 2,4-D @ 10mM, Benzothiadiazole @ 10mM and with a mean population of 11.56 and 11.38 nos./5 hills, respectively and all were on par with each other. The next best elicitors were Linalool @100mM, Indole @ 100mM and 2,4-D @ 100mM representing 11.31, 11.29 and 11.34 nos./5 hills, respectively and were on par with each other. The minimum mean population of 8.34 nos./5 hills was recorded in control. Buffer @ 50mM had a population of 9.14 nos./5 hills which was also on par with Indole @ 10mM and Benzothiadiazole @ 1mM. After the application of elicitors, coccinellid population increased in all the tested treatments as compared to pre-count. The highest coccinellid population of 13.91 nos./5 hills was recorded at 7 DAA of elicitors followed by 5 DAA and 3 DAA representing a population of 11.35 and 9.59 nos./ 5 hills, respectively. Linalool @10mM at 7 DAA recorded maximum cocinellid population (17.33 nos./5 hills) and was significantly different from all other tested elicitors. In this treatment, an approximately 1.95 times higher coccinellid population was observed as compared to pre-count and control. It was followed by 2,4-D @100mM at 7 DAA, Linalool 100mM at 7 DAA and Linalool 1mM at 7 DAA with a population of 15.43, 15.23 and 15.23 nos./5 hills, respectively and all were on par with each other. The next best treatments were Benzothiadiazole @ 10mM at 7 DAA and 2,4-D @ 10mM at 7 DAA with a population of 15.03 and 14.98 nos./5 hills, respectively and were on par with each other (Table 3). Reviews showing efficacy of synthetic elicitors against coccinellids of herbivores are scanty. However, broadly we can corroborate the present findings with Alborn [1], who reported that elicitors act as attractants for natural enemies of pest.

Table 1: Evaluation of elicitors on brown planthopper, *N. lugens* population under field conditions

Treatment		BPH population (nos./5 hills)					Mean
		P1	P2	P3	P4	P5	
		Pre- count	1 DAA	3 DAA	5 DAA	7 DAA	
T_1	Indole @ 1mM	118.21 (10.87)^{Z}	128.76 (11.34)^{Z}	78.56 (8.86)^{QR}	75.67 (8.70)^{O}	77.33 (8.79)^{P}	90.08 (9.49)^{k}
T_2	Indole @ 10mM	112.88 (10.62)^{Z}	122.65 (11.07)^{Z}	79.23 (8.90)^{RS}	62.88 (7.93)^{FG}	64.38 (8.02)^{H}	82.29 (9.07)^{h}
T_3	Indole @ 100mM	98.84 (9.94)^{X}	106.34 (10.31)^{Z}	92.10 (9.60)^{Z}	87.56 (9.36)^{W}	88.35 (9.40)^{X}	93.59 (9.67)^{k}
T_4	2,4 - D @ 1mM	89.99 (9.49)^{Y}	98.32 (9.91)^{Z}	88.29 (9.40)^{WX}	85.45 (9.24)^{U}	86.32 (9.29)^{V}	89.60 (9.47)^{i}
T_5	2,4 - D @ 10mM	103.84 (10.19)^{Z}	113.99 (10.67)^{Z}	55.67 (7.46)^{D}	51.23 (7.16)^{B}	52.43 (7.24)^{C}	68.33 (8.27)^{b}
T_6	2,4 - D @ 100mM	109.67 (10.47)^{Z}	118.73 (10.89)^{Z}	81.78 (9.04)^{T}	78.12 (8.84)^{Q}	79.87 (8.94)^{S}	89.63 (9.47)^{j}
T_7	Linalool @ 1mM	98.41 (9.92)^{Z}	107.44 (8.36)^{Z}	69.84 (8.36)^{N}	66.49 (8.15)^{K}	68.23 (8.26)^{LM}	78.00 (8.83)^{e}
T_8	Linalool @ 10mM	93.33 (9.66)^{Z}	102.55 (10.12)^{Z}	50.66 (7.12)^{B}	47.87 (6.92)^{A}	48.23 (6.94)^{A}	62.33 (7.89)^{a}
T_9	Linalool @ 100mM	92.43 (9.61)^{Z}	101.13 (10.05)^{Z}	65.34 (8.08)^{IJ}	62.88 (7.93)^{FG}	64.99 (8.06)^{HI}	73.59 (8.58)^{c}
T_{10}	BTH @ 1mM	107.76 (10.38)^{Z}	116.32 (10.78)^{Z}	68.78 (8.29)^{M}	65.88 (8.12)^{JK}	67.78 (8.23)^{L}	79.69 (8.93)^{g}
T_{11}	BTH @10mM	108.22 (10.40)^{Z}	110.32 (10.50)^{Z}	62.34 (7.90)^{F}	58.99 (7.68)^{E}	59.49 (7.71)^{E}	72.79 (8.53)^{d}
T_{12}	BTH @100mM	101.34 (10.07)^{Z}	119.11 (10.91)^{Z}	63.54 (7.97)^{G}	65.44 (8.09)^{IJ}	66.45 (8.15)^{K}	78.64 (8.87)^{f}
T_{13}	Buffer@ 50mM	101.55 (10.08)^{Z}	102.11 (10.10)^{Z}	104.52 (10.22)^{Z}	106.21 (10.31)^{Z}	108.47 (10.41)^{Z}	105.33 (10.26)^{l}
T_{14}	Control	98.95 (9.95)^{Z}	101.34 (10.06)^{Z}	105.33 (10.26)^{Z}	107.54 (10.37)^{Z}	110.65 (10.52)^{Z}	106.22 (10.31)^{l}

Mean	P1	P2	P3	P4	P5
	102.85 (10.12)^{d}	110.65 (10.51)^{e}	76.14 (8.68)^{c}	73.02 (8.49)^{a}	74.50 (8.58)^{b}

	Treatment	Period	T x P
SEd	0.001	0.006	0.023
CD (*P*=0.05)	0.018	0.011	0.042

*Mean of three replications, Figures in parentheses are square root transformed values. In the column, means followed by same letter (lower case for synthetic elicitors and time; upper case for elicitors(S) x time (T);) are not significantly different (*P*=0.05) by DMRT.*DAA-Days after application.

Table 2: Evaluation of elicitors on predatory mirid bug population under field conditions

Treatment		Mirid bug population (nos./5 hills)					Mean
		P1	P2	P3	P4	P5	
		Pre- count	1 DAA	3 DAA	5 DAA	7 DAA	
T_1	Indole @ 1mM	11.34 (3.37)^{VW}	12.34 (3.51)$^{Q-T}$	14.34 (3.79)$^{J-L}$	17.45 (4.18)^{EF}	19.84 (4.45)^{C}	15.99 (4.00)^{e}
T_2	Indole @ 10mM	10.65 (3.26)^{X}	11.73 (3.42)$^{T-V}$	13.82 (3.72)$^{K-M}$	15.37 (3.92)$^{G-I}$	17.84 (4.22)^{DE}	14.69 (3.83)^{fg}
T_3	Indole @ 100mM	12.83 (3.58)$^{O-R}$	13.82 (3.72)$^{K-M}$	15.38 (3.92)$^{G-I}$	17.34 (4.16)^{EF}	18.54 (4.31)^{D}	16.27 (4.03)^{d}
T_4	2,4 - D @ 1mM	13.02 (3.61)$^{N-R}$	14.44 (3.80)$^{J-L}$	14.87 (3.86)$^{H-J}$	16.93 (4.11)^{F}	18.46 (4.30)^{D}	16.18 (4.02)^{d}
T_5	2,4 - D @ 10mM	10.45 (3.23)^{X}	12.76 (3.57)$^{P-R}$	15.78 (3.97)^{G}	19.57 (4.42)^{C}	22.95 (4.79)^{A}	17.77 (4.22)^{b}
T_6	2,4 - D @ 100mM	13.74 (3.71)$^{L-N}$	14.52 (3.81)^{JK}	15.77 (3.97)^{G}	17.83 (4.22)^{DE}	19.65 (4.43)^{c}	16.94 (4.12)^{bc}
T_7	Linalool @ 1mM	11.53 (3.40)^{UV}	12.63 (3.55)$^{P-S}$	13.27 (3.64)$^{M-P}$	15.43 (3.93)$^{G-I}$	17.93 (4.23)^{DE}	14.82 (3.85)^{f}
T_8	Linalool @ 10mM	12.32 (3.51)$^{R-T}$	14.87 (3.86)$^{H-J}$	16.98 (4.12)^{F}	21.87 (4.68)^{B}	23.13 (4.81)^{A}	19.21 (4.38)^{a}
T_9	Linalool @ 100mM	10.78 (3.28)^{WX}	11.34 (3.37)^{VW}	12.39 (3.52)$^{Q-T}$	15.64 (3.95)^{GH}	18.05 (4.25)^{DE}	14.36 (3.79)^{gh}
T_{10}	BTH @ 1mM	13.27 (3.64)$^{M-P}$	12.84 (3.58)$^{O-R}$	13.93 (3.73)$^{K-M}$	15.77 (3.97)^{G}	17.34 (4.16)$^{E-F}$	14.97 (3.87)^{e}
T_{11}	BTH @10mM	12.82 (3.58)$^{P-R}$	13.26 (3.64)$^{M-P}$	15.88 (3.98)^{G}	17.55 (4.19)$^{E-F}$	19.88 (4.46)^{C}	16.64 (4.08)^{cd}
T_{12}	BTH @100mM	11.49 (3.39)^{UV}	12.01 (3.47)$^{S-V}$	13.03 (3.61)$^{N-Q}$	17.85 (4.22)$^{D-E}$	19.45 (4.41)^{C}	15.59 (3.95)^{e}
T_{13}	Buffer@ 50mM	10.33 (3.21)^{X}	11.45 (3.38)$^{U-V}$	12.56 (3.54)$^{P-S}$	12.03 (3.47)$^{S-U}$	13.55 (3.68)$^{M-O}$	12.40 (3.52)^{i}
T_{14}	Control	11.74 (3.43)$^{T-V}$	12.32 (3.51)$^{R-T}$	13.77 (3.71)^{LM}	13.77 (3.71)^{LM}	14.76 (3.84)$^{I-J}$	13.66 (3.70)^{h}

Mean	P1	P2	P3	P4	P5
	11.88 (3.44)^{e}	12.88 (3.59)^{d}	14.41 (3.80)^{c}	16.74 (4.10)^{b}	18.67 (4.32)^{a}

	Treatment	Period	T x P
SEd	0.023	0.014	0.051
CD (*P*=0.05)	0.045	0.027	0.099

*Mean of three replications, Figures in parentheses are square root transformed values. In the column, means followed by same letter (lower case for synthetic elicitors and time; upper case for elicitors(S) x time (T);) are not significantly different (*P*=0.05) by DMRT.*DAA-Days after application.

Table 3: Evaluation of elicitors on predatory coccinellid population under field conditions

Treatment		Coccinellid population (nos./5 hills)					Mean
		P1	P2	P3	P4	P5	
		Pre- count	1 DAA	3 DAA	5 DAA	7 DAA	
T_1	Indole @1mM	8.34 (2.89)$^{U-Y}$	8.87 (2.94)$^{S-V}$	10.41 (3.23)$^{M-O}$	11.28 (3.36)$^{I-L}$	14.03 (3.75)^{DE}	11.15 (3.34)$^{b-d}$
T_2	Indole @10mM	6.78 (2.60)^{Y}	6.98 (2.87)^{Y}	8.35 (2.89)$^{U-Y}$	10.45 (3.23)$^{M-O}$	13.23 (3.64)^{EF}	9.75 (3.12)^{f}
T_3	Indole @100mM	8.08 (2.84)$^{W-Y}$	8.83 (3.02)$^{S-V}$	10.58 (3.25)$^{L-O}$	11.54 (3.40)$^{I-K}$	14.22 (3.77)^{CD}	11.29 (3.36)^{bc}
T_4	2,4 - D @1mM	7.98 (2.82)^{XY}	8.03 (2.91)$^{W-Y}$	9.89 (3.14)$^{O-R}$	11.78 (3.43)$^{H-J}$	14.02 (3.74)^{DE}	10.93 (3.31)^{cd}
T_5	2,4 - D @10mM	7.56 (2.75)^{Y}	8.96 (2.99)$^{S-V}$	9.85 (3.14)$^{O-R}$	12.45 (3.53)$^{F-H}$	14.98 (3.87)^{BC}	11.56 (3.40)^{b}
T_6	2,4 - D @100mM	8.27 (2.88)$^{V-Y}$	8.87 (2.86)^{KV}	10.02 (3.16)$^{O-Q}$	11.03 (3.32)$^{J-M}$	15.43 (3.93)^{B}	11.34 (3.37)^{bc}
T_7	Linalool @1mM	7.94 (2.82)^{Y}	8.36 (2.81)$^{U-Y}$	9.49 (3.08)$^{P-S}$	11.65 (3.41)$^{H-K}$	15.23 (3.90)^{B}	11.18 (3.34)$^{b-d}$
T_8	Linalool @10mM	8.93 (2.99)$^{S-V}$	9.94 (2.64)$^{O-R}$	11.34 (3.37)$^{I-L}$	14.65 (3.83)$^{B-D}$	17.33 (4.16)^{A}	13.32 (3.65)^{a}
T_9	Linalool @100mM	6.28 (2.51)^{Y}	7.92 (2.84)^{Y}	9.23 (3.04)$^{R-T}$	12.84 (3.58)^{FG}	15.23 (3.90)^{B}	11.31 (3.36)^{bc}
T_{10}	BTH @1mM	6.34 (2.52)^{Y}	6.93 (2.73)^{Y}	8.65 (2.94)$^{T-X}$	10.23 (3.20)^{NP}	13.87 (3.72)^{DE}	9.92 (3.15)^{f}
T_{11}	BTH @10mM	7.87 (2.81)^{Y}	8.10 (2.80)$^{W-Y}$	10.32 (3.21)$^{M-O}$	12.06 (3.47)$^{G-I}$	15.03 (3.88)^{BC}	11.38 (3.37)^{bc}
T_{12}	BTH @100mM	6.87 (2.62)^{Y}	7.01 (2.69)^{Y}	9.03 (3.00)$^{S-U}$	10.94 (3.31)$^{K-N}$	13.75 (3.71)^{DE}	10.18 (3.19)^{e}
T_{13}	Buffer@ 50mM	8.32 (2.88)$^{U-X}$	8.87 (2.86)$^{S-V}$	9.02 (3.00)$^{S-U}$	9.23 (3.04)^{PT}	9.45 (3.07)^{QS}	9.14 (3.02)^{f}
T_{14}	Control	7.76 (2.79)^{Y}	7.72 (2.78)^{Z}	8.05 (2.84)$^{W-X}$	8.72 (2.95)$^{T-W}$	8.88 (2.98)$^{S-V}$	8.34 (2.89)^{g}

	P1	P2	P3	P4	P5
Mean	7.67 (2.76)[e]	8.24 (2.87)[d]	9.59 (3.09)[c]	11.35 (3.37)[b]	13.91 (3.72)[a]

	Treatment	Period	T x P
SEd	0.028	0.017	0.620
CD (*P*=0.05)	0.055	0.033	0.122

*Mean of three replications, Figures in parentheses are square root transformed values. In the column, means followed by same letter (lower case for synthetic elicitors and time; upper case for elicitors(S) x time (T);) are not significantly different (*P*=0.05) by DMRT.*DAA-Days after application.

4. Conclusion

The present study concluded that rice plants treated with linalool @10mM at 7 DAA harboured maximum number of mirids, coccinellids and the minimum BPH population load as compared to all other treatments. Linalool @ 10mM recorded 1.74 and 2.27 fold increase in population of mirids and coccinellids as well as 1.69 fold decrease in BPH population as compared to control. Even though, the preliminary results have shown that beneficial insects responded to the tested elicitors, further experiments are needed to verify the functions of these elicitors over multiple seasons as needed. Current research in this area focuses on the possibility of exploiting the practical application of these in crop protection and hence this study provides baseline information.

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