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RK Murali Baskaran
Principal Scientist
(Agric. Entomology)
ICAR-National Institute of Biotic Stress Management, Baronda, Raipur 493 225, Chhattisgarh, India

KC Sharma
Senior Scientist
(Agric. Entomology)
ICAR-National Institute of Biotic Stress Management, Baronda, Raipur 493 225, Chhattisgarh, India

Jagdish Kumar
Director (Acting)
ICAR-National Institute of Biotic Stress Management, Baronda, Raipur 493 225, Chhattisgarh, India

Correspondence
RK Murali Baskaran
ICAR-National Institute of Biotic Stress Management, Baronda, Raipur 493 225, Chhattisgarh, India
rcrkm2013@gmail.com

Seasonal and relative abundance of stem-borer and leaf-folder in wet land rice eco-system

RK Murali Baskaran, KC Sharma and Jagdish Kumar

Abstract
Seasonal abundance of rice stem-borer and leaf-folder was monitored in wet land rice during *kharif* 2016 at ICAR-National Institute of Biotic Stress Management, Raipur by erecting yellow stem-borer sex pheromone and light traps. Three species of stem-borer including yellow stem-borer, *Scirpophaga incertulas*, stripped stem-borer, *Chilo suppressalis* and white stem-borer, *Scirpophaga innotata* were found attacking rice, among them, *Sc. incertulas* dominated. First catch of female of yellow stem-borer in light trap appeared during 1st week of August 2016 (31st MSW) which caused 1.1% dead heart, thereafter reached the first peak catch during 3rd week of August 2016 (33rd MSW) and second peak during 4th week of August 2016 (35th MSW) which caused the dead heart of 3.60 and 3.83%, respectively. Leaf-folder damage was low throughout the crop period. Relative humidity and rainfall were positively correlated with trap catches while maximum (26.0 ^{0}C to 29.3 ^{0}C) and minimum (17.4 ^{0}C to 25.5 ^{0}C) temperatures were positively correlated to damage caused by two insects.

Keywords: Rice, stem-borer, leaf-folder, sex pheromone and light traps, species complex, damage potential, weather parameters

1. Introduction
In Chhattisgarh, rice (*Oryza sativa* L.) occupies an average of 3.6 million hectares with the productivity, ranging between 1.2 to 1.6 t/ha depending upon the rainfall [1]. Out of more than 100 species of insects attacking rice, stem-borers are reported to cause economic crop losses up to 60% [2, 3] by developing symptoms of dead heart and white ear during active tillering and reproductive stages of the crop, respectively. Similarly, the leaf-folder which was considered as pests of minor importance had increased in abundance in late 1980's and the yield loss caused by it is estimated from 30 to 80% under epidemic situation [4, 5]. Meteorological factors play an important role in seasonal abundance, distribution and population build-up of stem-borer and leaf-folder [6-8]. The maximum damage to rice was reported during 36th and 37th MSW for yellow stem-borer [9, 10] and 45th MSW for leaf-folder [11]. Stem-borer species diversity in rice was recorded elsewhere in Indian sub-continent [12-19, 3] while three to eight species of leaf-folder were recorded across the country [20-22]. The present monitoring was carried out during *kharif* 2016 at Baronda farm, Raipur (situated in Chhattisgarh plain agro-climatic zone) to find out the activities of stem-borer and leaf-folder and their relationship with weather parameters and species complex, 1st appearance of female adults and number of broods.

2. Materials and Methods
2.1 Installation of traps
In Baronda farm of ICAR-National Institute of Biotic Stress Management, Raipur (N 210 23'0" E 81"49'36" 288 msl), rice yellow stem-borer sex pheromone trap @ 5 number/acre and one light trap (18 watt LED bulb) @ one number/acre were erected at six days after transplanting (*kharif* 2016) of Mahamaya rice cultivar. Yellow stem-borer sex pheromone lure (Scirpolure) , manufactured by Pest Control of India Ltd., Bengaluru was mounted in traps and installed in transplanted rice field, one in each corner of the field (10 m away from bund) and fifth one at the centre of the field. Male stem-borer adults caught in the trap were counted, collected and killed, throughout the monitoring period (29 to 43 MSW). Lure was replaced with new one, once in a fortnight for seven times during the experimental period. Light trap was operated from 7 pm to 5 am and adults of both species of insects were collected, immobilized at -20 ^{0}C and segregated species and sex wise and counted, daily.

Date of first appearance of adults of both species of insects, number of peak catches and broods were recorded. Damage caused by both insects including dead heart, white ear and per cent leaf damage were recorded once in a week.

2.2 Observation

Damage potential of both insects was observed in five hills, selected randomly in five different places in an acre area and computed as per the formulae

$$\text{Percent dead heart} = \frac{\text{Number of dead hearts/hill}}{\text{Number of total tillers/hill}} \text{x} 100$$

$$\text{Percent white ear} = \frac{\text{Number of white ears/hill}}{\text{Number of productive tillers/hil}} \text{x} 100$$

$$\text{Percent leaf damage} = \frac{\text{Number of damaged leaves/hill}}{\text{Total number of leaves/hill}} \text{x} 100$$

Species complex of stem-borer and leaf-folder were recorded based on the light trap collections by following the formula

$$\text{Relative abundance} = \frac{\text{Total number of individuals of each species}}{\text{Total number of individuals of all species}} \text{x} 100$$

The weather data on maximum and minimum temperature, rainfall and relative humidity for 15 MSW were collected from meteorological station of Baronda farm and correlated with trap catches and damage potential of two insect pests. Light trap catches of stem-borer female adult were also correlated with its damage. Rice was cultivated under low land condition, following all agronomic practices and maintained under unprotected condition throughout experimental period.

2.3 Statistical Analysis

Correlation co-efficient (r) and regression of meteorological variables as independent factors were computed [23].

3. Results and Discussion

3.1 Relative abundance of rice stem-borer

Based on light trap catches during *kharif* 2016, the relative abundance of species of stem-borer at Baronda farm was assessed. Three species of stem-borer including yellow stem-borer, *Scirpophaga incertulas* Walker (Lepidoptera: Pyraustidae), stripped stem-borer, *Chilo suppressalis* (Walker) (Lepidoptera: Crambidae) and white stem-borer, *Scirpophaga innotata* (Walker) (Lepidoptera: Pyraustidae) were found attacking rice, among them, *Sc. incertulas* dominated (92.3%; 159 female adults), while *Ch. suppressalis* (7.7%; 15 adults) and *Sc. innotata* (>1%) ranked 2nd and 3rd rank of abundance in infesting rice . *Sc. incertulas* had appeared during tillering and reproductive stage while the appearance of *Ch. suppressalis* and *Sc. innotata* were noticed during late tillering and reproductive stage (Table 1; Fig. 1).

Yellow stem-borer
Scirpophaga incertulas Walker
(Lepidoptera: Pyraustidae)

Stripped stem-borer
Chilo suppressalis (Walker)
(Lepidoptera: Crambidae)

White stem-borer
Scirpophaga innotata (Fab.)
(Lepidotpera: Pyraustidae)

Fig 1: Species complex of stem-borer in wet land rice eco-system

Three species of stem-borer including yellow stem-borer (*Sc. incertulas*), pink stem-borer [*Sesamia inference* (Walker)] and dark-headed borer [*Chilo polychrysus* (Meyrick)] were observed in rice eco-system in which, *Sc. incertulas* was reported to be the dominant species in seven agro-climatic regions of Tamil Nadu [24, 25], however the later two species of stem-borer were not observed in the rice eco-system of the Baronda farm while five species of stem-borer, *viz*., yellow stem-borer (*Sc. incertulas*), pink stem-borer (*Se. inference*), dark headed stem-borer (*Ch. polychrysus*), stripped stem-borer (*Ch. suppressalis*) and white stem-borer (*Sc. innotata*) were recorded in Bangladesh [26, 3]. Stem-borer species diversity in rice was reported elsewhere in India [12- 19]. Information on species complex of stem-borer in plains of this region would be useful to plan for opt methods of plant protection measures and other eco-friendly interventions.

3.2 Relative abundance of leaf-folder

Single species of leaf-folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyraustidae) was noticed in rice eco-system of Baronda farm (Table 1), however, in Tamil Nadu, three species of leaf-folder including *Cn. medinalis*, *Marasmia patnalis* (Bradley) and *Marasmia ruralis* (Walker) were noticed [20, 22], in which *Cn. medinalis* was reported to be the dominant species and such information was useful during 1986 to relook and identify the efficient chemical insecticides for the management of all the three species through rescreening of existing insecticides. A mini review reported eight species of leaf-folder *viz*., *Cn. medinalis*, *Ma. exigua* (Butler), *Ma. billinialis* (Hampson), *Ma. patnalis*, *Ma. ruralis*, *Ma. suspicalis* (Guenee), *Bradina admixtalis* (Walker) and gelechid leaf-folder, *Brachmia arotraea* (Meyrick) across the country [21].

3.3 Light trap catches of rice stem-borer

First female yellow stem-borer appeared in light trap during first week of August 2016 (31st MSW) which caused 1.1% dead heart, thereafter the dead heart reached the maximum of 4.72% during first week of September 2016 (36th MSW). Similarly, first white ear appeared during 3rd week of September 2016 (38th MSW) and reached the maximum of 4.98% during 2nd week of October 2016 (41st MSW) (Table 1; Fig. 2). The activity and damage potential of yellow stem-borer in the present study was similar to that of the results [10, 27, 28, 9] who recorded the activity of yellow stem-borer from 1st week of August to last week of September during earlier *kharif* seasons while it is contradicted [18, 29, 30, 31] that the peak activity of yellow stem-borer during 2nd week of September or 1st fortnight of October at vegetative stage and 2nd week of November at reproductive stage of earlier *kharif* seasons which might be due to variation in climatic conditions, varietal influence and agronomic practices. Beyond 43rd MSW, the damage and trap collection of yellow stem-borer were negligible.

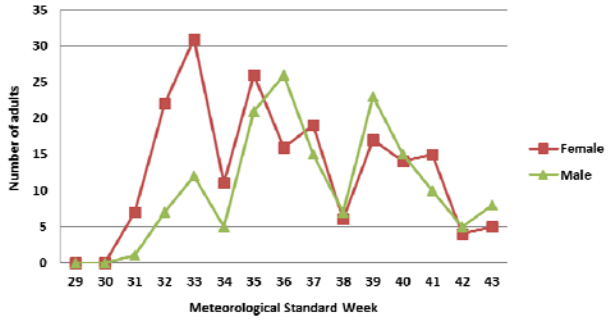

Fig 2: Light trap catches of rice yellow stem-borer during Kharif 2016

Light trap catches of yellow stem-borer female peaked twice, first peak (31 females) during 3rd week of August 2016 (33rd MSW) and second peak (26 females) during last week of August 2016 (35th MSW) which indicated that there were two broods for yellow stem-borer during *kharif* 2016 at Baronda farm (Table 1). This finding is protested by [32] who reported two major peaks of *Sc. incertulas* adults, one in October-November and another during February in West Bengal. Similar result was noticed [17], in which they observed two broods of *Sc. incertulas* of which, first was during the last week of September and another during 2nd week of November of earlier *kharif* seasons, which coincided with the dough stage of rice in Bhubaneswar. Information on brood is useful to identify the time of availability of maximum egg mass load of yellow stem-borer *ie*., 5 to 7 days from 3rd (1st peak catch) and last week (2nd peak catch) of August (pre-mating period + mating period + pre-oviposition period + oviposition period) when the initiation of the release of egg parasioitod, *Trichogramma* spp. will be appropriate for management at egg stage itself. The present observation will also be helpful to find out the time of availability of maximum larval load *ie*., 10 days after each peak when the larvae can be targeted with application of chemical insecticides.

3.4 Sex ratio of yellow stem-borer

Light trap catches of yellow stem-borer during 15 MSW of *kharif* 2016 indicated the impression of outnumbering of females than males (1:1.32 male: female) which gives the conclusion of that around 30% of males may have the behaviour of mating more than once with females.

3.5 Light trap catches of rice leaf-folder

Attraction of adults of leaf-folder to light trap was less in the Baronda farm, as the infestation level was very low (Table 1). The low incidence of leaf-folder was due to the high population of larval parasitoids like *Apanteles* sp., *Goniozus* sp. and *Trichomma cnaphalocrocis* Uchida [11]. [33] reported the maximum trap catches of leaf-folder during 45th MSW of November 2013-14 and 1st fortnight of November while [34] noticed the maximum adult catches of leaf-folder during 48th MSW of November-December. On the contrary of [35, 36] who reported that the peak population was observed during September and October at Balaghat and Tikamgarh. [37] also recorded the maximum appearance of the leaf-folder in the light trap during October of *kharif*.

3.6 Pheromone trap catches of yellow stem-borer

Pheromone trap catches of yellow stem-borer male initiated at 21 days after installation of traps in rice field *ie*., 23 males during 2nd week of August 2016 (32nd MSW) which reached to the maximum of 38 (33rd MSW; 3rd week of August 2016), 33 (34th MSW; 4th week of August 2016), 36 (35th MSW; 1st week of September 2016) and 36 numbers (36th MSW; 2nd week of September 2016) (Table 1). Interestingly the maximum catches of males coincided with the two broods of yellow stem-borer (33rd and 35th MSW) which indicated that sex pheromone trap was useful to find out number of broods and time of plant protection operations. First catch of males at 21 days after installation might have been decided by few factors like number of females/unit area, velocity and direction of air current and height of the canopy and trap.

3.7 Infestation level of rice yellow stem-borer and leaf-folder

During *kharif* 2016, the infestation level of both the pests was medium to low, however, incidence of stem-borer (4.72% dead heart; 4.98% white ear) was higher than leaf-folder (1.74% leaf damage). First dead heart (1.11%) appeared during 1st week of August 2016 (31st MSW) and reached the maximum of 4.72% during 1st week of September 2016 (36th MSW). First white ear (1.74%) appeared during 3rd week of September 2016 and appeared to become maximum of 4.88% (4th week of September 2016; 39th MSW), 4.22% (1st week of October 2016; 40th MSW) and 4.98% (2nd week of October 2016; 41st MSW) (Table 1; Fig. 3).

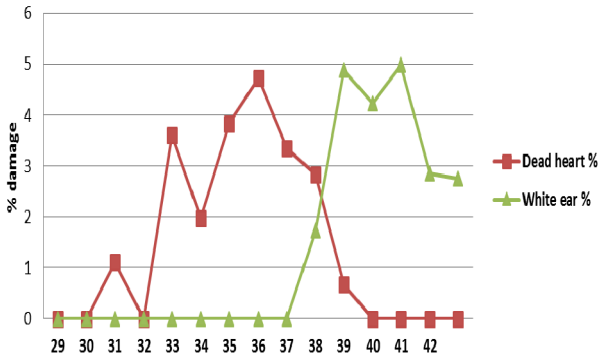

Fig 3: Damage by yellow stem-borer in rice during kharif 2016

Leaf-folder damage (0.46%) had started during 31st MSW (1st week of August 2016) and reached the maximum of 1.36% during 36th MSW (1st week of September 2016), 1.74% leaf damage on 38th MSW (3rd week of September 2016) which declined thereafter (Table 1). In contrast to this, the damage

potential beyond ETL caused by yellow stem-borer (18.48% dead heart; 24.21% white ear) [10] and leaf-folder (17% leaf damage) [11] was recorded in research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur during *kharif* 2013-14. The present level of infestation of stem-borer at Baronda farm is supported by the results of [9] who recorded 5.98% dead heart and 5.79% white ear at Gujarat during *kharif* 2012-13 and 2013-14. The medium to low infestation of stem-borer at the Baronda farm during *kharif* 2016 was not unreasonable that the reduced use of chemical insecticides which led to the encouragement of population of spiders including wolf, long jawed and lynx spiders and are the visible reasons, as pointed by [3].

3.8 Correlation between weather parameters and damage and trap catches

Maximum temperature, ranging from 26.0 ^{0}C to 29.3 ^{0}C (dead heart = + 0.427; leaf damage = + 0.069; pheromone trap male = + 0.125; light trap female = + 0.014; light trap male = + 0.348) and minimum temperature, ranging from 17.4 ^{0}C to 25.5 ^{0}C (dead heart = + 0.365; leaf damage = + 0.365; pheromone trap male = + 0.288; light trap female = + 0.338; light trap male = + 0.169) and relative humidity (dead heart = + 0.191; leaf damage = + 0.593; pheromone trap male = + 0.283; light trap female = + 0.451; light trap male = + 0.268) had positive association with the dead heart and leaf damage caused by yellow stem-borer and leaf-folder and catches by pheromone and light trap during *kharif* 2016 in wet land rice (Table 2), however the association of relative humidity with trap catches was found to be relatively high when compared to minimum and maximum temperatures.

Rainfall was negatively correlated with dead heart (r = - 0.126), white ear (r = - 0.355) and leaf damage (r = - 0.158) and positively correlated with trap catches (Pheromone trap male = + 0.097; light trap female = + 0.032; light trap male = + 0.109), but the extent of correlation with trap catches was not significant when compared to relative humidity. Light trap catches of female yellow stem-borer was positively correlated with dead heart (r = + 0.548) while it was negatively correlated with white ear (r = - 0.091). All weather parameters like maximum and minimum temperatures, relative humidity and rainfall were negatively correlated with white ear which is reasonable that all weather parameters which were declining in quantity ('^{0}C', '%' and 'mm') when the white ear appeared during reproductive stage (70 to 80 days after transplanting). Maximum temperature improved the male stem-borer catch in pheromone trap due to quick evaporation of volatiles from lure. Rainfall and relative humidity enhanced the light trap catches by providing conducive environment for the emergence of pupae of both insects. Disturbance in mating and wetting and dislodging of eggs and larvae of these insects might be the reasons for negative association between rainfall and damage caused by two insects.

The present correlation is supported by [9] who informed that maximum temperature and relative humidity had positive correlation with the activity of yellow stem-borer. In contrast, [38] established negative correlation between maximum temperature, rainfall, relative humidity and sunshine hours and yellow stem-borer moth population. [39] exhibited negative correlation of incidence of stem-borer with maximum temperature. [30] recorded positive correlation between yellow stem-borer and minimum temperature, relative humidity and rainfall. [28] illustrated a significant positive correlation with relative humidity and negative correlation with minimum temperature and rainfall. The present trend of relationship of incidence of leaf-folder with weather parameters is supported by [40, 41] who informed that relative humidity and minimum temperature were supportive to the multiplication of leaf-folder.

Table 1: Damage potential and trap catches of rice stem-borer and leaf-folder and meteorological parameters in wet land rice during *kharif* 2016

MSW	Yellow stem borer		Leaf folder (% leaf damage)	Pheromone Trap catches Male YSB (Nos.)	Light trap catches (Nos.)		Max. Temp (^{0}C)	Min. Temp (^{0}C)	RH (%)	Rain fall (mm)
	Dead heart (%)	White ear (%)			Female YSB	Male YSB				
29	0.00	0.00	0.00	0	0	0	28.3	25.0	84.7	50.0
30	0.00	0.00	0.00	0	0	0	28.0	24.5	88.5	15.1
31	1.11	0.00	0.46	0	7	1	28.0	25.5	87.3	0.6
32	0.00	0.00	0.78	23	22	7	26.9	24.9	91.3	35.4
33	3.60	0.00	0.18	38	31	12	27.5	24.6	87.9	5.3
34	1.98	0.00	0.33	33	11	5	26.8	23.8	86.5	18.4
35	3.82	0.00	0.49	36	26	21	27.9	24.8	90.9	33.2
36	4.72	0.00	1.36	36	16	26	29.3	25.1	86.9	10.0
37	3.36	0.00	0.74	17	19	15	28.0	24.6	85.6	5.6
38	2.84	1.74	1.74	7	6	7	27.9	24.3	90.2	2.4
39	0.67	4.88	1.23	17	17	23	29.1	24.7	88.4	0.7
40	0.00	4.22	1.50	8	14	15	26.8	24.0	93.0	30.6
41	0.00	4.98	1.50	10	15	10	26.0	23.8	88.4	0.2
42	0.00	2.85	0.00	4	4	5	28.0	20.2	79.5	0.0
43	0.00	2.75	0.00	5	5	8	25.9	17.4	78.5	0.0

MSW: Meteorological Standard Week; YSB: Yellow stem-borer

Table 2: Correlation between weather parameters and damage and trap catches of stem-borer and leaf-folder in wet land rice during *kharif* 2016

Independent factor (X)	Dependent factor (Y)	Correlation co-efficient (r)	Regression Equation value
Maximum Temp. (^{0}C)	Dead heart (%)	+ 0.427	Y = + 0.24 X + 27.27 R^2 = 0.18
	White ear (%)	- 0.279	Y = - 0.14 X + 27.82 R^2 = 0.08
	Leaf damage (%)	+ 0.069	Y = + 0.11 X + 27.55 R^2 = 0.01
	Pheromone Trap catches (Nos.)	+ 0.125	Y = + 0.01 X + 27.49 R^2 = 0.02
	Light trap catches-Female (Nos.)	+ 0.014	Y = + 0.01 X + 27.65 R^2 = 0.01
	Light trap catches-Male (Nos.)	+ 0.348	Y = + 0.04 X + 27.19 R^2 = 0.12
Minimum Temp. (^{0}C)	Dead heart (%)	+ 0.365	Y = + 0.45 X + 23.14 R^2 = 0.13
	White ear (%)	- 0.370	Y = - 0.40 X + 24.39 R^2 = 0.14
	Leaf damage (%)	+ 0.356	Y = + 1.22 X + 22.97 R^2 = 0.13
	Pheromone Trap catches (Nos.)	+ 0.286	Y = + 0.04 X + 23.14 R^2 = 0.08
	Light trap catches-Female (Nos.)	+ 0.338	Y = + 0.08 X + 22.80 R^2 = 0.11
	Light trap catches-Male (Nos.)	+ 0.169	Y = + 0.04 X + 23.36 R^2 = 0.03
Relative humidity (%)	Dead heart (%)	+ 0.191	Y = + 0.44 X + 86.53 R^2 = 0.04
	White ear (%)	- 0.034	Y = + 0.07 X + 87.27 R^2 = 0.01
	Leaf damage (%)	+ 0.593	Y = + 3.75 X + 84.59 R^2 = 0.35
	Pheromone Trap catches (Nos.)	+ 0.283	Y = + 0.08 X + 85.94 R^2 = 0.20
	Light trap catches-Female (Nos.)	+ 0.451	Y = + 0.19 X + 84.68 R^2 = 0.20
	Light trap catches-Male (Nos.)	+ 0.268	Y = + 0.13 X + 85.83 R^2 = 0.07
Rainfall (mm)	Dead heart (%)	- 0.126	Y = + 1.17 X + 15.56 R^2 = 0.02
	White ear (%)	- 0.355	Y = + 2.91 X + 17.99 R^2 = 0.13
	Leaf damage (%)	- 0.158	Y = + 4.04 X + 16.61 R^2 = 0.02
	Pheromone Trap catches (Nos.)	+ 0.097	Y = + 0.11 X + 12.12 R^2 = 0.10
	Light trap catches-Female (Nos.)	+ 0.032	Y = + 0.06 X + 13.12 R^2 = 0.01
	Light trap catches-Male (Nos.)	+ 0.109	Y = + 0.22 X + 16.06 R^2 = 0.02
Trap catch of female stem-borer	Dead heart (%)	+ 0.548	Y = + 2.93 X + 8.54 R^2 = 0.30
Trap catch of female stem-borer	White ear (%)	- 0.091	Y = - 0.43 X + 13.48 R^2 = 0.01

4. Conclusion

Monitoring of rice stem-borer and leaf-folder during 15 MSW of *kharif* 2016 at Baronda farm, Raipur was helpful to find out the first appearance of both insect pests and number of broods of yellow stem-borer which would envisage the period of availability of their eggs and larvae to time the release of egg and larval parasitoids and other relevant effective plant protection measures. Periodical monitoring on relative abundance of species of both insects would inform the dominant species and further shift in dominance by minor species in future which clarifies the necessary interventions, required to be made to contain the emerging species.

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