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Research Article

IMPACT OF YELLOW STEM BORER, *SCIRPOPHAGA INCERTULAS* (WALKER) DAMAGE ON SEQUENTIALLY PLANTED RICE CROPPING SYSTEMS

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Abstract: Investigations were carried out in rice field on the influence of sequential planting of rice crop on the incidence of stem borer and interaction with weather parameters. Monthly planting of two susceptible rice varieties *viz*., Pusa basmati-1 and TN-1 was taken out in Paddy Breeding Station, Tamil Nadu Agricultural University, India during the period January 2015 to December 2015. The results revealed at 30 days after planting (DAP) more dead heart damage was observed in January (15.80%) and February (10.08%) planted crops of Pusa basmati-1. Maximum dead heart damage was noticed in 45 days after planting (DAP) with 24.00 percent dead heart in the January planted crop. The stem borer damage declined in the middle of the year and again the incidence shoot up more than 10 percent during October (10.50%), November (12.70%) and December (21.30%) months. In var. TN-1 the incidence of stem borer was comparatively lower but the temporal pattern of damage was similar to *var*. Pusa basmati-1. The stepwise correlation analysis of stem borer damage with weather data during the period revealed that there was significant impact of various weather parameters. The minimum temperature and minimum relative humidity had significant negative correlation with stem borer damage. Wind speed also had significant negative correlation with stem borer damage in both varieties.

Keywords: *Rice, Yellow stem borer, Scirpophaga incertulas, Monthly planting, Dead heart damage, Correlation, Weather parameters*

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Introduction

Rice (*Oryza sativa* L.) is one of the major food crops in India and Asian countries. The crop is attacked by several insect pests from nursery to harvest, which cause severe yield loss [1]. Among several insects that feed on rice, the extent of damage caused by stem borer varied from 80 to 97 percent [2]. Yellow stem borer, *Scirpophaga incertulas* (Walker) is the most predominant pest and causing serious damage in rice growing tracts of India, Bangladesh and South East Asian countries [3]. It is considered as the serious and specific pest of irrigated and low land rice that caused heavy yield loss [4]. It causes two types of damage in the form of dead heart and white ear. Rice stem borers attack the crop from seedling to ear setting stages. Damage caused by stem borers differs depending on the growth stages of the plant. Caterpillars tend to destroy the stems through boring the leaf sheaths at the node point, feeding on the leaf sheath for about a week after which they enter the stem. Larval destructive effect on the terminal shoots are manifested through the damage symptom known as 'dead heart'. Dead heart symptom is characterized by whitish or discolored area at feeding site of leaf blade and finally the stem turns brown, wilts and dry. If the stem borers attack at the flowering stage of the plant the panicle becomes white and empty, this symptom is known as 'white head'. Asynchrony of the vulnerable growth stages of rice with yellow stem borer population can minimize pest infestation [5]. Both biotic and abiotic factors are believed to be responsible for pest population dynamics. Climatic factors such as temperature, rainfall and relative humidity greatly influence the outbreak of the insect population [6,7]. Population dynamics of this pest like any other species are thus liable to fluctuate according to the dynamic condition of its environment [8]. The present study was carried out to know the temporal distribution of yellow stem borer based on the damage at monthly planting of two susceptible rice varieties *viz*., Pusa basmati-1 and TN-1.

Materials and Methods

Field experiments were carried out at Paddy Breeding Station, Department of Rice, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India (10°59' N; 76°54'E; 420 MSL) during January 2017 to December 2017 with two susceptible rice varieties *viz*., Pusa basmati-1 and Taichung Native-1 (TN-1). Each variety was planted in the field with a plot size 520 sq.m area. Similar field size were followed for all plantings and totally 12 plantings were takenup at monthly interval in the specified period. Accordingly nursery beds were raised and standard agronomic practices, fertilizer recommendations were followed in the nursery and main field. However, all the experimental plots were maintained with insecticide-free condition. In the main field, *S. incertulas* incidence was recorded at fortnightly interval from 30 days after transplanting (DAT) up to harvest stage in each planting. During the period, the stem borer damage was assessed through expression of dead heart symptoms in the varieties. The white ear damage was recorded at the time of harvest. In each plot 10 hills were selected at random and stem borer damage was recorded. The mean data was worked out from 5 plots in each variety. The dead heart and white ear damage percent was calculated based on the following simple calculation:

$$Dead\ heart(\%) = \frac{Number\ of\ tillers\ with\ dead\ heart}{Total\ number\ of\ tillers} \times 100$$

$$White\ ear\ (\%) = \frac{Number\ of\ tillers\ with\ white\ ear}{Total\ number\ of\ productive\ tillers} \times 100$$

Weather parameters and statistical analysis

The meteorological data for the period was collected and utilized for stepwise correlation studies with stem borer damage. The weather parameters *viz*., maximum temperature, minimum temperature, rainfall, relative humidity morning and evening, sunshine hours, wind speed were used for stepwise correlation analysis.

Table-1 Temporal variation on the incidence of stem borer in rice var. Pusa basmati-1

S	Month of planting	Dead heart incidence (%)				White ear (%)
		30 DAT	45 DAT	60 DAT	75 DAT	
1	January 2017	15.80(23.42)j	24.00(29.33)l	22.50(28.32)l	7.80(16.22)h	18.10(25.18)l
2	February 2017	10.08(18.51)h	17.50(24.73)i	18.50(25.48)j	9.30(17.76)i	12.60(20.79)j
3	March 2017	8.50(16.95)g	14.00(21.97)g	14.50(22.38)i	10.20(18.63)j	9.60(18.05)i
4	April 2017	3.05(10.06)b	14.50(22.38)h	10.50(18.91)g	7.60(16.00)h	7.80(16.22)h
5	May 2017	3.50(10.78)c	7.60(16.00)e	5.20(13.18)e	3.50(10.78)e	5.00(12.92)g
6	June 2017	4.04 (11.59)d	5.30(13.31)c	2.00(8.13)a	2.10(8.33)b	3.50(10.78)e
7	July 2017	2.50(9.10)a	4.20(11.83)b	3.20(10.30)b	2.30(8.72)b	3.00(9.97)d
8	August 2017	6.50(14.77)f	4.00(11.54)a	3.80(11.24)c	2.60(9.28)a	1.10(6.02)b
9	September 2017	4.55(12.32)e	6.60(14.89)d	4.10(11.68)d	1.20(6.29)d	0.80(5.13)a
10	October 2017	10.50(18.91)h	11.80(20.09)f	8.20(16.64)f	3.50(10.78)g	1.60(7.27)c
11	November 2017	12.70(20.88)ij	18.70(25.62)j	12.50(20.71)h	6.30(14.54)c	4.00(11.54)f
12	December 2017	15.00(22.79)j	21.30(27.49)k	20.00(26.57)k	5.20(13.18)f	17.80(24.95)k

Values in parenthesis are arcsine transformed,

Data in the same column followed by different letters represent significant differences at the 0.05 level.

Table-2 *Temporal variation on the incidence of stem borer in rice var. TN-1*

S	Month of planting	Dead heart incidence (%)				White ear damage (%)
		30 DAT	45 DAT	60 DAT	75 DAT	
1	January 2017	10.00(18.43)h	18.70(25.62)j	15.40(23.11)f	10.40(18.81)i	11.80(20.09)j
2	February 2017	11.20(19.55)i	15.20(22.95)i	12.20(20.44)e	8.40(16.85)h	8.50(16.95)i
3	March 2017	4.50(12.25)d	10.20(18.63)f	8.60(17.05)d	7.60(16.00)g	5.40(13.44)h
4	April 2017	1.50(7.04)a	7.50(15.89)e	5.50(13.56)c	4.70(12.52)e	4.60(12.39)g
5	May 2017	2.50(9.10)b	7.20(15.56)e	5.00(12.91)c	3.80(11.24)d	3.50(10.78)f
6	June 2017	1.50(7.04)a	4.20(11.83)d	3.10(10.14)b	2.70(9.46)c	2.90(9.80)e
7	July 2017	1.60(7.27)a	3.00(9.97)c	2.40(8.91)b	5.50(13.56)f	1.50(7.03)c
8	August 2017	3.50(10.78)c	3.10(10.14)c	2.10(8.33)ab	2.30(8.72)b	1.50(7.03)c
9	September 2017	2.50(9.10)b	2.70(9.46)b	2.30(8.72)ab	1.80(7.71)a	0.20(2.56)a
10	October 2017	4.90(12.79)e	2.30(8.72)a	1.50(7.03)a	1.80(7.71)a	1.00(5.74)b
11	November 2017	5.80(13.94)f	15.05(22.83)h	10.80(19.19)d	7.40(15.79)g	2.30(8.72)d
12	December 2017	8.50(16.95)g	12.90(21.05)g	16.50(23.97)f	9.80(18.24)i	14.30(22.22)k

Values in parenthesis are arcsine transformed

Data in the same column followed by different letters represent significant differences at the 0.05 level

The data on stem borer damage during different periods of observations were subjected to statistical analysis in a complete randomized design using analysis of variance (ANOVA) with the help of IRRISTAT 4. Stem borer damage in different month were separated by least significant difference test (LSD) at P = 0.05 [9].

Results and Discussion

Influence of monthly planting on yellow stem borer

The observations revealed that there was significant variation in stem borer damage on rice crop planted at monthly interval. At 30 days after planting (DAP) the dead heart incidence was more (15.80%) in January planted crop among different planting period in the *var.* Pusa basmati-1 [Table-1]. Minimum damage was recorded in July planted crop (2.50%) and dead heart symptoms was more than 10 percent in the crops planted during January (15.00%) and February (10.08%) in the initial period of the year. Then the stem borer incidence declined in the middle of the year and the damage range during the period was 2.50 to 8.50 percent in the *var.* Pusa basmati-1. Again, the incidence shoot up more than 10 percent during October (10.50%) and November (12.70%) in the 30th day observations. Similar trend was noticed in the 45th day observations, but the damage level was more. The maximum damage of 24.00 percent dead heart was recorded in the January planted crop followed by December (21.30%). More than 10 percent damage was recorded in the crops planted at February (17.50%), March (14.00%), April (14.50%) and October (11.80%) and November (18.70%). The observations recorded on 60 DAP in the same variety showed maximum damage in the January planted crop (22.50%) and then decline in the damage level. However, the crops planted in the February (18.50%), March (14.50%), April (10.50%) and November (12.50%) recorded more than 10 percent damage at 60th day observations in different plantings. The 75th day observations showed maximum dead heart was recorded in March (10.20%) planting. The harvest time white ear counts revealed that the January (18.10%), February (12.60%) and December (17.80%) planted crops suffered maximum ear head damage in the *var.* Pusa basmati-1. The crops planted during August (1.10%), September (0.80%) and October (1.60%) had less than two percent white ear damage. The seasonal incidence of stem borer in rice by earlier works provides a varied pattern depend on location and time of planting. *S. incertulas* infestation in the form of dead heart (0.66%) appeared from first week of August and reached to its first peak (5.58%) during first week of September [10] in Gujarat, India. Thereafter, infestation declined gradually and found to be low and again increased during late stage of crop growth and found maximum white ear damage of 5.79 percent during first week of October. In another study, two major peaks of *S. incertulas* adult catches were reported [11] in October-November and another during February in West Bengal, India. More or less similar conclusion have been drawn in the studies [12] conducted at Bhubaneswar, India with two broods of *S. incertulas*, of which peak first was during the last week of September and another during second week of November, which coincided with the dough stage of rice in Bhubaneswar, India. In contrast to this, peak activity of yellow stem borer recorded at 2nd fortnight of October during *kharif* season [13] at Rajendranagar, Andhra Pradesh, India. The light trap catches revealed that peak occurrence of yellow stem borer during first fortnight of October [14]. Monitoring of adult yellow stem borer through light trap catches recorded at Coimbatore, Tamil Nadu indicated the prevalence of the adults throughout the study period with its peak activity on the second fortnight of December (189 nos.) [15]. The stem borer moth population increased from mid-August to mid-October in deep water rice [16]. Infestation of *S. incertulas* was found more during August-September and December-February in Southern part of Tamil Nadu [17]. These contrasts might be due to the effect of climatic conditions and cultural practices of a particular area. Most of the earlier attempts on population dynamics of stem borer and weather parameters were made based on adult moth activity through light traps or pheromone trap catches. The temporal variation of stem borer incidence and influence of abiotic factors based on the damage level was established in the present study. It was observed that the maximum stem borer damage in different monthly planted crops showed that dead heart damage was more during January and December planted crops (24.00 & 21.30%) at 45th days after planting in the *var.* Pusa basmati-1.

Table-3 *Correlation of stem borer damage with weather parameters in rice var. Pusa basmati-1**

Duration of crop	Maximum temperature	Minimum temperature	Relative humidity* (morning)	Relative humidity (evening)	Rainfall	Wind speed	Sunshine hours
30 DAP	-0.388	-0.735**	0.308	-0.734**	-0.028	-0.519**	-0.291
45 DAP	-0.268	-0.819**	0.391	-0.921**	-0.054	-0.689**	-0.233
60 DAP	-0.339	-0.911**	0.302	-0.217	-0.163	-0.594**	-0.046
75 DAP	0.124	-0.792**	0.430	-0.456	-0.096	-0.542**	0.252
Maturity stage (White ear)	-0.552**	-0.814**	0.080	-0.226	-0.307	-0.423	-0.093

** Figures are correlation co-efficient values (r value), ** Significant @ 5% level, DAP - days after planting*

Table-4 *Correlation of stem borer damage with weather parameters in rice var. TN-1**

Duration of crop	Maximum temperature	Minimum temperature	Relative humidity (morning)	Relative humidity (evening)	Rainfall	Wind speed	Sunshine hours
30 DAP	-0.459	-0.903**	0.374	-0.500**	-0.197	-0.536**	0.019
45 DAP	-0.345	-0.884**	0.384	-0.512**	0.123	-0.582**	-0.215
60 DAP	-0.464	-0.833**	0.152	-0.153	-0.021	-0.536**	-0.302
75 DAP	-0.464	-0.833**	0.152	-0.073	-0.021	-0.536**	-0.302
Maturity stage (White ear)	-0.610**	-0.736**	0.012	-0.136	-0.312	-0.397	-0.186

** Figures are correlation co-efficient values (r value), ** Significant @ 5% level, DAP - days after planting*

The incidence slowly declined in the subsequent months and again showed in increasing trend from September onwards. The white ear damage was maximum in January and December planted crops (18.10 & 17.80%). Among different period of observation 45th day noticed maximum dead heart incidence in overall planting periods.

Influence of varieties on yellow stem borer incidence

In the variety TN-1, though the incidence of stem borer was comparatively lower than Pusa basmati-1 the temporal pattern of damage was similar [Table-2]. In 30th day observation the dead heart incidence was more (11.20%) in February planted crop. Then there was decline during middle of the year with a range of 4.90 to 1.50 percent. The incidence shoots up at November planting with 5.80 percent damage. Among different interval of observations, the maximum dead heart incidence in the *var.* TN-1 was noticed at 45th day in the January planted crop (18.70%). During the period more than 10 percent damage was recorded in February (15.20%), March (15.20%), November (15.05%) and December (12.90%) planted crops of TN-1. In the remaining period the damage was ranged between 2.30 and 7.50 percent. The observations on 60 DAP in TN-1 showed maximum damage in January (15.40%), February (12.20%), November (10.80%) and December (16.50%) planted crops. In contrast to the observations recorded in *var.* Pusa basmati-1, TN-1 had more dead heart damage in 75th day of observations. More than 10 percent dead heart incidence was recorded in January (15.40%), February (12.20%), November (10.80%) and December (16.50%) planted crops. The white ear damage at harvest time recorded in January (11.30%) and December (14.30%) planted crops had maximum damage. The crops planted during July to October had less than two percent white ear damage (0.20-1.50%). Influence of planting time and cultivars on stem borer infestation were obvious [18]. However, on early sowing date (last week of June), the infestation was significantly low compared with medium (second week of July) and late sowing (fourth week of July) treatments. The dead heart infestation level in the early, medium and late sown crops was 3.96, 8.13 and 14.45 percent respectively. Similarly white ear incidence was 6.67, 7.82 and 12.46 percent respectively. In the present study also the early season crops which were planted during June to September showed less dead heart incidence as well as white ear damage. The late season crops of December, January and February and planted plots suffered maximum damage by stem borer. Among two varieties tested in the present study, the *var.* Pusa basmati-1 showed more damage by stem borer and maximum dead heart and white ear noticed compared to the variety TN-1. Maximum damage of 24.00 percent dead heart noticed at 45th DAT in January planted Pusa basmati-1, where as in TN-1 maximum of 18.70 percent dead heart was recorded at the same period (Fig.1&2). The white ear infestation was also more in Pusa basmati-1 and maximum damage of 18.10 percent recorded in the plots planted in the month of January. In TN-1, maximum of 14.30 percent white ear noticed in the December planted crop. The aromatic rice variety is most susceptible to stem borer damage than the normal variety. Non-aromatic IR-8 and Sharshar had 3.21, 2.47 percent dead hearts, 6.05 and 4.24 percent whiteheads respectively, while aromatic Basmati-370 recorded with 5.44 percent dead heart and 8.94 percent white ear damage. These considerable variations were found due to more attractiveness of borers by aromatic varieties for oviposition and this contributed to higher borer damage. High stem borer damage to aromatic varieties was apparently due to elevated feeding activities of the larvae especially the fifth instar larvae which are most voracious [18]. The variety Pusa basmathi-1 used in the present study is an aromatic type which clearly shows its susceptibility to stem borer damage. The *var.* TN-1 also had more dead heart damage in 75th day observations in January (15.40%), February (12.20%), November (10.80%) and December (16.50%) planted crops. Varietal characters may play a role in the late expression of dead heart in the variety TN-1, which shows more dead heart symptoms in later period of the crop.

Correlation of weather parameters with yellow stem borer damage

The correlation analysis of stem borer incidence with weather parameters during the period revealed that there was significant impact of various weather factors in both rice varieties [Table-3]. The minimum temperature had significant negative correlation (r: correlation coefficient) with dead heart incidence in Pusa basmati-1 during entire period of observations at 30 DAT (r = -0.735), 45 DAT (r = -0.819), 60 DAT (r = -0.911), 75 DAT (r = -0.792) as well as white ear damage expression (r = -0.814). But the maximum temperature had negative non-significant relation with the stem borer dead heart damage. However, white ear damage showed a significant negative correlation with the maximum temperature. The observations on variety TN-1 also showed similar trend of results in correlation studies [Table-4]. The minimum temperature had significant negative correlation with the observations on 30th day (r = -0.903), 45th day (r = -0.884), 60th day (r = -0.833), 75th day (r= -0.833) and white ear counts (r= -0.736). The maximum temperature showed non-significant negative correlation with dead heart incidence and significant negative correlation with white ear damage (r= - 0.610). The maximum relative humidity data had positive correlation but non-significant to stem borer damages of both dead heart and white ear symptoms in the varieties. But the minimum relative humidity data had significant negative correlation with the dead heart damage during 30 DAT (r= -0.734) and 45 DAT (r= -0.921) observations in Pusa basmati-1. Similar results were obtained with the variety TN-1 (r= -0.500 & - 0.512). The rainfall had no significant impact statistically on the incidence of stem borer in both the varieties. However, it recorded a negative relation with the stem borer damage. Interestingly, wind speed had significant negative correlation with the stem borer dead heart damage in all the observations, *viz.*, 30 DAT (r= -0.519, -0.536), 45 DAT (r= -0.689, -0.582), 60 DAT (r= -0.594, -0.536) and 75 DAT (r= -0.542, -0.536) in the varieties Pusa basmati-1 and TN-1 respectively. However, white ear damage showed non-significant negative relation for both varieties (r= -0.423, -0.397). The sunshine hours recorded a varied non-significant relation with the stem borer damage. The relationship of environmental parameters with population build-up of yellow stem borer indicated that evening relative humidity and rainfall showed significant negative correlation with the population in the adult moth catches [19]. Minimum temperature (r = 0.21), maximum temperature, morning relative humidity had non-significant positive correlation with the population of stem borers. Similar findings of positive and significant correlation with maximum temperature while relative humidity exerted a negative correlation with stem borer damage [20].

Negative relation with maximum temperature, rainfall, relative humidity, wind velocity and positive correlation with minimum temperature, evaporation and sunshine hours to yellow stem borer adult moth population was reported earlier [21]. Minimum temperature, rainfall and relative humidity are important factors that influenced the yellow stem borer outbreaks [22]. Rainfall had non-significant negative impact and sunshine hours recorded significant positive impact of sunshine on stem borer activity and infestation [11,23]. Rainfall negatively affected yellow stem borer light trap catches directly as well indirectly through relative humidity [24]. Heavy rainfall might adversely affect the stem borer population through physical destruction of its development stages, while high humidity might promote entomopathogens. Minimum temperature, rainfall and maximum relative humidity exhibited negative relationship with yellow stem borer catches. The pooled data over 15 years in different rice centers of India collected revealed that the peaks of yellow stem borer catches occurred between December first week and December fourth week [24]. The present study corroborates with the finding that the maximum stem borer damage was recorded in December and January planted crops of Pusa basmati-1 and TN-1. The yellow stem borer is a resident pest as it hibernates in rice stubbles of same field and previous season's population density has influence on ensuing season's infestation level. It thus follows that after initial emergence of yellow stem borer adults, interfield migration is important for its population buildup and spread in an area. Insects being cold-blooded animals, temperature plays a crucial role in their development and distribution [25] and this borer pest is no exception to this thermal principle. Significant influence of minimum temperature on yellow stem borer catches is understandable because moth movement and population build in a particular area takes place during night. Cooler nights seemed to have favored yellow stem borer movement. Similar results on interactive effect of relative humidity and mean minimum temperature on rice stem borer were also reported [23,26]. Yellow stem borer damage showed that rainfall has significant positive impact, change in rainfall has significant negative impact, temperature difference has significant negative impact, rate of change of temperature difference has significant positive impact, limited difference of relative humidity has significant positive impact, wind speed has significant negative impact [27]. Relationship of weather parameters indicated that they play a major role in creating the variation in *S. incertulas* prevalence [28].

Conclusion

It could be concluded that the weather parameter plays crucial role in the population builup and damage by yellow stem borer in paddy crop. It is apparent that the minimum temperature, minimum humidity and wind speed had a significant impact on the incidence of stem borer in rice crop. Decrease in temperature may favours the development and activity of stem borer larva. The increase in wind speed may not favourable for the stem borer as the adult moths may not able to tolerate strong winds and there by decrease in the oviposition rate. The varieties also play an important role in the yellow stem borer damage on paddy crop. However, it could be also influenced by the climatic factors to decide their susceptibility towards these insect pests.

Application of Research: Study of yellow stem borer peak incidence in rice growing areas to advisory services and follow various management strategies.

Research category: Agriculture Entomology

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Cultivar / Variety / Breed name: Rice - TN 1, Pusa Basmati 1

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