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Influence of staggered cultivation and weather parameters on the outbreak of rice yellow stem borer, *Scirpophaga incertulas* walker in Polonnaruwa district of Sri Lanka

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Abstract

An outbreak of Rice yellow stem borer, *Scirpophaga incertulas* Walker was occurred in Polonnaruwa district of Sri Lanka during 2018 *Yala* season causing heavy yield losses. An early pest infestation was also observed in the same area during 2018/19 *Maha* season. Hence, this survey was conducted to investigate whether there is any relationship among weather factors, cultural practices and rice stem borer outbreak in Polonnaruwa district in 2018 *Yala* season. Delayed planting, staggered cultivation, lack of awareness among the farmers on identification of the pest and its damage symptoms, along with lack of knowledge on control measures and improper use of insecticides were identified as the major cause of the problem. Continuous cultivation of rice varieties that are more vulnerable to the Rice Yellow Stem Borer attack also contributed to the population build up. The climatic conditions prevailed during the season contributed to aggravate the damage by increasing the RYSB population leading to an outbreak of the pest population resulting in heavy yield losses.

Key words: Pest outbreak, Rice yellow stem borer, *Scirpophaga incertulas*, Staggered cultivation, Weather parameters

Introduction

Rice is the major crop grown in Sri Lanka, which covered an extent of 1,040,954 ha during 2017/18 *Maha* and 2018 *Yala* seasons (Anon, 2018). The Rice Yellow Stem Borer, *Scirpophaga incertulas* Walker (Lepidoptera: Pyralidae) (RYSB) is a serious pest of long duration rice varieties at all growth stages in many rice growing countries throughout tropical South and Southeast Asia. RYSB incidence is predominant in tropical lowland rice and deep-water rice. It is considered as one of the major pest species damaging rice crop in Sri Lanka too (Fernando *et al*., 1954; Kudagamage and Nugaliyadde, 1990).

Mature larvae of RYSB pupate within the rice stems and emerge as adult moths from the stems. The entire life cycle lasts 1 ½ to 2 months, so that they can complete at least 2 generations on long-duration rice crops. Over-lapping generations are common as the pest attacks all stages of the crop. Farmers in Sri Lanka tend to use broad-spectrum insecticides to control pests of this nature that cause heavy damage without considering whether such insecticides are recommended against the pest. Use of short duration varieties, synchronized planting, management of the level of nitrogen fertilizer, use of light traps and destroying of stubble of heavily infested crops are the recommended cultural practices for the management of RYSB in Sri Lanka (Anon, 2017).

The RYSB cause high amount of yield losses mainly in rice crops grown in the dry zone of Sri Lanka. During certain years, RYSB causes heavy damage to the rice crops grown in wet zone too. During 2018 *Yala* season, the rice crops grown in Polonnaruwa district were severely damaged by RYSB. Most crops were damaged by 30% to 50% with dead hearts while some farmers had to abandoned their fields as the damage level was so high (70% to 90% white heads) at the harvesting stage. In general, many farmers had obtained very low yields ranging from 0.7-2.0 t/ha where they obtain 4-5 t/ha usually. Approximately 1,000 ha in Pulasthigama, Sevagama, Medirigiriya, Galamuna, Hingurakgoda, Bakamuna and Aththanakadawala areas were damaged due to RYSB outbreak (Personal communication with Mr. K.A. Kamal Premarathne, Subject Matter Officer/Paddy, Inter Province, Polonnaruwa). Hence, this study including the farmer survey was conducted in four selected Agriculture Instructor (AI) divisions of Polonnaruwa district where heavy RYSB damage occurred, with the objective of investigating the cause of RYSB outbreak that lead to severe crop damage and yield loss.

Materials and Methods

Sample collection and pest identification

Ten damaged plant samples were collected from five randomly selected, severely damaged farmers' fields from four AI divisions of Polonnaruwa district (namely Bisobandara *yaya* of Manik Horowwa, Divulankadawela, Weerapura and Al-hilalpura of Sanghabodhigama and Athumalpitiya of Kadawalawewa AI divisions). The samples were brought in to the laboratory at RRDI, Batalagoda and were planted in clay pots. The plants from each location were kept separately in cages and left for adult emergence. Adult moths that emerged from each cage were collected into Petri-dishes separately. These moth samples were compared with the reference insect collection at the Insect museum of the Department of Agriculture at the Division of Entomology, Horticulture Research and Development Institute, Gannoruwa for identification of the species.

Farmer survey

A survey was conducted in four selected locations (Bisobandara, Divulankadawela, Weerapura and Athumalpitiya) with the participation of 40 randomly selected farmers including both small scale and commercial farmers. A questionnaire was prepared to collect information from the farmers on rice crops grown during 2018 *Yala* and 2018/19 *Maha* seasons. Information was collected from the farmers on cultural practices of each farmer, varieties grown, pest damages observed and magnitude of damages, time of the occurrence of RYSB damage, amounts of different insecticides and fertilizers used, yields obtained, and awareness of the farmer on recommendations of insecticide usage for RYSB management. Other information on locations affected/damaged fields by Grama Seva division basis, time of water issue for paddy cultivation during the particular season and time of planting, time of water issue and pest infestation in the paddy fields in surrounding *yayas* were collected from the relevant extension officers. Meteorological data of the area during the period of cropping obtained from the Department of Meteorology.

Varietal reaction to RYSB outbreak

Information on the damage occurred to a particular variety grown by each farmer, as a percentage of white heads was used to estimate the overall average percentage of damage by RYSB to each variety in the affected area.

Yield loss

Average yield of each rice variety grown in the affected area during 2018 *yala* season was calculated by averaging the yields obtained from the particular rice variety by each farmer that participated in the survey. District average yields of each rice variety for three consecutive *Yala* seasons prior to 2018 *yala* were obtained from the data base of the Department of Census & Statistics and were averaged over the three seasons to obtain an average value for the district for each variety. Crop loss for each variety during 2018 *Yala* season were calculated based on these average district yield values.

Results and Discussion

The moths that emerged from the infested plant samples of each location were identified as Rice Yellow Stem Borer, *S. incertulas* Walker (RYSB). Therefore, it is clear that the severe damage occurred in paddy fields in Polonnaruwa district during 2018 *Yala* season was due to an outbreak of RYSB population. Environmental factors and/or any other factor that prevailed during 2018 *Yala* season would have favoured build up of the pest population to an outbreak.

Time of crop establishment

Large area under paddy cultivation in Polonnaruwa district, is fed by major irrigation systems. Hence, farmers as a whole practice double cropping in *Yala* and *Maha* seasons. According to the information received from the extension officers of the area, there are a few locations where the paddy fields get water from minor tanks. Farmers in these locations practice either double cropping or single cropping (from February to June) of paddy depending on the availability of water.

In the area under investigation, there were two locations where two adjacent yayas in both locations received water with a gap between the time of water issue or availability of water. During the *Yala* 2018, different yayas (Kavudulla project Stage 1 and Stage 2) of Bisobandara in Medirigiriya AI division that fed by Kavudulla tank received water at different times with a gap of about 20-25 days due to difficulties in water supply because of topographical problems of paddy lands. Similarly, in Weerapura *yaya* of Pulasthigama AI division, which is fed by Parakrama samudraya reservoir received first water issue in May and within the *yaya* also water issue was done in shifts resulting in staggered cultivation of paddy. The adjacent *yaya*, which is fed by Kumbukkan oya, was cultivated

2 ½ to 3 months earlier in mid February when compared to the others. This *yaya* is usually cultivated in a '*meda kannaya*' with 4 to 4 ½ month varieties mainly Bg 450 because they can grow only one paddy crop per year due to the limitation of water. Although the early planted paddy crops in particular *yayas* were infested by RYSB, no yield loss was reported. However, the late-planted crops in Weerapura *yaya* and Bisobandara stage 1 *yaya* were severely damaged and yield loss was as heavy as 45.83% to 100% (Figure 1).

Month	February				March				April				May				June				July				August				Sept.
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Kavudulla project Stage1																	xxxxxx			30-60% D.H.						70-90% W.H.			0 -2.5
Kavudulla project Stage 2														xxxx				5-20% D.H.											3.25-4.5
Weerapura Parakrama Samudraya																xx							25-50% D.H.		50-80% W.H.				1.75-3.75
Weerapura Adjacent to Kumbukkan oya yaya Parakrama Samudraya																xxx						40-50% D.H			70-90% W.H.				0.5-1.75
Kumbukkan oya yaya																													

	Time of water issue
x x x x x x x x	Time of seed sowing
	Time of infestation -% Dead Heart (D.H.)
	Time of infestation -% White heads (W.H.)
	Yield (t/ha)
	Time of harvesting

Figure 1. Effect of the time of water issue and crop establishment on Rice yellow stem borer infestation levels and yields of paddy crops in different *yayas* in the surveyed area that are fed by different water reservoirs

Tsou (1947) showed that the rice stem borer inflicts severe damage to the late crop in areas where double cropping is practised and damage increases with delayed planting. Manickavasagar and Miyashita (1959) stated that the RYSB is most destructive, especially in areas where rice is grown in an intensive scale and double cropping is practised. The recorded damage percentage had been ranging from 0.1% to 80.0% during certain seasons in heavily infested areas through South East Asia. In accordance to that, present investigation also showed that, due to staggered cultivation of rice in the study area created a favourable environment for the RYSB moths to breed and develop their population to an outbreak situation causing heavy damage to the late planted crops.

Varietal reaction to RYSB outbreak

The rice varieties, Bg 352, Bg 374, Bg 366 and Bw 367 were widely grown by the farmers in Polonnaruwa district during 2018 *Yala* season. In addition to these varieties, some farmers had grown Bg 357, Bg 360, Bw 372 and an unknown variety in small extent. Information by farmers showed that out of these varieties, the RYSB caused a very high damage to the varieties Bg374, Bw372, Bg 360 and to the unknown variety in all 4 locations. Damage to variety Bg 352 had a very wide range (16.7-90.0% white heads) while Bg 366 and Bw 367 were moderately damaged (Figure 2). This indicates that Bg 374, Bw 372, Bg 357, Bg 360 and the unknown variety are more vulnerable to RYSB damage than other varieties if the population increased to an outbreak level. Further, these results show that although there is no resistance found in rice varieties against RYSB, some varieties may have inherent tolerance for RYSB damage. The low damage and yield loss of varieties Bg 366 and Bw 367 under this outbreak situation suggests that these varieties may have resistance to RYSB.

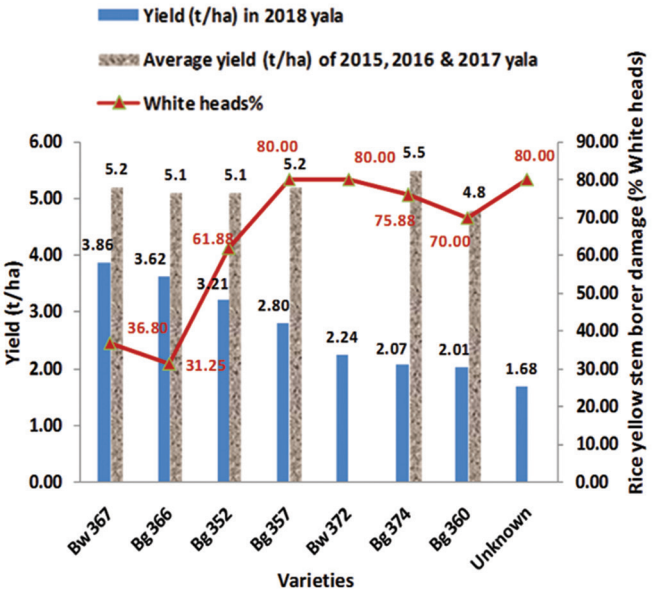

Figure 2. Effect of level of damage by Rice yellow stem borer as overall average of percentage of white heads, on the yields of different rice varieties in 2018 *Yala* season, in the Rice yellow stem borer affected area in Polonnaruwa district, compared with average of yields of three consecutive *Yala* seasons (2015, 2016 and 2017) for the same varieties in Polonnaruwa district

Yield loss

Yield of different rice varieties were reduced along with the increase of the RYSB damage indicated by the percentage of white heads (Figure 2). The varieties Bg 374, Bg 360, Bw 372 and the unknown variety were heavily damaged by RYSB causing high percentage of white heads and low yields. The yield loss of variety Bg 374 was ranged from 45.5 to 100%. The yields obtained from the varieties Bg 352, Bg 366 and Bw 367, which had the low percentages of white heads were higher than the yields of other varieties. However, the yields in these varieties were lower than the average of the yields in three consecutive *Yala* seasons (2015, 2016 & 2017) of the particular varieties in Polonnaruwa district (Unpublished, Data base on rice varietal distribution in Sri Lanka 2015, 2016 & 2017, Rice Research and Development Institute, Batalagoda,). Yield losses of the same variety cultivated by different farmers were within a wide range. This would have been attributed to the facts that the efficacy of insecticides used, level of nitrogen

fertilizers used and cultural practices by individual farmers. On top of all that, the time of planting would also have had a cumulative effect on the RYSB population build up and ultimately on crop damage and yield loss.

Use of insecticides

The survey results showed that 24% of the farmers have used more than four different insecticides (diazinon 5% G, carbosulfan 200 g/l SC, fipronil 0.3% G, quinalphos 250 g/l EC, etofenprox 100 g/l EC, fenobucarb 500 g/l EC, profenophos 500 g/l EC and imidacloprid 200 g/l SC) in 2018 *Yala* season to control RYSB. Out of total farmers, 58% have used insecticides that are recommended for RYSB control (diazinon 5% G, carbosulfan 200 g/l SC, fipronil 0.3% G and chlorantraniliprole 20% + thiamethoxam 20% WG). However, rate of application of insecticide mixture was lower (less than 240 l spray mixture per ha) than the recommendation (320-400 l per ha at tillering stage). Rest of the farmers have used insecticides that were not recommended for RYSB control (quinalphos, fenobucarb, profenophos, etofenprox, and imidacloprid). Out of that, 24% of the farmers have used etofenprox 100 g/l EC. Awareness of farmers on RYSB management and recommendations on insecticide usage was poor during 2018 *Yala* season. It was found that the farmers could not properly recognize the damage at the early tillering stage. They have used the recently recommended insecticide (chlorantraniliprole 20%+thiamethoxam 20%WG) after the extension service of the district made them aware along with the outbreak. By the time they recognized the need for application of an insecticide, the crop was already damaged. This would have contributed to the inability of controlling the pest at tillering stage and led to cause severe damage to the panicles at booting stage, which developed into white heads. Pest control operations should be done with proper timing to control the pest before the damage has been done, by routine crop inspection and the timely recognition of the existence of pests that can cause considerable damage to the crop. This kind of action by farmers is due to the ignorance that seriously recognizes the necessity for action only when the pest has built up into epidemic proportions and the damage to the crop is at devastating level (Fernando *et al*., 1954).

A similar study conducted in Tanzania also reported the same situation. The rice farmers continue to experience losses due to stem borers. Most of the farmers apply chemical insecticides against rice insect pests, particularly stem-borers while very few

farmers use cultural methods. The information on farmers' knowledge and perceptions of rice stem borers is limited and most farmers have limited knowledge on the recommended stem borer management practices (January *et al*., 2018).

The present survey results showed that in the 2018/19 *Maha* season, 58% farmers have used correct recommendation and have applied the insecticide at correct time. This indicated that the knowledge of the farmers on the pest and control measures has been improved. It must be the result of the experience of the previous season and the campaigns conducted by the extension officers to educate the farmers. Therefore, even though the 2018/19 *Maha* crops were infested earlier than usual within 1 month after sowing, no significant damage or yield loss was reported. However, to revise the recommendation of insecticides, a study to test the effectiveness of the recommended insecticides against RYSB is in progress at the Rice Research and Development Institute, Batalagoda.

Fernando (1970) studied the various natural enemies of the RYSB and reported that nine species parasitizing the immature stages of the host, however, only the egg parasitoids play a major role in regulating or limiting the pest. Using broad-spectrum insecticides at the early growth stages of the crop lead to destroy these natural enemies allowing the pest population to build up. However, certain broad-spectrum insecticides are used in an ecologically selective manner so that their greatest effect or impact is on the target species. This has been done by using granular formulations (Wickramasinghe, 1978).

Effect of environmental factors

Many researchers have studied the relationship between weather factors and RYSB population. Those studies indicated that several factors like rainfall and humidity strongly influence the relative abundance of stem borer populations. However, according to those findings, development of stem borer life stages is strongly driven by temperature. Results of the present study also showed a relationship among weather factors and damage caused by RYSB (Figure 3).

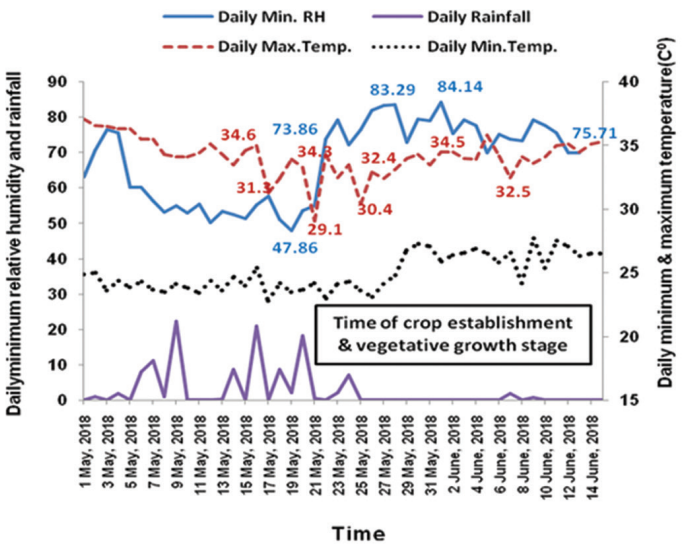

Figure 3. Daily minimum relative humidity, rainfall, maximum and minimum temperature prevailed at Polonnaruwa during the period of rice yellow stem borer infestation occurred in 2018 *Yala* season (Source: Department of Meteorology)

Meteorological data obtained from the Department of Meteorology for Polonnaruwa show that daily minimum relative humidity suddenly increased from 24th May 2018 and high level of relative humidity between 73% and 84%, prevailed throughout the period that coinciding with the seed sowing to booting stage of the crops in the affected area. Maximum temperature reduced and prevailed between 29.1 °C and 34.5 °C simultaneously at the same period of time. Most of the farmers have established their rice crops by 20th May and they have reported that their crops were damaged heavily (about 50% dead heart) during the tillering stage by the end of June.

This indicates that the increase of minimum relative humidity and reduction of maximum temperature during tillering stage of the rice crop during 2018 *Yala* would have had an impact on build up of RYSB population. Several studies conducted in South-East Asian countries in the past indicates that low temperature, high relative humidity and rainfall resulted in yellow stem borer outbreaks (Patel and Singh, 2017). Hussain *et al.* (2018) reported that Relative humidity has a significant positive impact on *S.incertulas*

population. They further stated that temperature range for the activity of *S.incertulus* was recorded as 16-34 °C. Extreme trap catches were documented in April and September where a temperature range was 26-32 °C. This temperature range has been ideal for insect light trap catches and activity of yellow and white stem borer. The temperature prevailed in Polonnaruwa during the 2018 outbreak also had temperature range (29.1-34.5 °C) similar to the above finding. In India, it was reported that drop in mean temperature (< 28 °C) in association with continuous rainfall was the congenial weather condition for outbreak of RYSB (Chattopadhyay and Samui, 2003). Significant positive impact of rainfall on yellow stem borer was reported by Mandal and Mondal (2018). Previous local information on the relationship of climatic conditions and RYSB population build up is lacking. Therefore, it is important to conduct a systematic study on this aspect to understand the influence of weather parameters on RYSB population outbreaks under local conditions. Future studies on forecasting the timing of generations under field conditions using light trap data and current weather data for the location is required.

Conclusion

The outbreak of rice yellow stem borer in Polonnaruwa district during 2018 *Yala* season occurred as a result of compound effect of several factors. Delayed cultivation, staggered cultivation, lack of awareness of the farmers on identification of the pest damage and insecticide recommendations along with lack of knowledge on cultural control techniques and improper use of insecticides were the major cause of the problem. Continuous and intensive cultivation of varieties that are more vulnerable to the yellow stem borer attack also would have contributed to the population build up of RYSB. The climatic conditions prevailed during the season have aggravated the damage by facilitating the population build-up of rice yellow stem borer leading to an outbreak of the pest population causing severe yield losses.

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