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Weather – based crop protection stewardship at Pattambi, Kerala

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सार – केरल, जिसे ''धान'' का कटोरा कहा जाता है, धान में लगने वाले प्रमुख कीटों के प्रकोप को नियंत्रित करने के लिए अधिकतम कीटनाशकों का उपयोग करने की समस्या का लगातार सामना कर रहा है। धन में लगने वाले कुछ प्रमुख उष्णकटिबंधीय कीटों के आक्रमण का पूर्वानुमान करने के लिए मौसम के आँकड़ें और सिनॉप्टिक परिस्थितियों का उपयोग किया गया है। कीटों के प्रकोप के पूर्वानुमान के संबंध में कीटों के बायोनॉमिक्स पर मौसम के प्रभाव की जाँच की गई। केरल में पटटम्बी और उसके आसपास स्टेम बोरर और लीफ फोल्डर के प्रकोप की पूर्व चेतावनी के लिए सिनॉप्टिक स्थितियों और मौसम पर आधारित सूचकांकों पर विचार किया गया है। इस शोध–पत्र में कीटनाशकों के उपयोग और पर्यावरणीय प्रदूषण कम करने के उद्देश्य से मौसम पर आधारित पूर्व चेतावनी प्रणाली का उपयोग करके कीटनाशकों के अनुप्रयोग के अनुकूलतम समय का पता लगाने का प्रयास किया गया है।

ABSTRACT. Kerala, a bowl of rice is continuously facing problem of using maximum pesticide for controlling outbreak of major rice pests. Weather data, synoptic conditions have been used to predict outbreaks of certain important tropical rice pests. Weather influences on the bionomics of pests is examined the context of forecasting outbreaks. The synoptic situations as well as weather based indices are considered to forewarn the outbreaks of stem borer and leaf folder at and around Pattambi, Kerala. An attempt is made to work out optimal time of pesticide application using weather based forewarning system approach with an aim to reduce the pesticide consumption and environmental pollution.

Key words – Rice Pests, HTRmax Ratio, HTRmin Ratio, HSSH Ratio, Pesticide Stewardship.

1. Introduction

India is losing about Rs. 1.40 lakh crore worth of agricultural produce annually to pests (Ramasamy, 2008). Among different plant protection measures like cultural, mechanical, biological and chemicals, use of pesticides is still the most convenient, easiest and effective means for pest management. Even in IPM programmes pesticides are kept as the last resort, particularly when other options fail to deliver desired results. India has 170 mha of arable land with average pesticide consumption of 0.5 kg/ha. In terms of total consumption, India is placed tenth in the world.

The cropping pattern in India is fast changing, particularly towards export-oriented, value added crops. Some of the crops like grapes require as high as 30 sprays in a year. Similarly other crops such as small cardamom (12 insecticide and six fungicide sprays per year), irrigated chillies and cotton need 12 rounds of pesticide sprays per season. Therefore, pesticides are being pumped excessively into such agro-ecosystem in India. Being the second wettest country in the world, receiving maximum rainfall thereby considerable run-off, 1% loss of one kilogram pesticide applied in an acre can contaminate all of the drainage from a field in a normal rainfall year at 5ppb level (Sreeja *et al*., 2008). In India maximum pesticide is used for cotton (32%), rice (23%) and vegetables (9%). Therefore, pesticide stewardship would help in reducing pollution and contamination of the environment.

India has the largest area under rice in the world, and consequently a large diversity in rice-growing environments. The yield loss due to stem borer is 10-48% (AICRIP, 1988) and leaf folder 10-50% (Nair, 1995) in selected states. Stem borer and leaf folder are major constraints to higher rice yield (Heinrichs, 1994). It is observed that Rabi rice is mainly infested by stem borer and kharif rice is mainly infested by leaf folder year after year at Pattambi during last 17 years (Samui *et al*., 2002 and 2007). But the intensity of attack depends on

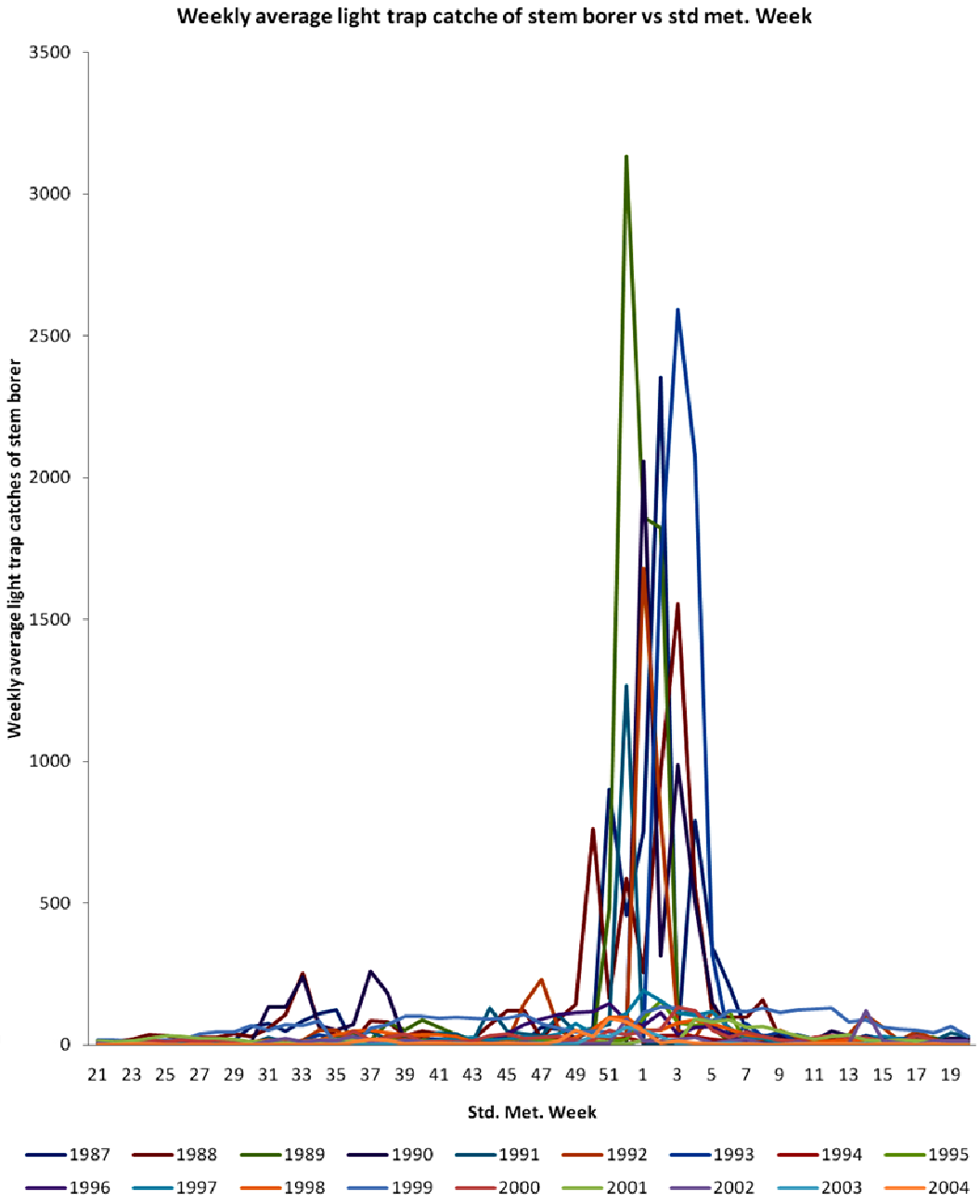

Fig. 1. Weekly average light trap catches of stem borer at Pattambi, Kerala

favourable meteorological conditions, natural enemies, predators, parasites etc. in the crop growing seasons. Damage due to stem borer and leaf folder is much higher in southern states where the pest multiplies throughout the year and shifts from one crop to next (Samui *et al*., 2004). On an average 25 to 30% and 15 to 20% damage has been reported due to stem borer and leaf folder respectively at Pattambi (Karthikeyan, 2002). Here an attempt is made to explore the feasibility to develop forewarning system on the basis of three weather based indices and use them in minimizing pesticide application and thereby adapting crop protection stewardship.

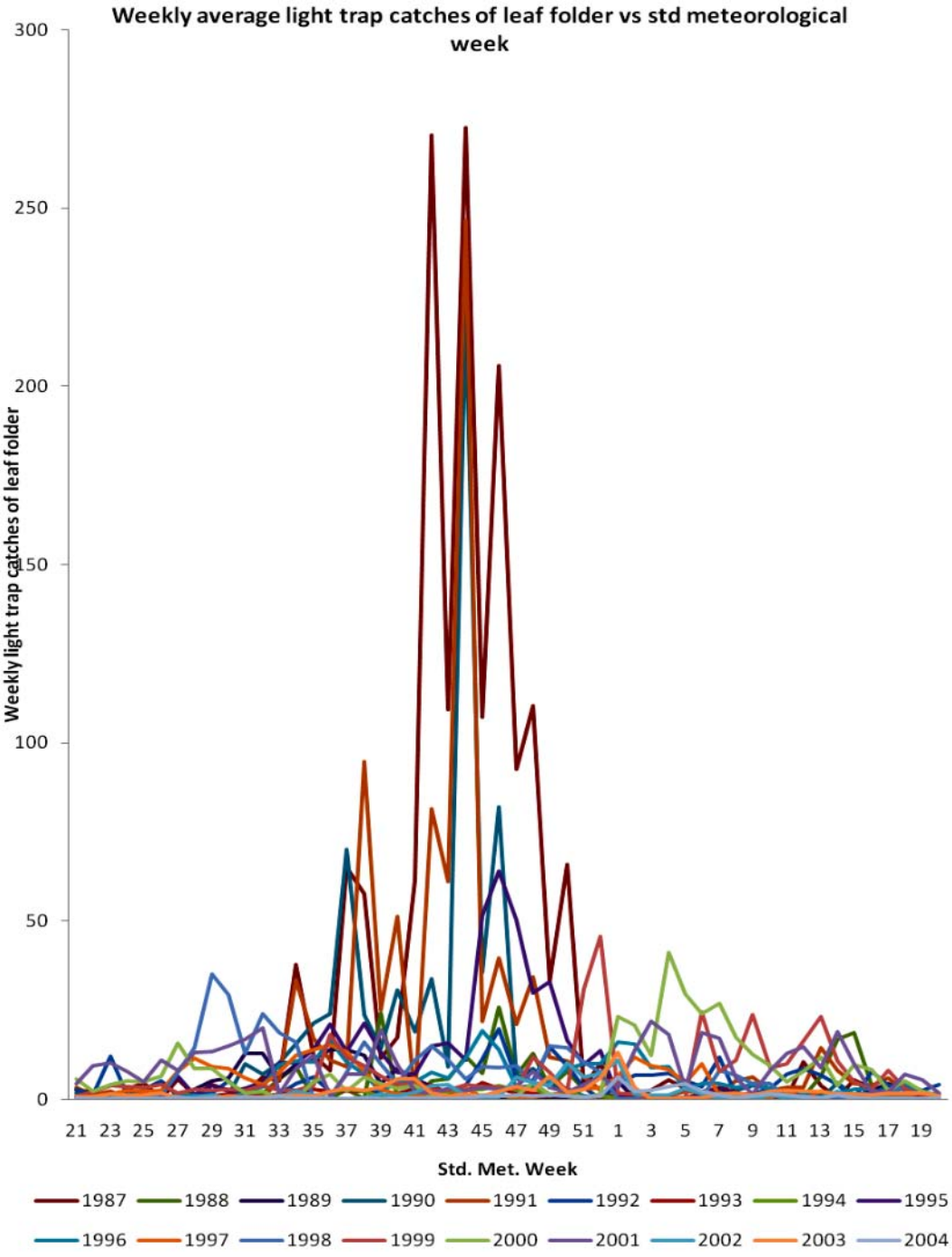

Fig. 2. Weekly average light trap catches of leaf folder at Pattambi, Kerala

2. Materials and method

Chinsurch type light traps were installed in the rice field at Regional Agricultural Research Station (RARS), Pattambi for trapping various rice pests. Daily observations of stem borer and leaf folder were recorded by the Entomologist, RARS and Meteorological data by the Meteorological Office at Pattambi respectively. The data recorded from 1987-2004 for 17 years were utilized for this study (Figs.1 and 2).

TABLE 1

Regression equation, multiple correlation coefficient (M.C.C.), *t* value, level of significance and *F* values of stem borer for different generation with different meteorological parameters in summer rice season

Pest generation/Std. Week No.	Regression Equations	M.C.C.	*t* value	*F* value
	Stem borer			
1st generation at 48th week	P = 816.76-23.5X1 + 0.271X3 - 1.24X6 Where, X1 =Maximum Temperature for 45th std. week X3 =Morning Relative Humidity for 44th std. week X6 =Weekly total Rainfall for 45th std. week	0.72 *	2.96	2.21
2nd generation at 2nd week	P= -9094.66 + 211.2X1 + 20.6X3 - 18.38X4 + 4.08X6 Where, X1=Maximum Temperature for 2nd std. week X3 =Morning Relative Humidity for 52nd std. week X4 =Afternoon Relative Humidity for 52nd std. week X6 =Weekly total Rainfall for 52nd std. week	0.79*	3.83	2.20
3rd generation at 6th week	P = -759.95 + 17.97X2 + 6.744X3 - 2.07X4 Where, X2 =Minimum Temperature for 6th std. week X3 =Morning Relative Humidity for 2nd std. week X4 =Afternoon Relative Humidity for 6th std. week	0.81*	3.98	5.33
	Leaf folder			
1st generation at 39th week (24-30th Sep)	P = 9.17 - 0.13X4 + 0.09X6 Where, P = Leaf folder population X4 = Afternoon Relative Humidity for 39th std. week X6 = weekly total Rainfall for 39th std. week	0.72*	3.37	5.19
2nd generation at 43rd week (22-28th Oct)	P = -174.72 - 12.17X2 + 4.01X3 + 1.3X4 Where, P = Leaf folder population X2 = Minimum Temperature for 41st std. week X3 = Morning Relative Humidity for 43rd std. week X4 = Afternoon Relative Humidity for 39th std. week	0.76*	3.98	4.5
3rd generation at 47th week (19-25th Nov)	P = -305.73 + 16.5X1 - 3.8X2 - 1.9X4 Where, P = Leaf folder population X1 = Maximum Temperature for 47th std. week X2 = Minimum Temperature for 43rd std. week X4 = Afternoon Relative Humidity for 44th std. week	0.82*	4.79	6.3

* Significant at 1% level

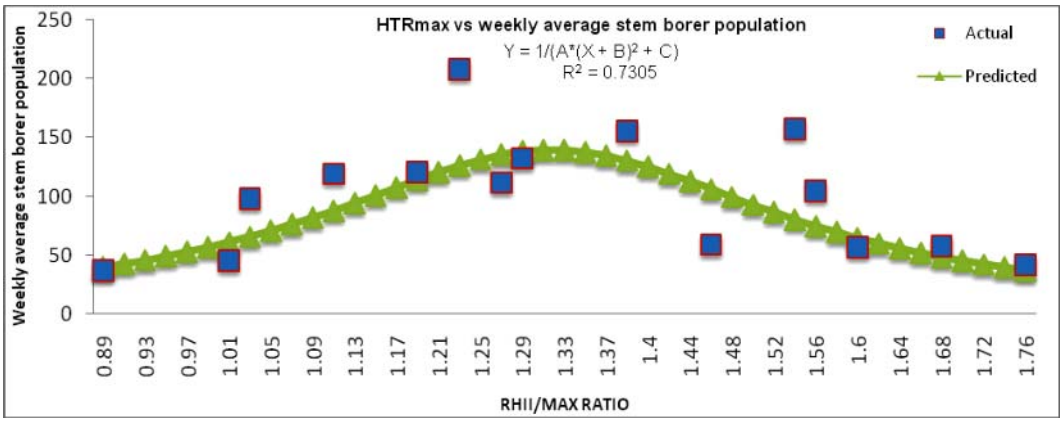

Fig. 3. Relationship between weekly average light trap catches of stem borer and HTRmax ratio

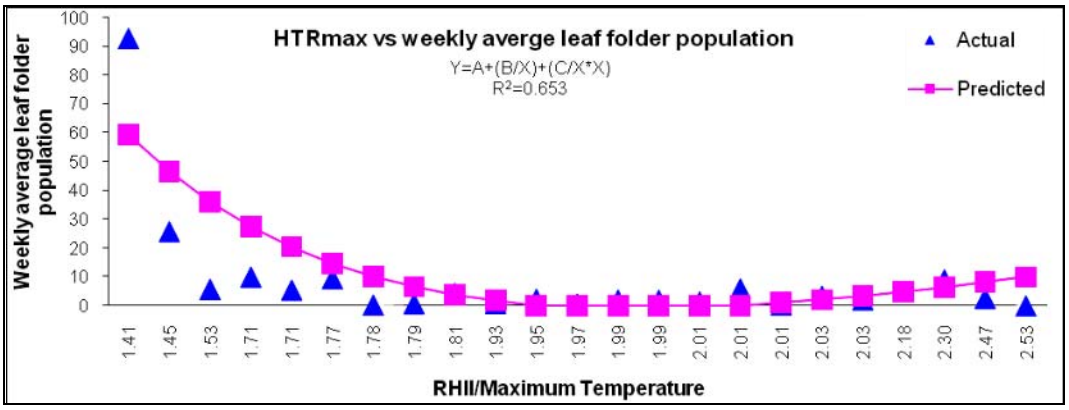

Fig. 4. Relationship between weekly average light trap catches of leaf folder and HTRmin ratio

Correlation coefficients (CCs) between stem borer and leaf folder population and individual meteorological parameters for the corresponding and each of the four previous weeks have been worked out. Weekly mean maximum temperature (*T*max), minimum temperature (*T*min), relative humidity for 0730 and 1430 hrs IST (RH-I and RH-II), bright sunshine hours (SSH), total weekly rainfall (RF) were used to work out the association of meteorological parameters on infestation of stem borer and leaf folder. The meteorological parameters significant at 5% and 1% levels were selected for further analysis and developing forewarning models. The parameters which were found most predominant by stepwise multiple regression technique was chosen for the development of the multiple regression equations (Table 1).

The CCs at week no 39th, 43rd and 47th for leaf folder and 48th, 2nd and 6th for stem borer were found highly significant. The meteorological parameters at these weeks were used for calculating the HTRmax, HTRmin & HSSH ratios. The afternoon relative humidity divided by maximum temperature for the corresponding week gives Humidity-Maximum Temperature ratio (HTRmax). Similarly afternoon relative humidity divided by minimum temperature for the corresponding week gives Humidity-Minimum Temperature ratio (HTRmin) and afternoon relative humidity divided by bright sunshine hours gives Humidity-Sunshine ratio (HSSH). These ratios were plotted with weekly average light trap catches of stem borer and leaf folder. The best fit equations were developed for operational use for stem borer and leaf folder.

3. Results and discussion

3.1. *Weekly average pest's population and HTRmax ratio*

Relationship between the afternoon relative humidity to maximum temperature and light trap catches of stem borer and leaf folder are presented in Figs. 3 and 4 respectively. The HTRmax ratios observed were 0.89 and

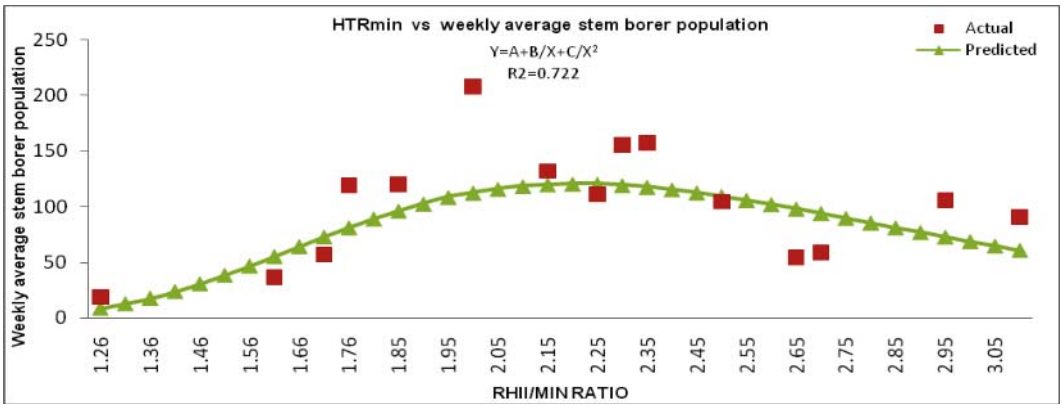

Fig. 5. Relationship between weekly average light trap catches of stem borer and HTRmin ratio

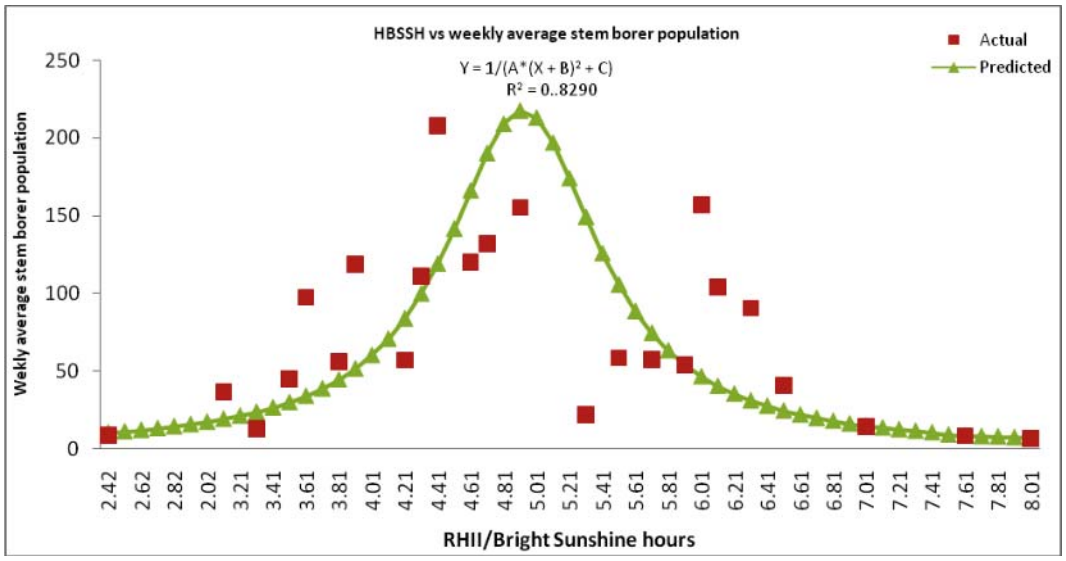

Fig. 6. Relationship between weekly average light trap catches of stem borer and HSSH ratio

1.24 respectively for the lowest and highest values (excluding extreme high values) of stem borer population. However the HTRmax ratios between 0.89 and 1.24 significantly indicate the sudden outbreak of stem borer attack. This corresponds to the afternoon relative humidity ranges between 48 & 31% and maximum temperature range between 32.7° C & 34.5° C. The Cauchy type equation for HTRmax ratios and light trap catches of stem bore with $R^2 = 0.73$ (significant at 5% level) is;

$$Y = 1 / (0.0977^* (X-1.318)^2 + 0.007171)$$

Where, Y = Weekly average light trap catches of stem borer population and X = HTRmax ratio.

The equation accounted for 73% of variation of stem borer population. Stem borer population (Fig. 3) increased with the increase in HTRmax ratios gradually up to 1.24 and then it starts decreasing with increase in HTRmax ratio up to 1.76. It is also seen that Cauchy equation predicted weekly average stem borer population fairly well.

The lowest and highest values of leaf folder population are 0 and 92.6 respectively during the peak infestation period. The HTRmax ratio observed were 1.40 and 1.96 respectively for the lowest and highest values of leaf folder population. The values between 1.40 and 1.96 are significantly indicative of the sudden outbreak of leaf folder attack. This corresponds to the afternoon

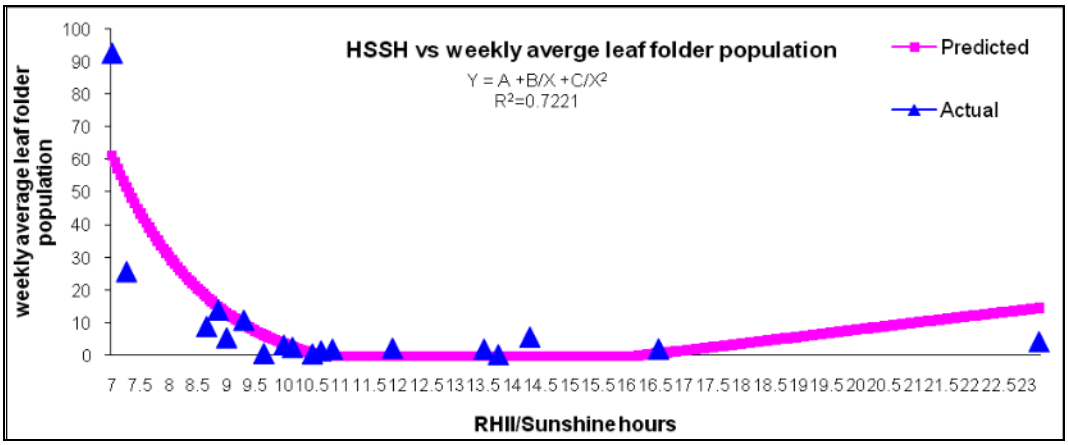

Fig. 7. Relationship between weekly average light trap catches of leaf folder and HSSH ratio

relative humidity range between 63 & 47% and maximum temperature 31.5 & 33.4° C. The equation $Y = 301.3 – 1224.0/X + 1239/X^2$ was found to be the best fit for HTRmax ratios and light trap catches of leaf folder with R^2 values 0.68 (significant at 5% level) Where, Y = Weekly average light trap catches of leaf folder and X = HTRmax ratio. Leaf folder population decreased with increase in HTRmax ratio up to 2.40 and then it remained almost constant (Fig. 4).

3.2 *Stem borer population and HTRmin ratio*

Relationship between the afternoon relative humidity to minimum temperature ratio and weekly average light trap catches of stem borer is presented in Fig. 5. The lowest and highest values of stem borer population are 42 and 160 respectively during the peak infestation period. The HTRmin ratios observed are 1.62 and 2.46 respectively. Ratio between 1.80 & 2.20 highly reflect the sudden outbreak of stem borer attack which correspondence to the afternoon relative humidity of 41 to 31% and minimum temperature of 22.4 to 19.1° C. A 2nd order hyperbola equation $Y = A + B/X + C/X^2$ was found to be the best fit in this case with $R^2 = 0.72$ (significant at 1% level) where, Y = Weekly average light trap catches of stem borer and X = HTRmin ratios. It may be seen from the Fig. 5 that the equation predicted stem borer population fairly well.

3.3. *Weekly average population of stem borer/leaf folder and HSSH ratio*

Relationship between the afternoon relative humidity to bright sunshine hour ratio, stem borer and leaf folder population are presented in Figs. 6 and 7. The lowest and highest values of HSSH ratio were observed as 2.42 and 8.01 for stem borer and 7 to 23 for leaf folder. The lowest value of stem borer population is 10 and highest 240 corresponding to 2.42 and 4.91 HSSH. The sudden increase in stem borer population was observed when HSSH ranged from 3.85 to 5.02. The Cauchy equation $Y = 1/ (A*(X+B)^2 + C)$ was found as the best fit for stem borer population with $R^2 = 0.83$ significant at 1% level. Where, Y = weekly average light trap catches of stem borer and X = HSSH ratio. The population was mainly affected by the afternoon relative humidity between 45 & 38% and bright sunshine hours between 9.8 & 9.1 hours. Similarly for leaf folder the lowest and highest population corresponded to 4 and 60 at HSSH ratio 7.0 to 16.5 respectively. The ratio was inversely proportional to leaf folder population. A 2nd order hyperbola equation $Y = A + B/X + C/X^2$ was found to be the best fit for leaf folder ($R^2 = 0.72$ significant at 5% level). The population was concentrated mainly in the range of 7 to 10.05 corresponding to bright sunshine hours 3.8 to 6.7 hours and RH-II between 63 & 47%. The "Actual and predicted" values of stem borer and leaf folder population indicate that the equations predict fairly well.

4. Crop protection stewardship

Besides mitigating a pest, most pesticides have a broader impact on the Agro-ecosystem. Particularly their impact on beneficial insects and soil organisms may disrupt the functioning of Agro-ecosystem, reduce their health and increase the risks of further pest problems. In addition use of pesticide may have negative health, environmental and economic implications. Pesticides account for a major share of the cost of cultivation of rice in India (about 26%). Thus, crop protection stewardship becomes highly important for not only reducing the cost of cultivation but minimizing the environmental pollution.

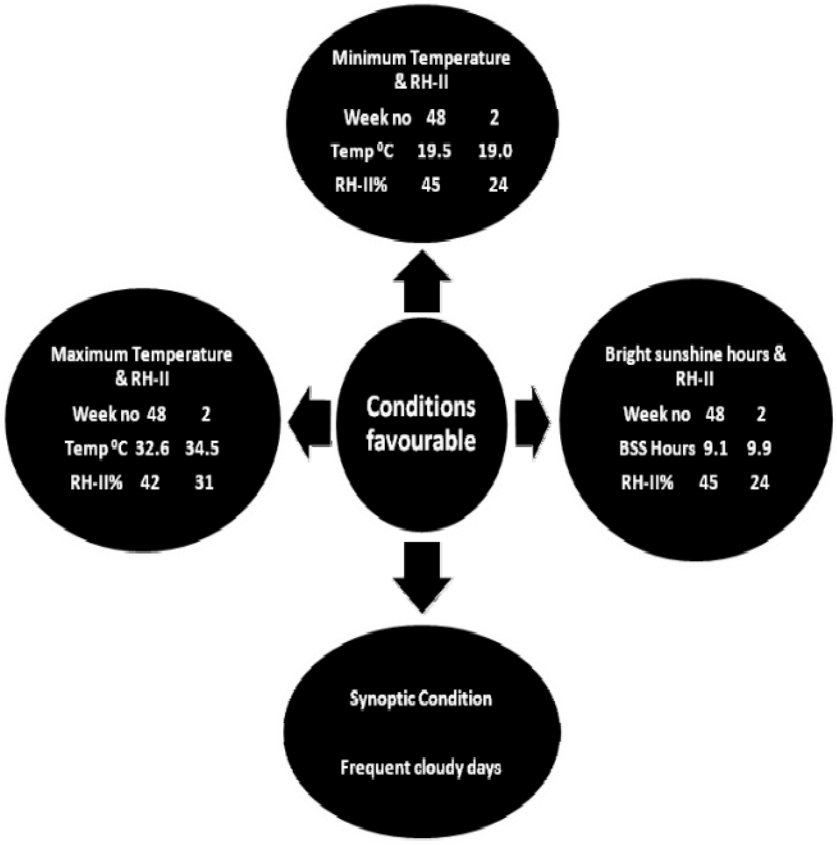

Fig. 8. Conditions favourable for stem borer attack at Pattambi, Kerala

TABLE 2

Actual weather and synoptic conditions during the peak infestation years of stem borer

Year	Maximum population		Prevailing weather		Synoptic conditions
	48 week	2 week	48 week	2 week	
1988	11.3	109.3	*T*Max = 32.8° C	*T*Max = 34.0° C	At 48th week rain or thundershowers occurred at one to two places on some days in Kerala (Scanty rainfall). At 2nd week there was no rain and sky was partially cloudy.
			*T*Min = 19.3° C	*T*Min = 18.5° C	
			RH-II = 51%	RH-II = 40%	
			SSH = 8.1 hrs	SSH = 8.3 hrs	
1992	24.9	61.1	*T*Max = 32.2° C	*T*Max = 32.5° C	At 2nd week the trough in low level easterly from south interior Karnataka to Gujarat region was seen from south Kerala to southwest Madhya Pradesh on 12th and 13th January. Rain or thundershowers have occurred almost at all places on occasionally.
			*T*Min = 20.3° C	*T*Min = 17.5° C	
			RH-II = 54%	RH-II = 40%	
			SSH = 9.5 hrs	SSH = 8.7 hrs	
1996	13	15.6	*T*Max = 32.9° C	*T*Max = 32.6° C	Rain or thundershower occurred at a few places on some days in Kerala.
			*T*Min = 21.0° C	*T*Min = 19.5° C	
			RH-I = 91%	RH-I = 90%	
			RH-II = 62%	RH-II = 45%	
			SSH = 6.0 hrs	SSH = 9.1 hrs	

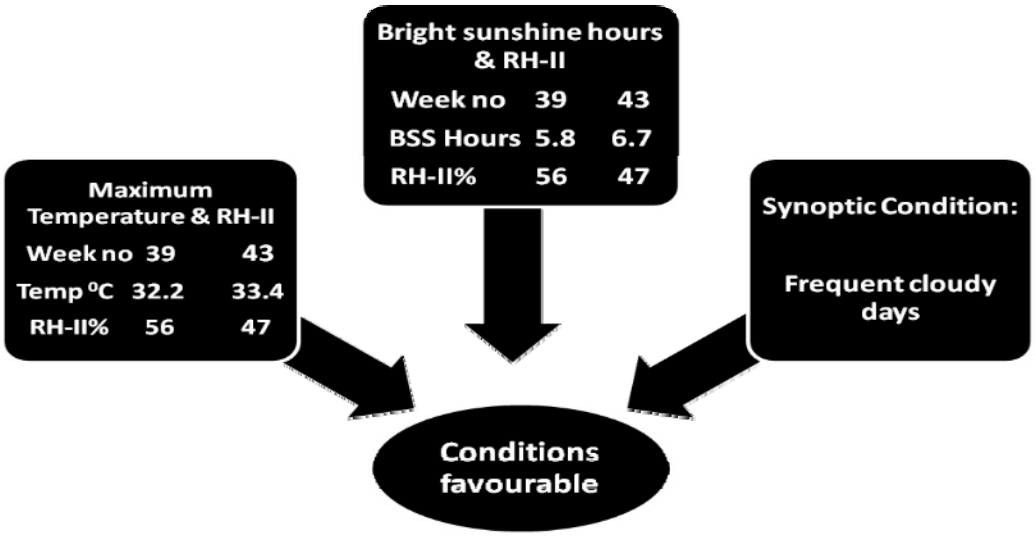

Fig. 9. Conditions favourable for leaf folder attack at Pattambi, Kerala

TABLE 3

Actual weather and synoptic conditions during the peak infestation years of leaf folder

Year	Maximum population		Prevailing weather		Synoptic conditions
	39 week	43 week	39 week	43 week	
1988	11.3	109.3	*T*Max = 29.5° C	*T*Max = 32.1° C	At 39th week trough on sea level chart from north Maharashtra coast to Kerala coast persisted throughout the week. Rainfall was generally widespread on 6 to 7 days in Kerala. In 43rd week rain or thundershowers occurred at a few places on some days.
			RH-II = 77%	RH-II = 59%	
			SSH = 4.5 hrs	SSH = 5.9 hrs	
			RF = 82.4 mm	RF = 3.2 mm	
1992	24.9	61.1	*T*Max = 30.2° C	*T*Max = 31.0° C	In 39th week monsoon has been vigorous on some days in Kerala. In week no 43rd the sky was cloudy and scanty rainfall reported at many places in Kerala.
			RH-II = 81%	RH-II = 69%	
			SSH = 2.5 hrs	SSH = 5.8 hrs	
			RF = 163.1 mm	RF = 8.4 mm	

Crop protection stewardship aimed at improving standard of crop and pest management among small growers through adoption and adaptation of locally developed IPM techniques. It aims to maximize benefits and minimize risks from using crop protection products. Normally this is undertaken in partnership with a range of stakeholders and pesticide industry.

This study clearly identified (Figs. 1 & 2) that almost every year the stem borer and leaf folder peak population occurs at 2nd and 43rd std. weeks respectively. The weather conditions at 2nd and previous 4th std. weeks played very important role for the outbreak of stem borer. As the major pest development cycle seems to starts around the 48th week and ends with outbreak around 2nd week of the subsequent year, spraying operation can be scheduled to minimize number of the sprays as well as the loss due to the pest attack. Favourable weather situations for outbreak of stem borer are summarized in Fig. 8. In the years of maximum population at 2nd week a trough of low was observed over North Indian Ocean and adjoining South Bay. A trough of low at sea level was also seen extending

from Southwest Bay to West central Bay of north Tamilnadu-Andhra coast (Table 2). Thus, a close monitoring of synoptic situation and weather elements during the seasons when population reaches above ETL would help to decide pesticide application in time, and reduce further sprays in subsequent generations.

Based on observed pest and meteorological data at 39th week as well as synoptic situation which may lead to sudden leaf folder outbreak around 43rd week, *i.e*., lower BSSH, higher RH-II, cloudy condition with intermittent RF at 39th week (one or two spells of rain) it would be possible to provide an advisory to the farming community. These results match with those reported by Khan and Ramamurthy, (2004) on correlation studies between light trap and net sweep collection with weather parameter on population build up of leaf folder at IARI, New Delhi. Thus, a spray during the 39th week would minimize the loss due to pest outbreak. In case synoptic conditions (Fig. 9) are not favourable chance can be taken to postpone spraying. A keen watch on pest population and weather will help to decide spraying between 39th and 43rd week. In general, it was found that northeast monsoon rains commenced over Kerala during 43rd week. It was vigorous and active during 43rd week for 1 to 2 days. Day temperatures were above normal on 1 to 3 days over Kerala (Table 3). In such situations spraying may postpone for some days so that pesticide should not be wash out by heavy rains.

5. Constraints to weather based crop protection stewardship

The aim of the weather based crop protection stewardship is to bring down the pesticide usages in the country thereby reduce the risk to the environment and public health. Nevertheless in the case of multiple cropping systems particularly in Kerala, numbers of pest attacks with high intensity are observed. Therefore, it is essential to develop a protocol for farming based on weather and weather sensitive pest development for each agro-ecosystem. The role of self help group's in popularizing the use of weather based pesticide stewardship among local farmers would play a very important role in achieving this goal.

6. Conclusions

(*i*) Peak populations for stem borer and leaf folder in Kerala were observed around 2nd and 43rd standard meteorological weeks respectively in most of the years. This draws attention for preparedness for plant protection measures during these periods.

(*ii*) Indices based on ratios between maximum, minimum temperatures, afternoon relative humidity and bright sunshine hours were developed and were related to pest outbreak periods.

(*iii*) Close monitoring of such situation with optimum values and developed indices are useful for forewarning of stem borer and leaf folder of rice at and around Pattambi, Kerala through the Agromet Advisory Bulletins.

Acknowledgement

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