

Weather based forewarning of green jassid attack on kharif rice and operational crop protection at Pattambi, Kerala

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सार – 1987 से 2001 तक की 15 वर्षों की अवधि में केरल में पट्टम्बी में रिकार्ड किए गए दैनिक कीट वैज्ञानिक और मौसम वैज्ञानिक आँकड़ों का उपयोग करके ग्रीन जैसिड कीट के आक्रमण की रोकथाम के लिए मौसम वैज्ञानिक पूर्व चेतावनी की उपयुक्तता का पता इस शोध पत्र में लगाया गया है। इसमें पूर्व चेतावनी के निदर्शों को तैयार करने के लिए चरणबद्ध तरीके से बहु समाश्रयण तकनीक का उपयोग किया गया है। इस अध्ययन से यह पता चला कि धान की खरीफ की फसल पर अधिकतम और न्यूनतम तापमान, सुबह और दोपहर की सापेक्ष आर्द्रता, अच्छी घूप का समय तथा अच्छी साप्ताहिक वर्षा ग्रीन जैसिड कीट की उत्पत्ति और उसकी अवस्थावार वृद्धि के लिए बहुत अनुकूल है। 1987 से 1999 तक की अवधि के आँकड़ों का उपयोग करके कीट की प्रत्येक अवस्था में इसके तीव्र प्रकोप की अवधि के लिए मौसम पर आधारित बहु समाश्रयण निदर्शों का विकास किया गया और 2000 से 2001 तक के प्रेक्षित मौसम वैज्ञानिक और कीट संबंधी आँकड़ों का उपयोग करके इस निदर्श की सार्थकता की पुष्टि की गई है। इस अध्ययन के परिणामों के आधार पर धान की खरीफ की फसल में ग्रीन जैसिड कीट के लिए कीट मौसम कैलेंडर बनाया गया है। यह कैलेंडर पूर्व चेतावनी और ग्रीन जैसिड कीट के आक्रमण से धान की फसल के व्यावहारिक रूप से संरक्षण के लिए उपयोगी सिद्ध होगा।

ABSTRACT. The feasibility of meteorological forewarning of green jassid attack has been made using entomological and meteorological data for a period of 15 years from 1987- 2001 recorded daily at Pattambi in Kerala. Stepwise multiple regression technique is used in this study for developing forewarning models. The study revealed that maximum and minimum temperature, morning and afternoon relative humidity, bright sunshine hours and weekly totals of rainfall have profound effect on the development of green jassid at their successive generations on kharif rice crop. Weather based multiple regression models for the peak infestation period for each of the generations of the pest were developed using data for the period 1987-99 and validated using observed meteorological as well as pest data for 2000-01. Based on the findings of this study pest weather calendar for green jassid of kharif rice was prepared. This calendar would be useful for early warning and operational rice crop protection from green jassid attack.

Key words – Green jassid, Weather based forewarning, Operational rice protection.

1. Introduction

Rice is grown all through out the year at Pattambi (10° 48' N, 76° 12' E), Kerala. Because of variation in meteorological parameters, natural enemies, predators, parasites etc in the crop growing seasons, the intensity of attack varies considerably. The yield in both the seasons is much below the potential yield due to several reasons. One of the most important reasons is the pest and diseases attack, which cause considerable damage to the crop. Under favourable weather conditions this crop is infested heavily by various pests. Kharif rice is mainly infested by green jassid (*Nephotettix virescens*) leaf folder (*Cnaphalocrocis medinalis*) and gall midge (*Orseolia oryzae*) year after year (Samui *et al.*, 2002) where as other pests *viz.*, stem borer (*Scirpophaga incertulas*) and brown plant hopper (BPH) though remain near economic threshold level in most of the years yet became destructive on some occasions. It is observed that summer rice is mainly infested by stem borer and rice bug (*Leptocorisa*

acuta) at Pattambi. However damage due to green jassid is much higher in southern states where the pest multiplies throughout the year and shifts from one crop to the next. On an average 5-10% damage has been reported due to green jassid attack at Pattambi (Kartikeyan, 2002). It is reported that proper plant protection measures at appropriate time can save the loss in yield of rice even up to 50% (Rangaswamy, 1988). With this in view, an attempt has been made to explore the feasibility to develop forewarning models based on the weather experienced by the rice pests at successive generations by finding the possible relationship between the pest population and various weather parameters. These relationships would be useful in evolving a pest management scheme at and around Pattambi, Kerala.

2. Materials and method

Systematic and detailed daily observations relating to green jassid and weather during kharif season at different

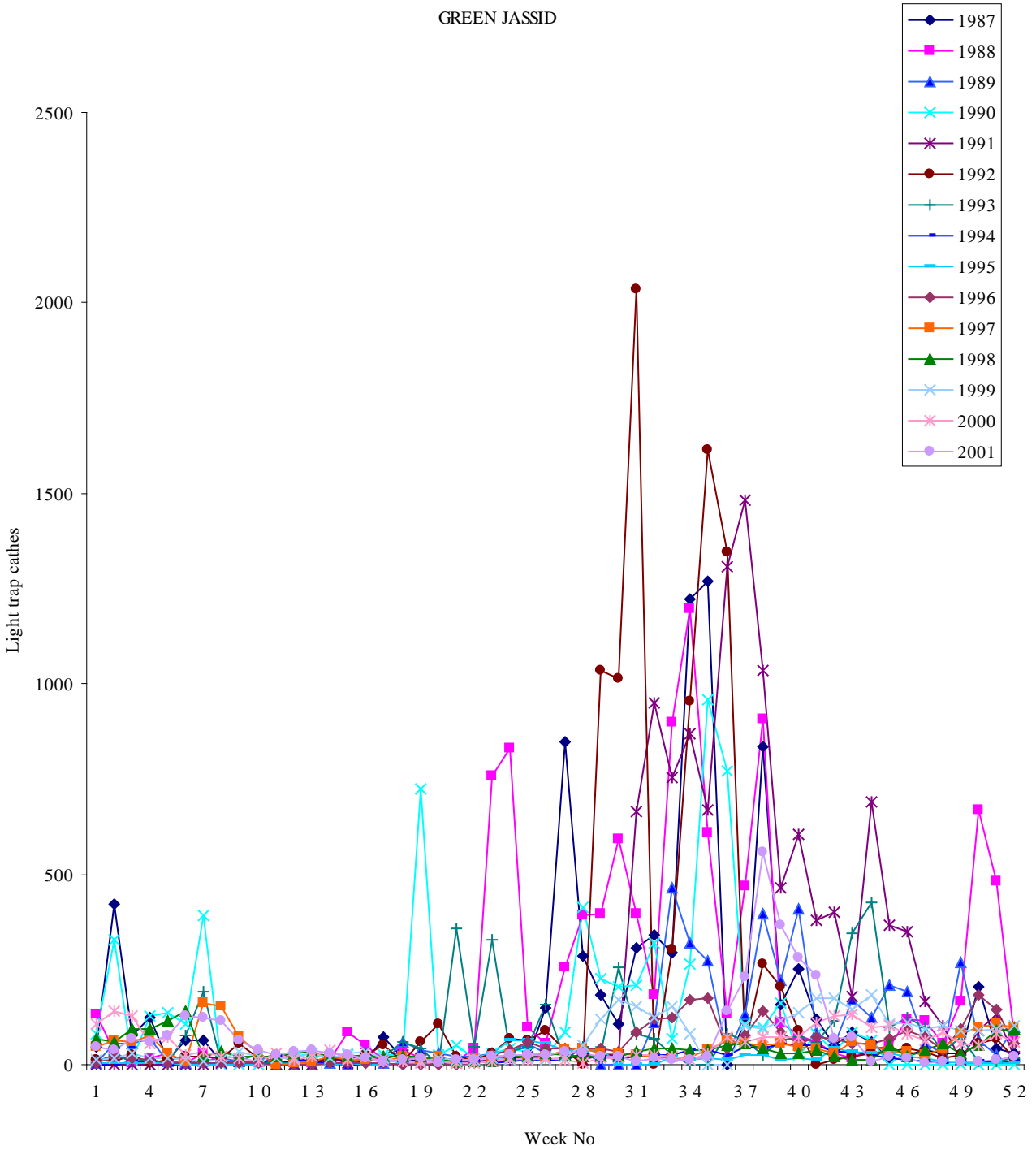
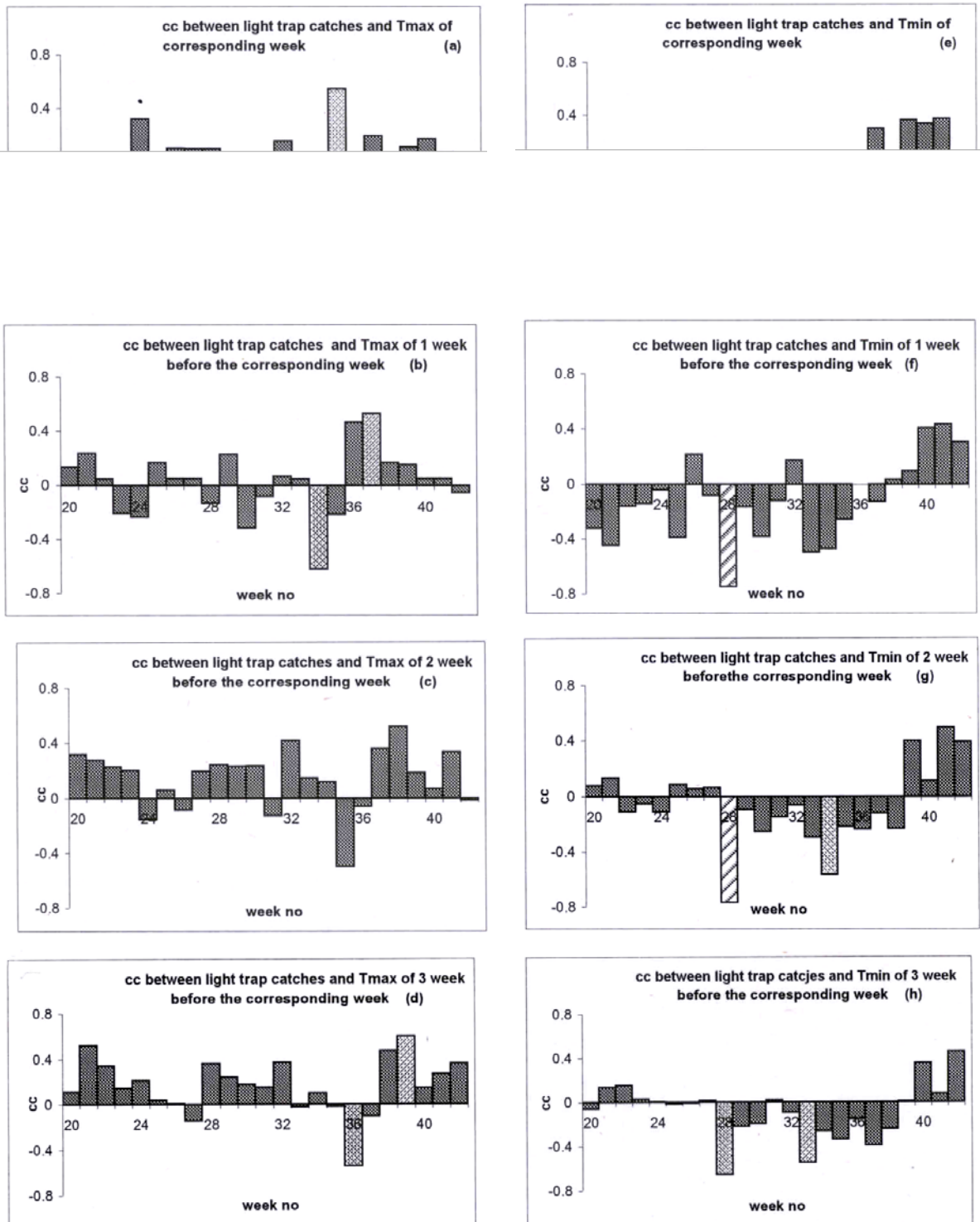


Fig. 1. Variation of weekly Green Jassid catches in different rice growing seasons at Pattambi, Kerala state

generations were recorded using light trap for 15 years (1987-2001) at Pattambi by the Entomologists, Regional Rice Research Station and Meteorological data by the Meteorological Office at Pattambi respectively. Green

jassid data were recorded using light trap which is a mechanical device consisting of a 200W bulb and suitable pest trapping arrangement fitted on a iron mast of 1.5m height. Chinsurah type light trap was installed in the rice



Figs. 2(a-h). Correlation coefficients between light trap catches and T_{max} for (a) corresponding week, (b) previous week, (c) 2 weeks previous, (d) 3 weeks previous and between light trap catches and T_{min} for, (e) corresponding week, (f) previous week, (g) 2 weeks previous and (h) 3 weeks previous

TABLE 1
Regression equation, multiple correlation coefficient (M.C.C.), *t* value, and F values of green jassid for different generation with different meteorological parameters

Eqn. No.	Pest generation/ Std. Week No.	Regression Eqn.	M.C.C.	<i>t</i> value	F value
1	1 st generation at 33 rd week (13-19 August)	$P = 3853.57 - 76.32X_1 - 120.43X_2 + 16.9X_4 - 8.85X_5 + 0.51X_6$ Where, X_1 = Maximum Temperature for 33 rd std. week X_2 = Minimum Temperature for 30 th std. week X_4 = Afternoon Relative Humidity for 33 rd std. week X_5 = Bright sunshine hours for 33 rd std. week X_6 = Weekly total rainfall for 33 rd std. week.	0.839*	5.55	4.29
2	2 nd generation at 37 th week (10-16 September)	$P = 14614.65 - 105.0X_1 - 124.4X_3 - 1.96X_4 + 131.8X_5$ Where, X_1 = Maximum Temperature for 36 th std. week X_3 = Morning Relative Humidity for 37 th std. week X_4 = Afternoon Relative Humidity for 36 th std. week X_5 = Bright sunshine hours for 36 th std. week	0.819*	4.73	4.09
3	3 rd generation at 39 th week (24-30 September)	$P = 4237.69 - 24.08X_1 - 35.17X_3 - 3.39X_4 + 32.7X_5$ Where, X_1 = Maximum Temperature for 36 th std. week X_3 = Morning Relative Humidity for 37 th std. week. X_4 = Afternoon Relative Humidity for 36 th std. week X_5 = Bright sunshine hours for 36 th std. week	0.816*	4.73	4.00

* Significant at 1% level

field at RARS, Pattambi for trapping various rice pests. This is a very effective device against various rice pests and attracts pest from an area of about 2 ha around the trap. The pests are attracted towards light trap in the night and observations are recorded early in the morning by counting each of the pest separately. Weekly average of green jassid catches is reported in this study.

In this analysis correlation coefficients (c.c.s) between green jassid population and individual meteorological parameters for the corresponding and each of the three previous weeks have been worked out and presented in Figs. 2 to 4. 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 were chosen for the development of the multiple regression equations (Table 1).

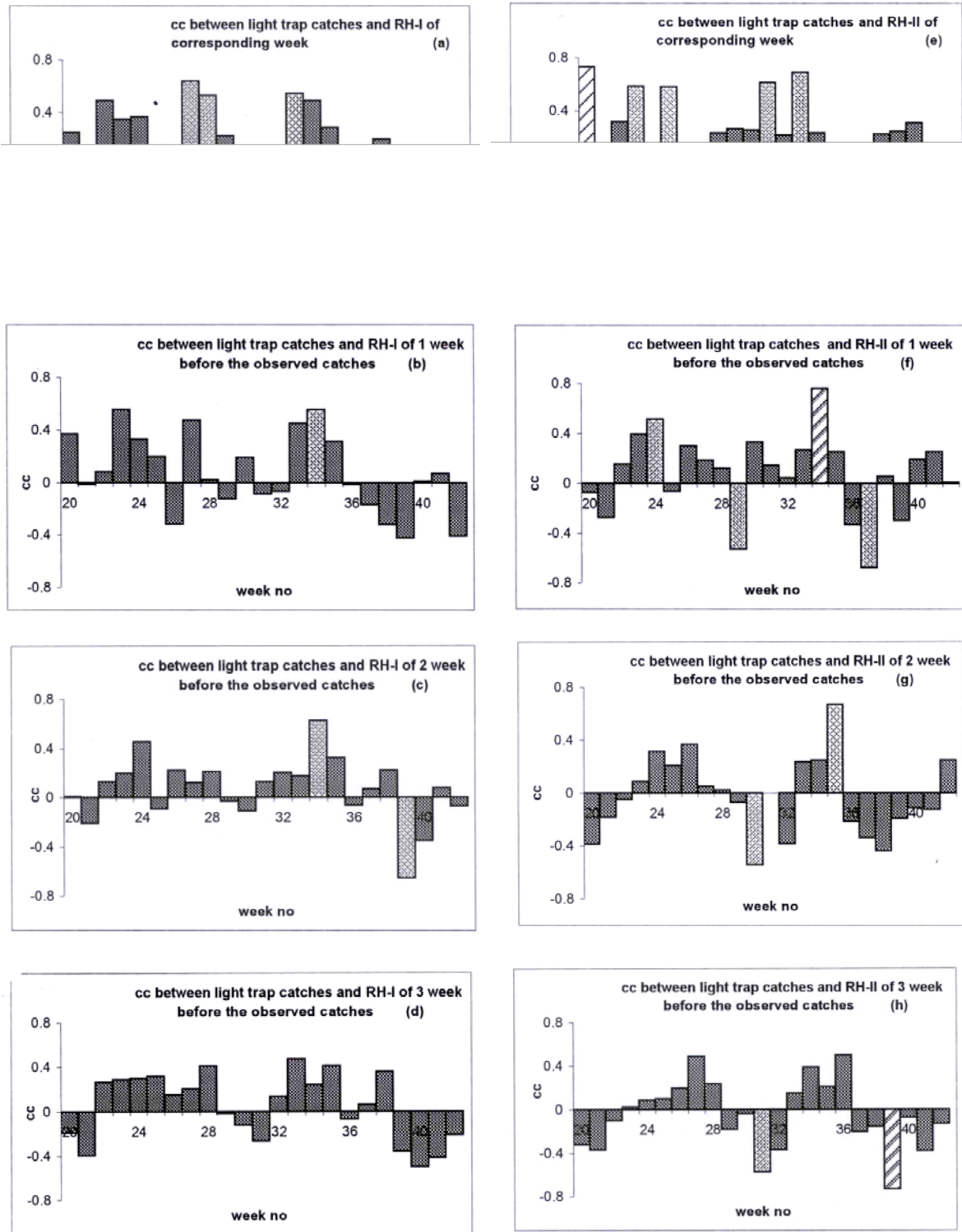
Meteorological elements such as weekly mean maximum temperature (*T*_{max}), minimum temperature (*T*_{min}), relative humidity for 0700 and 1400 hr LMT

(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 green jassid on kharif rice.

3. Weather and green jassid activity at Pattambi

Pattambi is located at 25 m.a.s.l. in Palghat district of Kerala. The district has a tropical climate with an oppressive hot season and fairly assured rainfall during southwest monsoon season. The average annual rainfall in the district is 2396.6 mm. March is the hottest month with the mean daily maximum temperature at 37.4° C and the mean daily minimum temperature at 24.5° C. The air is highly humid throughout the year, the relative humidity being generally over 70% (I.M.D, 1986).

Green jassid was found most active in kharif season (June-September). The maximum green jassid attack was observed between the 28th (9-15th July) to 39th (24-30th September) standard week (std. week) in kharif season. The nymphs and adults cause direct damage by feeding on the sap of young plant leaves, in addition these species are



Figs. 3(a-h). Correlation coefficients between light trap catches and RH-I for (a) corresponding week, (b) previous week, (c) 2 weeks previous, (d) 3 weeks previous and between light trap catches and RH-II for, (e) corresponding week, (f) previous week, (g) 2 weeks previous and (h) 3 weeks previous

known as vectors of virus diseases and 'Tungro' is considered to be most important disease transmitted by them. Generally the feeding of green hoppers is confined to the leaves and the upper part of the rice plant. They suck sap and plug the phloem and xylem vessels resulting in yellowing of leaves and stunting of plant growth. The adults are 3.2 to 5.3 mm long, greenish in colour with black spots on the forewarning except in *N. impticiceps*.

Female deposits 23-27 eggs under epidermis of young leaf sheaths. Incubation period is from 5-10 days. Nymphal period takes about 12-21 days. The adult which hide by day time and feed on leaf tissues during the night. They over winter on weeds, male lives 3 weeks while female 4 weeks.

4. Weather and green jassid relationship

Correlation coefficients worked out between weekly average green jassid catches and different meteorological parameters that the pest experienced during different generations are discussed below :

4.1. Correlation with maximum temperature (T_{max})

Correlation coefficients (c.c.s.) between the weekly average green jassid population (GJP) and T_{max} during the peak infestation period between 33rd to 39th weeks (both corresponding and each of the four previous weeks) show profound influence of T_{max} on growth and development of green jassid [Figs. 2(a-d)]. Out of 115 c.c. values, 78 (68%) c.c.s positively and 37 (32%) c.c.s. were negatively correlated [Figs. 2(a-d)]. Out of the 10 c.c.s. significant at 5% level, 7 were positively and 3 were negatively correlated. Only c.c. was negatively but significantly correlated at 1% level.

It is interesting to note that development of adult green jassid at 33rd week was profoundly influenced by the lower T_{max} of 33rd week. Development of larva of green jassid at 37th week was influenced by higher T_{max} at 37th std. week (c.c significant at 5% level). The development of adult green jassid at 33rd and larva of green jassid at 36th week were influenced by lower T_{max} at 33rd and higher T_{max} at 36th week respectively. Though none of the c.c.s. were significant between light trap catches and T_{max} of 2 week's before yet all the c.c. were found positively correlated except for weeks no.24, 32 and 36. The lower T_{max} at 33rd and higher T_{max} at 36th week were favourable for adult at 33rd week and egg laying and hatching at 36th week. [Figs. 2(a-d)].

4.2. Correlation with minimum temperature (T_{min})

Out of 115 c.c. values worked out between GJP and T_{min} during the peak infestation period (33rd to 39th weeks), 43 c.c.s. (37%) were positively and 72 c.c.s. (63%) were negatively correlated. Out of 9 significant c.c.s. (2 at 1% and 7 at 5% level), 8 c.c.s. were negatively and 1 was positively correlated. 28th week's GJP were negatively and significantly correlated with 28th, 27th and 26th week's T_{min} . Similarly 33rd weeks GJP were negatively and significantly correlated with 33rd, 30th weeks T_{min} . GJP of 34th week and T_{min} of 32nd week negatively and significantly correlated.

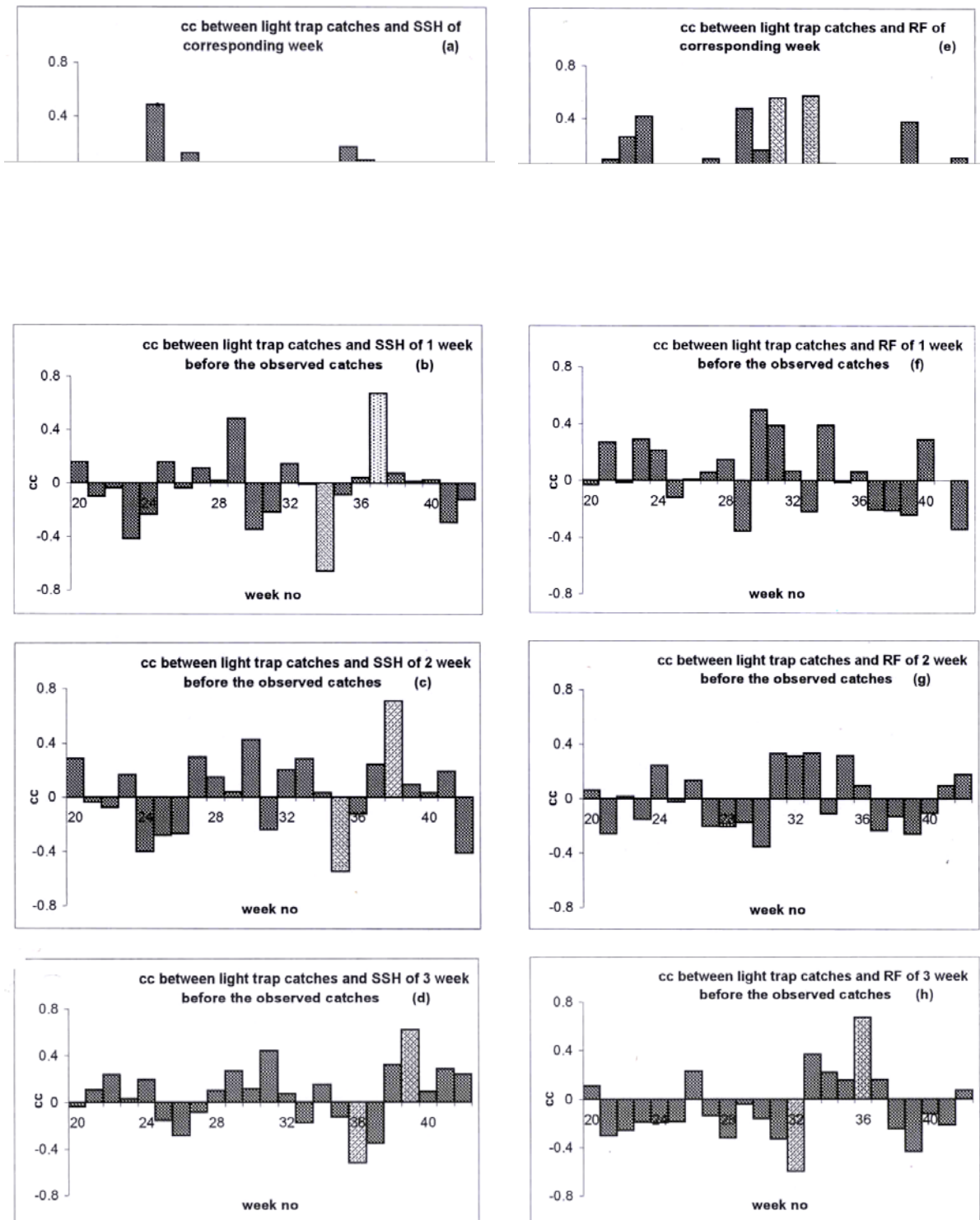
Thus lower T_{min} than the average value (Avg. $T_{min} = 22.6^{\circ} C$) was found beneficial for the egg laying and development of the larva and adult at 28th and subsequent weeks [Figs. 2(e-h)]. Similarly 33rd and 34th week's negatively significant c.c. values between GJP and T_{min} of the corresponding and previous 3 week's [Figs. 2(e-h)] indicate that development of moth were hindered by higher T_{min} . The negatively significant c.c.s. between GJP and T_{min} of the 28th, 33rd and 34th weeks clearly indicated that lower minimum temperature during 1st generation had played the profound role in the development of the green jassid where as higher T_{max} had contributed significantly for hatching, larva, pupa and multiplication of green jassid during all the three generations.

4.3. Correlation with morning relative humidity (RH-I)

Out of 115 c.c. values 69 c.c.s. (60%) were positively and 46 c.c.s. (40%) were negatively and significantly correlated. GJP of 27th, 28th and 33rd weeks and RH-I of the corresponding week were correlated positively and significantly. It is interesting to note that all significant c.c. values between GJP and RH-I were positively correlated except two c.c. values between 37th week's GJP and 37th week's RH-I and 39th week GJP and RH-I of 37th week when c.c.s. were negatively and significantly correlated. Thus higher RH-I at 33rd week and lower RH-I at 37th, 39th week were found favourable for the egg hatching at 33rd, 37th and 39th week [Figs. 3(a-c)].

4.4. Correlation with afternoon relative humidity (RH-II)

Afternoon relative humidity also showed profound effect in building up GJP during 33rd to 39th weeks. Out of 115 c.c. values 64 c.c.s. (56%) were positively and 51 c.c.s. (44%) were negatively correlated. Out of 14



Figs. 4(a-h). Correlation coefficients between light trap catches and SSH for (a) corresponding week, (b) previous week, (c) 2 weeks previous, (d) 3 weeks previous and between light trap catches and RF for (e) corresponding week, (f) previous week, (g) 2 weeks previous and (h) 3 weeks previous

significant c.c. at 5% level 5 were positively and 9 were negatively correlated. Similarly 2 c.c.s. were significant at 1% level. (One positively and one negatively correlated).

The significant and positive c.c. value between the pest population at 33rd week and RH-II of 33rd week clearly indicates that higher RH-II was beneficial for adult development at 33rd week. The green jassid population at 33rd week was mostly positively correlated with the previous week's RH-II [Figs. 3(e-h)]. GJP of 37th week was negatively and significantly correlated with RH-II of 36th [Fig. 3(f)] indicating a contrasting and quite a different requirement of the larva stage to pupa stage of the GJP in a short time span of about 28 days when T_{min} was relatively low. The GJP at 39th week and RH-II of 36th week was negatively and significantly correlated which clearly indicates that lower RH-II at 36th week was beneficial for egg laying and hatching of 3rd generations green jassid. The completely opposite requirements of RH-II for first, second and third generations clearly indicate that requirement of RH-II for larva stage in a short time span of 28 days and also in the adult stage are quite different and need critical examination under control chamber study.

4.5. Correlation with bright sunshine hours (SSH)

C.c.s. between GJP and SSH were not significant during 20th to 32nd weeks. However GJP of 33rd week was found significant and negatively correlated with 33rd week SSH at 5% level, c.c.s. between SSH and green jassid population were mostly negatively correlated. Lower SSH at 33rd week were beneficial for adult development. The GJP of 33rd week and SSH of 36th week were positively and significantly correlated. This indicates that higher SSH is beneficial for larval development of GJP. The GJP at 39th week and SSH of 36th week was positively correlated. This show higher SSH is beneficial for egg laying and hatching.

4.6. Correlation with rainfall (RF)

Almost equal percentage of positively and negatively significant c.c.s. between GJP and RF indicated that rainfall played important role in building up GJP. 4 c.c.s. were significant at 5% level, 3 of them positively and one negatively correlated. The higher amount of rainfall provided adequate leaf wetness for multiplication and development of green jassid. The positive c.c. between the 33rd week's GJP and 33rd week RF indicates that higher rainfall during the hatching of eggs as well as during the adult formation stage of 1st and 3rd generations of green jassid is detrimental [Figs. 4(e-h)].

5. Forewarning models

We have developed three multiple regression equations (Table 1) using meteorological parameters having significant correlation coefficients for each of the three generations. As development of one generations overlap with other one it is very difficult to distinguish exact duration of one generation from that of others. Based on peak activity and their life cycles only three overlapping generations are discussed here. The green jassid population at 33rd week was negatively and significantly correlated with the T_{max} of 33rd week ($cc = -0.78$), T_{min} of 30th week ($cc = -0.54$), SSH of 33rd week ($cc = -0.68$) it was positively and significantly correlated with RH-II of 33rd week ($cc = 0.69$) and weekly total RF of 33rd week ($cc = 0.57$). When all these five meteorological parameters were subjected to regression analysis with GJP at 33rd week the resultant MCC was 0.839 (significant at 1% level) which accounted for 70% variation in GJP (Eqn. 1 in Table 1). The study revealed that maximum temperature $< 29.5^{\circ} C$ of 33rd week, minimum temperature $< 22.1^{\circ} C$ of 30th week, afternoon relative humidity $> 75.2\%$ of 33rd week, bright sunshine hours < 4.0 hour of 33rd week and total weekly rainfall > 86.0 mm of 33rd week contributed significantly for the development of GJP of rice at 33rd week. It is worth mentioning that variations in GJP during 1st generation can not be explained more than 70% because of the fact that there are several other factors such as natural enemies, parasites etc. also equally played important role in reducing the development of the pests.

The second generation of green jassid starts multiplying under favourable weather conditions at 37th week. The multiple regression equation developed using the weather parameters and green jassid population at 37th week was presented as Eqn. 2 in Table 1. The resultant M.C.C was 0.819 (significant at 1% level) which accounted for 68.4% variation in the GJP. Weather conditions which were found favourable for the green jassid development at 37th week are: morning relative humidity $< 94.0\%$ of 37th week, afternoon relative humidity $< 71.0\%$ of 36th week and bright sunshine hours > 5.3 hours at 36th week.

The third generation of green jassid starts multiplying at and around 39th std week. Multiple regression equation for the 3rd generation was developed using GJP of 39th week and maximum temperature of 36th week ($cc = 0.61$), morning relative humidity of 37th week ($cc = -0.65$) afternoon relative humidity of 36th week ($cc = -0.74$) and bright sunshine hours of 36th week ($cc = 0.62$). When all these four meteorological parameters were subjected to regression analysis with the green jassid population at 39th std week the resultant

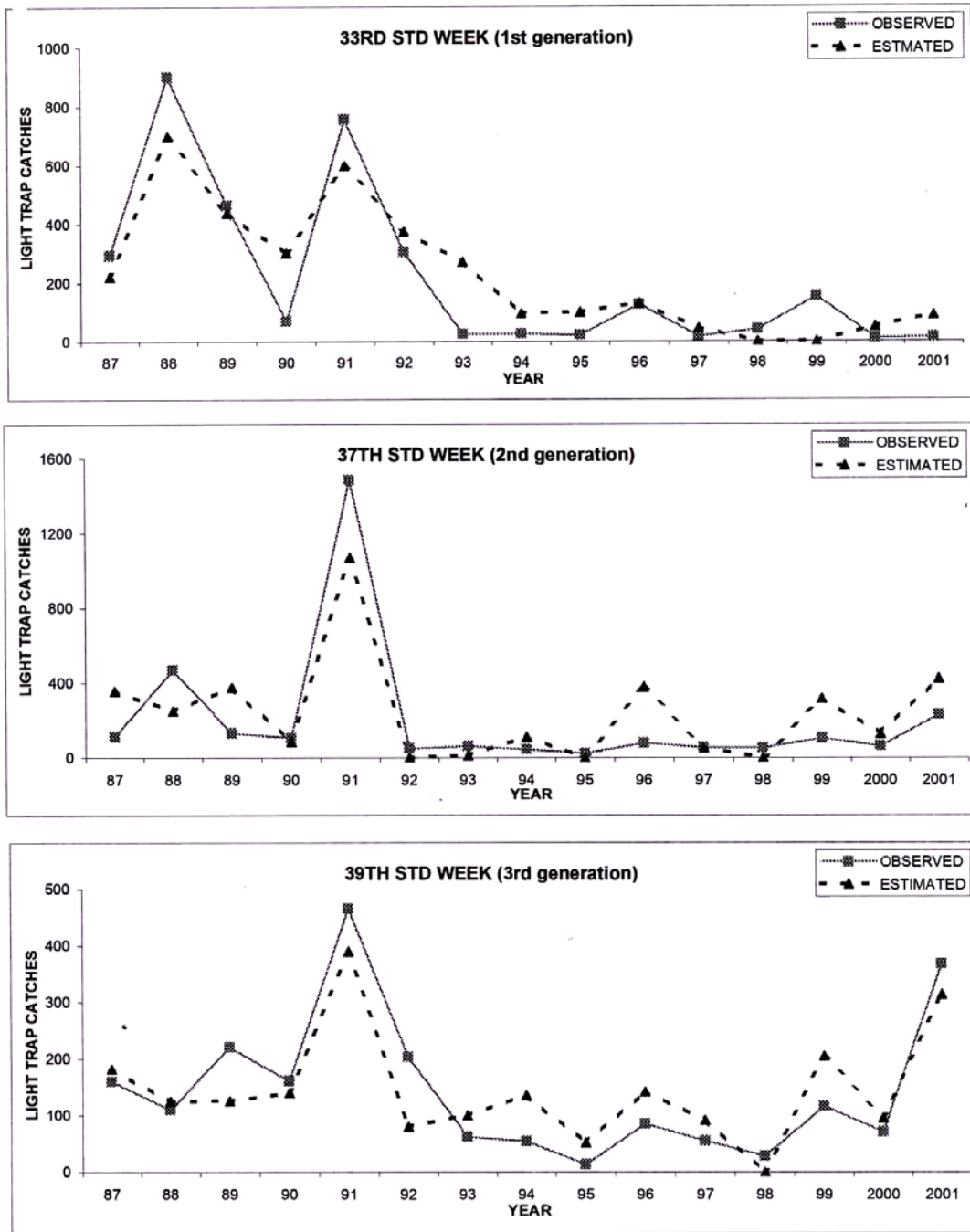


Fig. 5. Weekly mean observed and estimated green jassid population during first, second and third generations

M.C.C. was 0.816 (significant at 1% level) which accounted for 68% of variation in green jassid population (Eqn. 3 in Table 1). Weather conditions which were found favourable for the development of 3rd generation of green jassid are : maximum temperature > 29.9° C of 36th week, morning relative humidity < 94% of 37th week, afternoon

relative humidity < 71.1% of 36th week and bright sunshine hours > 5.3 hours of 36th week.

Thus the study clearly indicates that there is a distinctly different weather requirement for adult, egg laying, hatching of eggs and also for the larva and pupa.

Pest weather calendar

State : Kerala
Station : Pattambi

Crop : Rice
Pest : Green Jassid

Season : Kharif

Weather warnings	Max. temp. (°C)																				< 29.5° C at 33 rd week	> 31.2° C at 36 th week	> 29.9° C at 36 th week														
	Min. temp (°C)																					< 22.1° C at 30 th week															
	Morning RH %																						< 94.0% at 37 th week	< 94.0% at 37 th week													
	Afternoon RH %																					> 75.2% at 33 rd week	< 71.0% at 36 th week	< 71.1% at 36 th week													
	Sunshine hours																					< 4.0 hrs at 33 rd week	> 5.3 hrs at 36 th week	> 5.3 hrs at 36 th week													
	Total rainfall																					> 86.0 mm at 33 rd week															
Weekly normal weather	Rainfall (mm) total	204.9	151.4	127.5	154.4	103.6	96.8	89.0	63.1	38.2	37.9	33.8	41.5	65.7	47.2	55.2	78.1	61.7	53																		
	Max. temp. (°C)	28.6	28.8	28.9	28.6	28.7	29.1	29.0	29.2	29.8	30.1	30.5	30.6	30.5	30.8	31.2	31.5	31.4	31.9																		
	Min. temp (°C)	22.4	22.6	22.5	22.5	22.6	22.7	22.7	22.8	23.0	22.8	22.9	22.9	22.9	22.9	22.9	22.9	22.8	22.7																		
	Sunshine hours	2.1	2.3	2.8	2.7	3.1	4.0	4.0	4.6	5.7	6.3	6.8	6.3	6.3	6.0	6.3	5.7	6.2	6.7																		
	Morning RH %	96	96	96	96	96	96	96	96	95	94	94	94	94	95	95	95	94	94																		
	Afternoon RH %	83	79	80	80	81	78	78	76	72	70	67	70	67	69	68	68	67	64																		
Mean dates of important epochs of crop growth and pest development																																					
Standard weeks		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44																		
Months		July					August				September				October																						

Fig. 6. Pest weather calendar

Earlier studies have also shown that the eggs, first instar larva and adult are highly susceptible to changes in relative humidity (Rao *et al.* 1971).

The information on economic threshold value of the pest along with favourable meteorological conditions at all the three generations will help to take decision regarding possible rapid multiplication of the pest and crop protection measures to be adopted subsequently.

The multiple regression models developed for each of the generations of green jassid were validated using meteorological data for 2000-2001. Estimated and observed light trap catches for each of the generations during the study period 1987-2001 are presented in Fig. 5. It may be seen from Fig. 5 that all the regression models performed fairly well. Validated results show that forewarning of green jassid attack could be taken up based on weather information in and around Pattambi, Kerala. However information on host plants, natural enemies, green jassid population from the field and weather

condition on real time basis would help to forewarn the farmers well in advance. Observations on pest population from the field, present and forecast weather based on synoptic situations would also help to forewarn the possibilities of rapid multiplication and development of the pest in subsequent generations.

6. Pest weather calendar

Keeping in view of the weather requirement of rice crop as well as weather conditions favourable for development of green jassid at their successive generations, pest weather calendar has been prepared and presented in Fig. 6. Based on the findings of this study and weather conditions (both favourable and unfavorable) during the peak infestation time *i.e.*, 28th to 39th std weeks for kharif rice crop along with warning to be issued for plant protection purposes at each of the generations, the optimum weather requirements for green jassid development are highlighted at the top of the calendar. The middle portion shows the normal weather at Pattambi,

Kerala. The bottom portion shows the months and standard weeks along with life history and mean important epochs of pest development and crop growth. This also depicts the important stages of pest like egg laying, larva, and adult. It also shows crop growth stages like, sowing and emergence, transplanting, active vegetative growth, reproductive stage, ripening stage and harvesting respectively.

For issuance of warning on pest incidence as well as for advisories to the farmers for crop protection, observation on green jassid population from the field and a comparison of actual weather conditions and weather requirements for the development of the pest at each of the generations of pest will help to take plant protection measures in time and to minimise loss due to infestation of the pest. In case of unfavorable weather conditions for green jassid development strict watch may be kept on pest population and even when the population reaches near economic threshold values the farmers may be advised to postpone spraying operations till further increase in population is noticed.

7. Operational crop protection

The critical factors in the proper application and use of chemicals are temperature and precipitation during the succeeding 24 hours and the speed and direction of wind at the time of spraying. Temperature determines its effectiveness where as precipitation immediately following application can dilute or wash off the chemicals. Such operational crop protection is an interagency collaborative work and is required to be taken up on real time basis. All concerned agencies such as meteorological, entomological and extension departments are required to act quickly based on information on past, present and future weather conditions and field observation on pest population. Active participation of workers from the extension wing of the State Agricultural Department and Agricultural Universities would be required for real time plant protection measures. Dissemination of such information especially the exact time of spraying of pesticide for operational plant protection through TV/Radio/Telephone/Personal contact on real time basis would help to protect crop from infestation of green jassid attack. Timely application of insecticide, pesticides and fungicides has not only become economical but it can also minimize the amount of noxious chemicals released into the atmosphere. This would also help the farmers to obtain maximum control with a minimum number of chemical sprays.

On the basis of the findings of this study and forewarning models developed for green jassid of rice, useful operation of agro meteorologically based

TABLE 2

Weather requirements for spraying and dusting operation.
(After WMO 1991)

Weather Factor	Spray	Dust
Wind (ms ⁻¹)	0.8	0.4
Dew	Undesirable	Desirable
Precipitation	Undesirable	Undesirable
Convection	None of slight	None of slight
Relative Humidity	Not important	Optimum 90% or more
Temperature (°C)		
Lower limit	About 2	Not important
Upper limit	About 32 with low Relative Humidity	Not important

information and advice for rice protection from green jassid attack could be introduced successfully in the meteorological sub divisions of Kerala. Information on probability of rainfall and synoptic situation and observation on green jassid population from the rice field by the extension workers of the State Agricultural Department / Agricultural University at and around 28th to 39th (succeeding year) standard weeks would help to take up decision regarding spraying operations. Information on favourable weather for green jassid development and weather likely to be experienced in near future could be used for issuing forewarning for green jassid attack and spraying/dusting operations (Table 2) or negative forecast. *i.e.*, advisory against spraying /dusting operations when the likelihood of pest attack is negligible. Weather experienced by the pest and expected weather in succeeding days (using short and medium range forecast) juxtaposed with the optimum weather requirement for green jassid for their out break would also help to advise the farming community for the spraying operations.

8. Conclusions

(i) The maximum activity and damage due to high population density of green jassid was observed during kharif rice season from 28th to 39th std. weeks.

(ii) Egg laying, hatching and rapid multiplication of green jassid start at and around 33rd std. week under favourable weather conditions. Maximum temperature < 29.5° C at 33rd week, minimum temperature < 22.1° C of 30th week, afternoon relative humidity > 75.2% of 33rd week, and weekly total rainfall > 86.0 mm of 33rd week triggered the green jassid multiplication.

(iii) A critical examination of significant correlation coefficient between green jassid population and meteorological parameters revealed that morning relative

humidity < 94% of 37th std week, afternoon relative humidity < 71.0% of 36th std week, and bright sunshine hour > 5.3 hour of 36th std week played an important role in the development and out break of 2nd generation of green jassid at 37th std. week. 37th week was found to be the epicenter week for outbreak of green jassid and favourable meteorological condition at this week would favour the development of the pest at 37th and subsequent weeks.

(iv) Development of third generation of green jassid were favoured by higher maximum temperature > 29.9° C at 36th week, morning relative humidity < 94% of 37th week, afternoon relative humidity < 71.1% of 36th week and bright sunshine hours > 5.3 hours of 36th week.

(v) The turning points in correlation coefficient with the minimum temperature, rainfall, morning and afternoon relative humidity during the peak infestation period (28th to 39th std. week) clearly indicate that optimum and favourable weather requirements for adult green jassid at and around 33rd week and for hatching of eggs and development of larva at and around 33rd, 37th and 39th week's are quite different. More studies under controlled temperature and humidity conditions are necessary for determining the exact requirements.

(vi) Under favourable weather conditions egg laying, hatching of eggs and larva development takes place in short interval of time overlapping one with other and causing it difficult to distinguish clearly one generation from that of the other generation. Thus it would be desirable to conduct controlled study under laboratory conditions. Perhaps this is the reason for not explaining more than 70% variation in green jassid population by the multiple regression equation.

(vii) Forewarning models and pest weather calendar for green jassid of rice could be used as a useful aid in agro

meteorological forewarning and operational crop protection.

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