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Weather based forewarning of stem borer (*Scirpophaga incertulas*) on rice

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सार – इस शोध पत्र में विनाशकारी कीटों की आपदा का सही समय पर मौसम के आधार पर पूर्वानुमान जारी करते हुए धान के पौधे के डंठल में हुए छिद्रों से होने वाले नुकसानों को नियंत्रित/कम करने की संभावनाओं का निरीक्षण करने के लिए अध्ययन किए गए हैं। पादप संरक्षण, संगरोधन और भंडारण विभाग, फरीदाबाद द्वारा 1988 से 1995 के दौरान किए गए सर्वेक्षण से यह पता चला है कि रबी/ग्रीष्म ऋतु की अपेक्षा खरीफ के मौसम में डंठल में छिद्रों की घटनाएँ अधिक पाई गई थी तथा विशेष रूप से गुजरात, उड़ीसा, आँध्र प्रदेश, असम, हरियाणा और पंजाब में यह घटना प्रायः सामान्य से प्रचंड पाई गई है। वर्षा के लगातार होने के परिणामस्वरूप औसत तापमान (<28°सें.) में आई गिरावट से धान की फसल में कीटों की स्थिति के लिए अनुकूल मौसम परिस्थितियाँ उत्पन्न होती हैं। इस अध्ययन से यह निष्कर्ष निकलता है कि वर्षा होने के साथ–साथ अधिकतम और न्यूनतम तापमान में गिरावट लाने वाली मौसम की प्रबल स्थितियों में धान की फसल के डंठलों में छिद्रों की बीमारी की घटना की पूर्वसूचना संभवतः कृषि मौसम सलाहकार सेवाओं के माध्यम से दी जा सकती है।

ABSTRACT. Studies were made to explore the possibility of control/minimise the damages caused by the stem borer on rice by issuing timely weather based forecast on the incidences of the pest. From the survey conducted by the Department of Plant Protection, Quarantine and Storage, Faridabad from 1988-95, it was observed that stem borer incidences were comparatively more in *kharif* than *rabi/summer* season and it appeared more frequently in moderate to severe intensity particularly in Gujarat, Orissa, Andhra Pradesh, Assam, Haryana and Punjab. Drop in mean temperature (< 28° C) in association with continuous rainfall was found to be the congenial weather condition for the incidence of the pest on rice. It is concluded that forewarning of the incidence of the stem borer on rice, based on the prevailing weather conditions that cause rainfall as well as drop in minimum and maximum temperature, could be possible through Agromet Advisory Service.

Key words – Rice, Stem borer, Forewarning, Weather, Operational plant protection.

1. Introduction

Paddy is one of the most important crops cultivated in almost all parts of eastern (West Bengal, Bihar, Orissa), north eastern (Assam), Central (Madhya Pradesh) northern (Uttar Pradesh, Punjab, Rajasthan and Jammu & Kashmir), southern (Tamil Nadu, Kerala, Andhra Pradesh, Karnataka) and west coast of India (Maharashtra) in different seasons. Inspite of the intensive efforts to step up the paddy production by employing different modern methods and technologies, there is a heavy annual toll, year after year, due to the attack of pests and diseases. In some rice growing regions, pesticides are applied in excess as a preventive measure to control the pests and diseases of paddy. Excessive use of this noxious chemicals not only causes the economical restrains on the farmers but also have harmful side effects on the environment, especially to the ground water and natural predators present in the soil and natural vegetation. A feasible solution to this vexed problem is the timely application of required amount of pesticides on the crops. This is possible through proper understanding of interrelationship between the pests and diseases incidence and meteorological parameters which trigger their outbreak under favourable conditions.

Stem borer [*Scirpophaga* (Tryporyza) *incertulas* (Walk.)] is a serious pest of rice and distributed throughout the rice growing areas of India in different seasons. It has been reported that the damage due to the stem borer is much higher in southern states where the pest multiplies throughout the year and shifts from one crop to the next. Stem borer was found to cause significant loss in yield during the major paddy season at Cuttack in Orissa, Thanjavur in Tamil Nadu and west Godavari district in Andhra Pradesh (Singh *et al*. 1972). Based on the qualitative information from the selected experimental farms in the country under the All India Co-Ordinated Crop Weather Scheme, Dubey *et al*. (1985) found that southern parts of Bihar, coastal parts of Orissa, northeastern parts of Assam, northern parts of Andhra Pradesh and west-coast of peninsular India are affected by

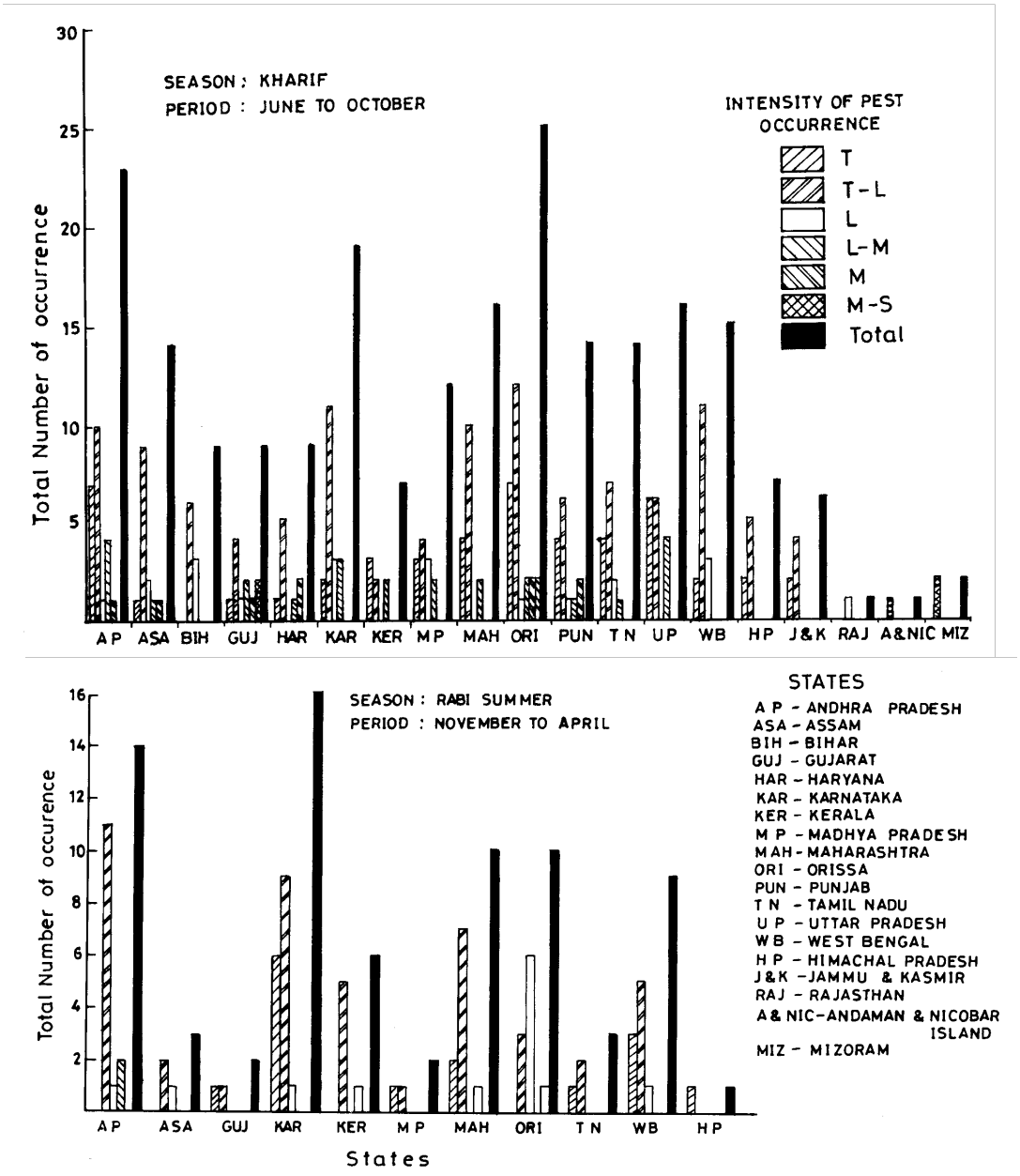


Fig. 1. Occurrence of stem borer on rice in different intensities in various states of the country

heavy attacks of stem borer. It becomes the major hurdles in achieving higher yield in Warangal and Godavari delta in Andhra Pradesh (Krishnamurthy *et al.* 1985). In northern India though the damage is not serious throughout the region, but known to be severe in certain pockets (Atwal 1986). In West Bengal, stem borer causes damage to aman crop during monsoon season and boro crop raised in the post monsoon and early summer season (Datta and Kundu 1987). Under favourable weather conditions this pest damages rice substantially in Bihar (Sahu and Sinha 1990). Sensitivity of the prevailing weather conditions on the stem borer incidence was reported by a number of workers (Kazi *et al.* 1982, Dubey *et al.* 1985, Dubey and Ronghe, 1986).

Keeping in view of the above, the present study was undertaken with the following objectives :

(*i*) Identification of duration and intensity of occurrence of stem borer in *kharif* and *rabi*/*summer* season in different states of the country.

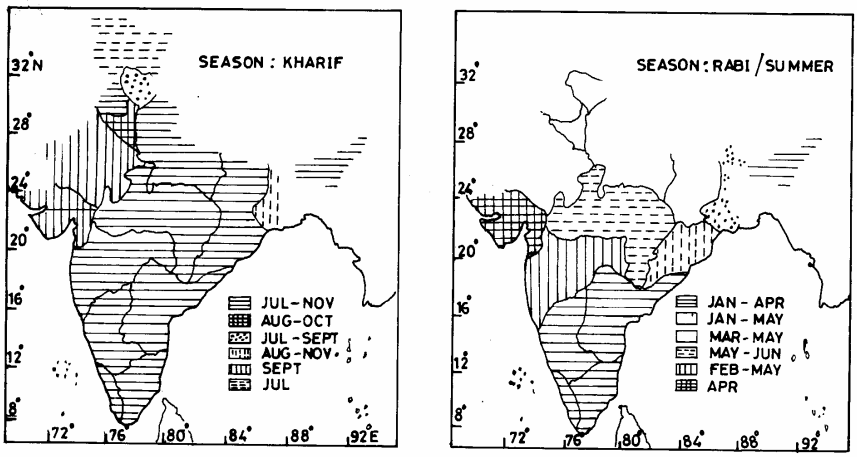


Fig. 2(a). Duration of occurrence of stem borer on rice in different seasons in the country

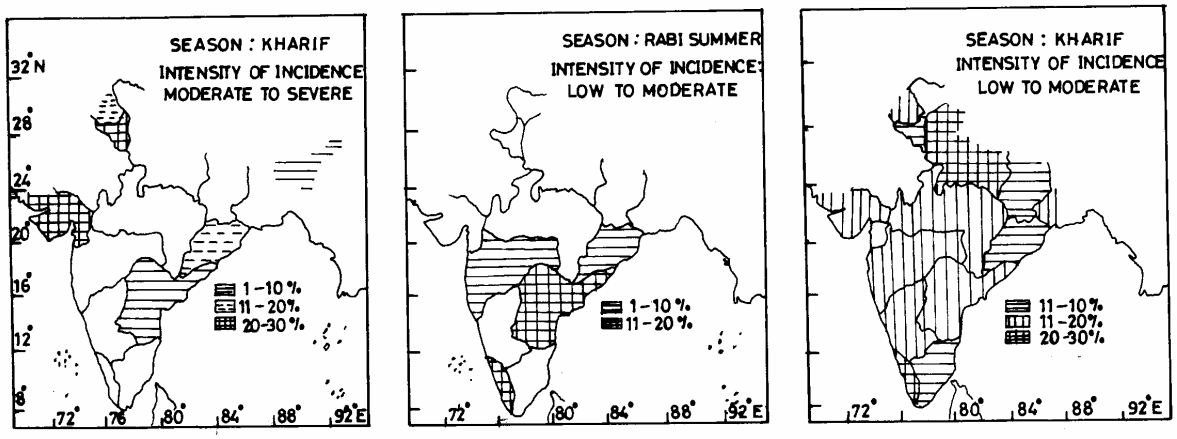


Fig. 2(b). Intensity of occurrence of stem borer on rice in different seasons in the country

(*ii*) To establish the relationship, if any, between the incidence of stem borer and meteorological parameters.

(*iii*) Development of weather based forecasting guidelines for the stem borer incidences on rice.

(*iv*) Dissemination of the forecasting guidelines to the user's community through Agromet Advisory Service for efficient plant protection measures at right time.

2. Data and methodology

Central Integrated Pest Management Centers, Directorate of Plant Protection, Quarantine and Storage (PPQ&S), Government of India, Faridabad in collaboration with the State Departments of Agriculture and Indian Council of Agricultural Research monitors pests and disease situation on major crops every month by deputing their staff in the predetermined routes in the country. Based on the survey report received from different parts of the country, PPQ&S prepares and issues Rapid Roving Survey Report every month. In the present study, information regarding intensity of stem borer attack, place of attack, stage of the crop damage etc. were collected from these reports for last 7 years (1988-95). Data of 1992 for some stations could not be incorporated as the same was not readily available. Appearance and intensity of attack of this pest in trace, low, moderate and severe level in different months of the paddy growing seasons in various states were found out. Meteorological parameters such as rainfall, maximum and minimum temperature, relative humidity (0300 and 1200 UTC), cloud amount (0300 and 1200 UTC) recorded at different stations during the period of pest incidence were obtained from the National Data Centre, India Meteorological Department (IMD), Pune. Information on the synoptic situation from the weekly weather reports and synoptic charts were obtained from the Office of the Deputy Director General of Meteorology (Weather Forecasting), IMD, Pune.

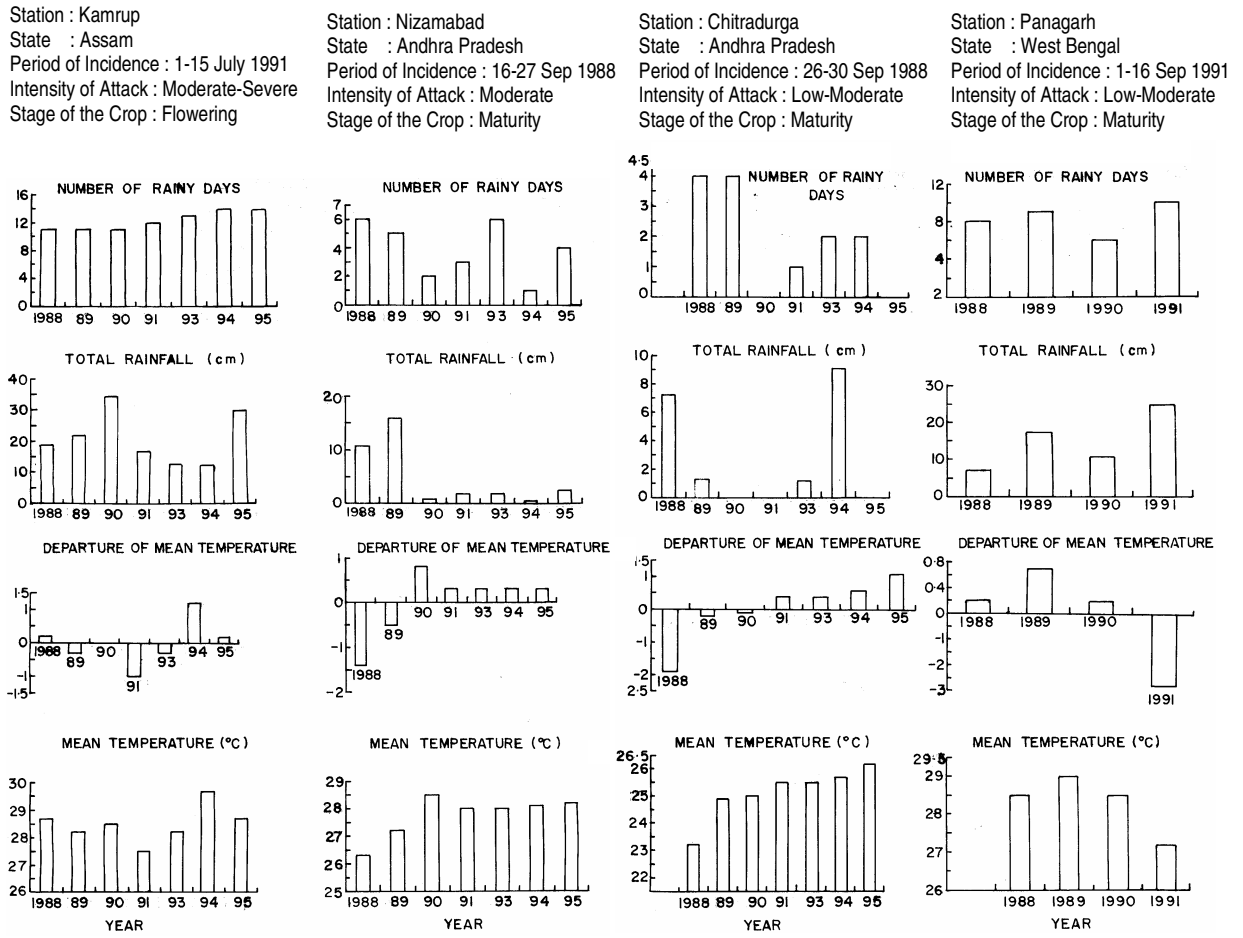


Fig. 3. Mean temperature and rainfall condition during the period of stem border incidence at different stations

Ten stations from nine states namely Assam, Andhra Pradesh, West Bengal, Karnataka, Kerala, Orissa, Maharashtra which reported either moderate or severe incidences of the stem borer were selected to study the sensitivity of the pest to the meteorological parameters. Prevailing synoptic situations were studied in relation to the pest incidence. Graphical superimposition techniques were applied to understand the relation between the weather parameters and the pest incidence. Critical values of the corresponding meteorological parameters favourable for the pest incidence were also worked out.

3. Results and discussion

The qualitative information on the stem borer incidences on rice were critically analysed to demarcate the prone areas where the pest appeared at regular interval with greater intensity under favourable weather condition. Secondly the role of different meteorological variables on the incidences of the pest were worked out. Ultimately scope of utilising the forecasting guidelines, generated from this study, for operational plant protection of the pest on rice through Agromet Advisory Service was explored.

3.1. *Duration and intensity of occurrence of stem borer on rice in the country*

Incidences of stem borer attack in different intensifies, *viz.*, trace, trace to low, low, low to moderate, moderate, moderate to severe level observed in different states of the country during *kharif* season and *rabi/summer* season are presented in Fig. 1. Trace to low incidence indicates that pest population below economic threshold level (ETL) while moderate and severe intensity imply above ETL and economic injury level (EIL). During *kharif* season occurrence of the pest was highest (25) in Orissa followed by Andhra Pradesh (23), Karnataka (19), Maharashtra (16) and Uttar Pradesh (16). In this season stem borer incidence was reported from July to November in Assam, Bihar, Punjab, Uttar Pradesh and all the southern states and central India whereas in the remaining

states it was observed in certain month/months between July to November Fig. 2(a). Moderate and moderate to severe attacks of the stem borer were found in Gujarat, Haryana, Orissa, Punjab, Andhra Pradesh and Assam. Percentage of occurrence of stem borer under this category was highest in Gujarat and Haryana followed by Orissa, Punjab, Assam and Andhra Pradesh Fig. 2(b). Except Rajasthan, Himachal Pradesh and Jammu and Kashmir, low to moderate attack of stem borer was experienced by the crop in all the states of the country and this type of incidence was reported more in Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. Thus during *kharif* season the pest appeared in sizeable proportion in Gujarat, Haryana, Orissa, Punjab, Andhra Pradesh, Assam, Karnataka, Maharashtra, Madhya Pradesh and West Bengal.

In *rabi/summer* season, incidence of stem borer was not reported from the states in northern India except Himachal Pradesh. The incidence was observed between January to May in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Orissa, Madhya Pradesh, Gujarat, Assam, West Bengal and Maharashtra. Occurrences of the pest were more in Karnataka (16), Andhra Pradesh (14), Maharashtra (10), Orissa (10) and West Bengal (9). Thus, in both the seasons stem borer was active and appeared more frequently in Andhra Pradesh, Karnataka, Maharashtra and Orissa. In this season moderate to severe incidence of the pest was not reported in the country. Low to moderate infestation was reported in Andhra Pradesh (2), Orissa (l), Maharashtra (l) and Kerala (l). Among these states percentage of occurrence of stem borer in low to moderate level was more in Kerala and Andhra Pradesh Fig.2(b). Thus it is seen that incidences of stem borer were more frequent and appeared in higher intensity in *kharif* than *rabi/summer* season. And during *kharif* season the incidences of stem borer were mainly confined to south, east, north and central India whereas in rabi season the incidences of the pest were observed in east, central and peninsular India. It was observed that the pest damaged the rice during tillering to maturity stage of the crop.

3.2. *Sensitivity of weather parameters to stem borer incidence*

A critical analysis of daily meteorological parameters in relation to stem borer incidences at eight stations reported moderate or severe attacks was made. It revealed that both temperature and rainfall played important role for the outbreak of the pest (Fig. 3). In general, it was observed that drop in mean temperature below normal by 1° C or more in association with comparatively heavy rainfall in more number of days created an ideal environment for the outbreak of stem borer on paddy at all the eight stations located in different parts of the country. At Kamrup lying in north-eastern region of the country, decrease in mean temperature (27.5° C) of 1° C in association with continuous rainfall (166mm) for 12 days from 1 to 15 July 1991 might have created an ideal environment for moderate to severe attack of the pest. At Nizamabad in Andhra Pradesh drop in mean temperature (26.3° C) by 1.5° C and rainfall of 107 mm from 10 to 27th September 1988 favoured stem borer attack on rice. Similar findings were observed at Puri in Orissa (16-31 August 1988), Palghat in Kerala (8-9 December 1988), Chitradurg in Karnataka (26-30 September 1988), Aurangabad in Maharashtra (19-22 September 1989), Hyderabad in Andhra Pradesh (20 June to 5 July 1990), Nizamabad in Andhra Pradesh (26-30 August 1990), Kakinada in Andhra Pradesh (6-23 February1990), Panagarh in West Bengal (1-16 September 1991) and Kanpur in Uttar Pradesh (1-30 October 1991). It was observed that the mean temperature dropped at least below 28° C during the period of the pest incidence on rice in all the stations under study. Kazi *et al.* (1982) found that maximum temperature at 14th standard week (2-8 April) gave highest negative correlation with the seasonal index of stem borer infestation at Pattambi. Moreover, the seasonal index of the stem borer was found to be quite low when the maximum temperature in the 14th week exceeded 37° C. Mean temperature lower than 30° C and relative humidity exceeding 60% at Aduthurai were found to be favourable for higher stem borer infestation (Kazi and Balkundi 1983). At Bhubaneswar, minimum temperature lower than 23° C in March caused higher degree of infestation of stem borer on paddy by increasing the larval activities (Dubey *et al.* 1985). Dubey and Ronghe (1986) found that maximum temperature higher than 33° C at 39th week (24 - 30 September) reduced the stem borer activity and minimum temperature between 17 - 18° C at 45th week (5 - 11 November) increased the infestation.

Departure of the mean temperature at ten stations representing different regions which experienced incidence of stem borer attack in different years are shown in Fig. 4. Figures in the parenthesis in maps indicate the total accumulated rainfall recorded in the stations during the survey period when incidence of stem borer attack was observed. In 1988 more number of stations situated in the southern peninsula reported stem borer attack on rice. It was observed that in most parts of Karnataka, Maharashtra, Andhra Pradesh and small pockets in Orissa and Assam where the departure of mean temperature was -1° C or more, the crop was infested with stem borer. In this year stem borer appeared one occasion in severe intensity and four times in moderate intensity in Orissa. In Karnataka and Kerala moderate intensity of stem borer attack was reported 4 and 2 occasions respectively.

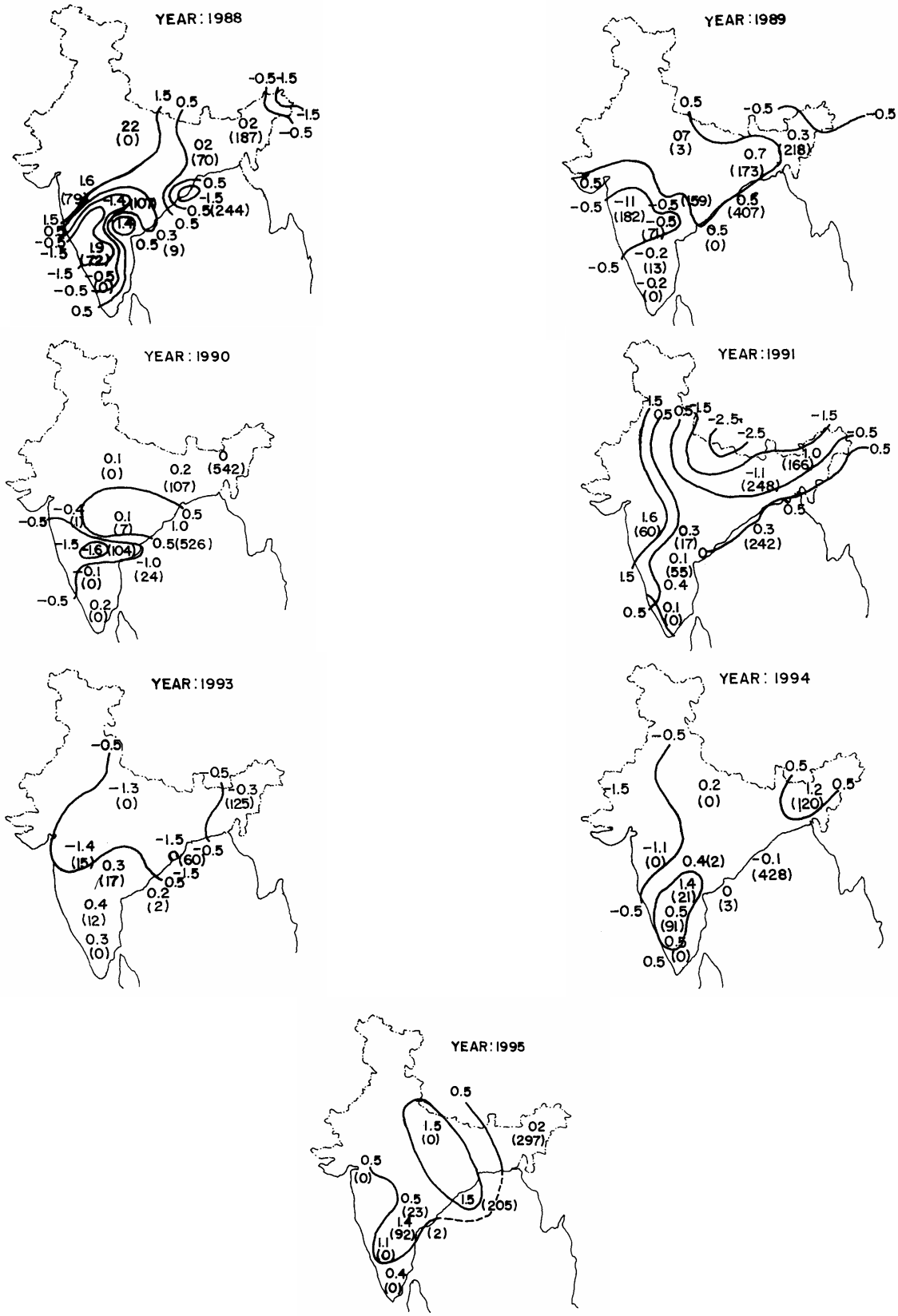


Fig. 4. Departure of mean temperature and rainfall at different stations during the period of stem borer incidence on rice in different years

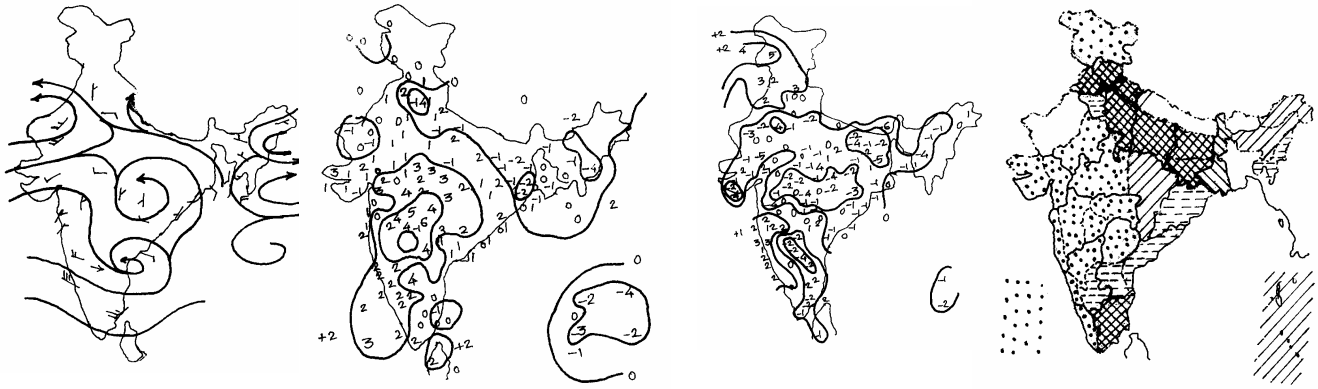
(a) Period of incidence : 1-16 September 1991
Area and intensity of pest of incidence : Low to moderate attack in Burdwan, Midnapore, 24-Parganas and Bankura district

Date : 13 September
Chart : Upper level (0.9 km)
Hours of observation : 0300 UTC

Date : 14 September
Chart : Change chart
(Departure of maximum temperature from normal)
Hours of observation : 1200 UTC

Date : 14 September
Chart : Change chart
(Departure of minimum temperature from normal)
Hours of observation : 0300 UTC

Rainfall for the week ending 11 September



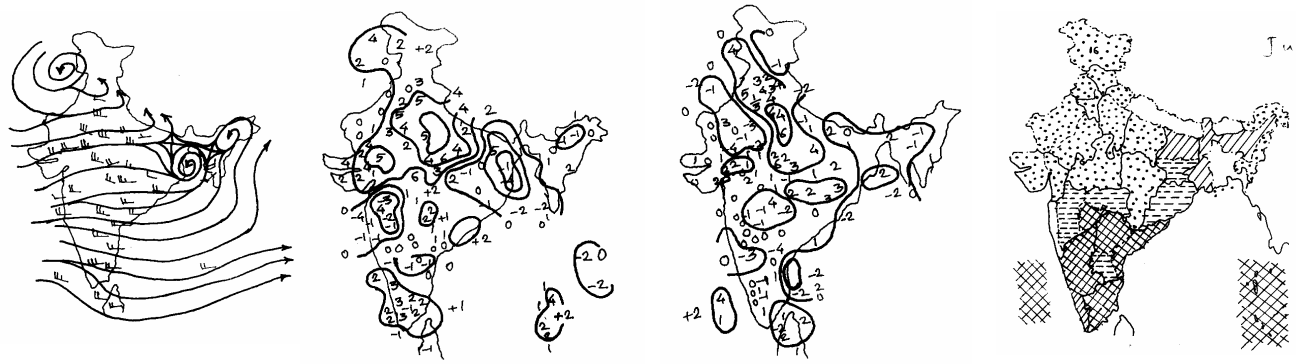
(b) Period of incidence : Ending 15 July 1991
Area and intensity of pest of incidence : Low to moderate infestation in the following survey route :
Guwahati-Mirze-Chhaygaon-Boko-Dudhnoi-Krishnai-Paikan-Bajeng-Doba-Tura-Dahu-Guwahati
Moderate to severe infestation in scattered fields in south Kamrup and Gopalpura districts

Date : 3 July
Chart : Upper level (0.9 km)
Hours of observation : 0300 UTC

Date : 3 July
Chart : Change chart
(Departure of maximum temperature from normal)
Hours of observation : 1200 UTC

Date : 4 July
Chart : Change chart
(Departure of minimum temperature from normal)
Hours of observation : 0300 UTC

Rainfall for the week ending 10 July



Figs. 5(a&b). Weather charts during the period of stem incidence (a) 1-16 September 1991 and (b) Ending 15 July 1991on rice

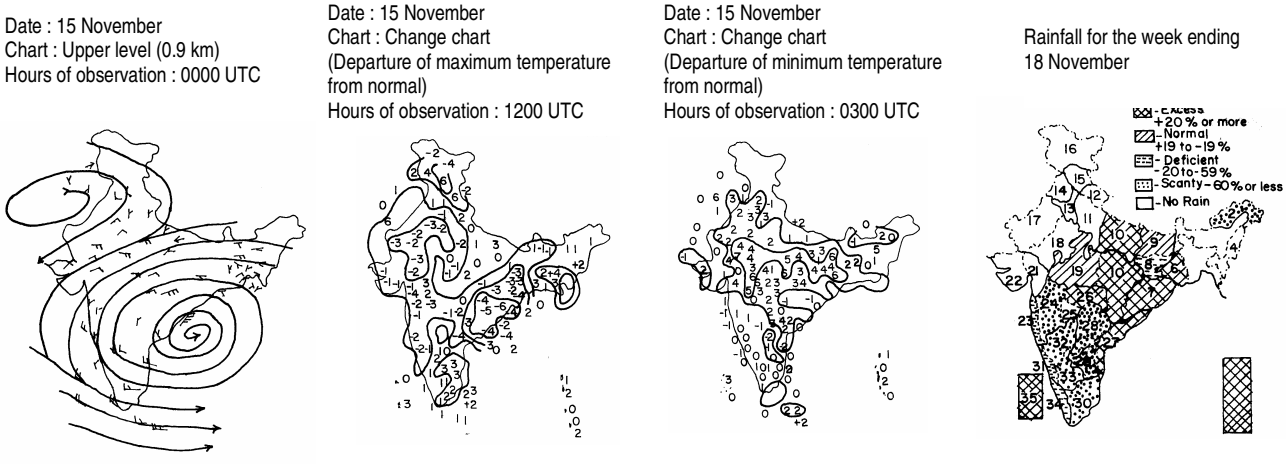
Similarly in 1989 and 1990 most parts of southern peninsula were infested when the departures of mean temperature were on the negative side of the normal and most of the stations experienced rainfall during the period of incidence. Thus incidence of stem borer attack may reach even upto severe intensity when mean temperature falls well below the normal range in association with heavy rainfall, particularly during the monsoon months (June to September). Similar situations were observed in Uttar Pradesh, Madhya Pradesh, Orissa, Bihar, West Bengal and some parts of Karnataka in 1993; on the contrary in 1994 (except Aurangabad and Puri) and 1995, departures of mean temperature at number of stations were on the positive side of the normal when no major incidences of stem borer were observed in any parts of the country.

3.3. *Conditions of stem borer incidence on rice*

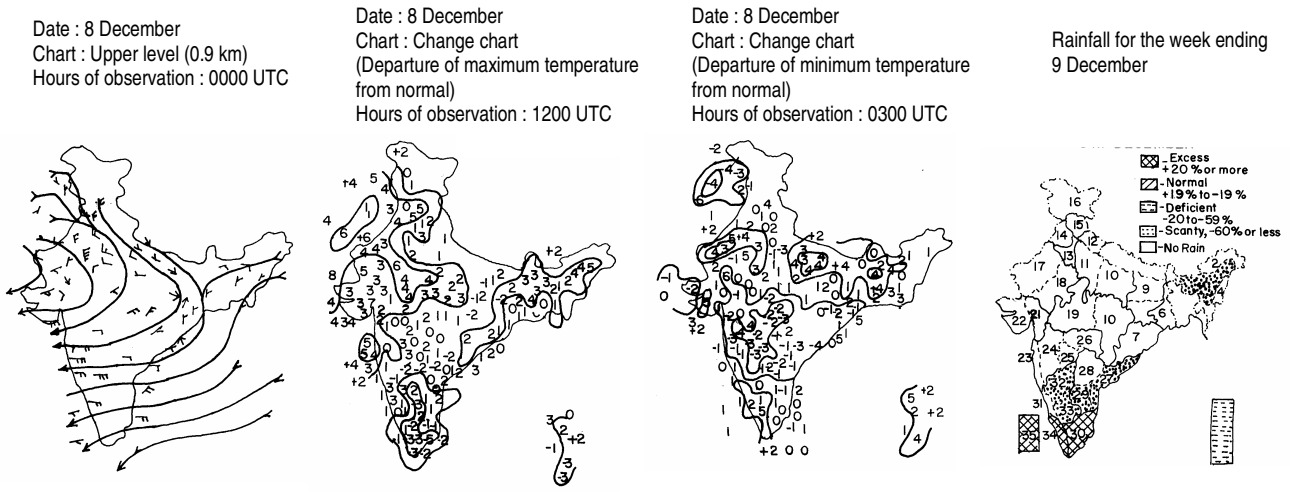
Thus there are essentially four conditions for the outbreak of stem borer incidence on rice.

(*i*) Rice should be from tillering to maturity stage.

(a) Period of incidence : 16-19 November 1998
Area and intensity of pest incidence : Low to moderate incidence of stem borer areas observed in Kakatpur block of Puri district



(b) Period of incidence : 10 December 1998
Area and intensity of pest of incidence : Moderate incidence in Ankamali in Ernakulam district (Kerala)



Figs. 6(a&b). Weather charts during the period of stem incidence (a) 16-19 November 1998 and (b) 10 December 1998 on rice

(*ii*) Drop in maximum and minimum temperature (Mean temperature < 28° C.)

(*iii*) Continuous rainfall.

(*iv*) Development of synoptic situation *e.g.* western disturbance, appearance of cyclonic circulation (storm, depression, low pressure).

3.4. *Operational aspect of control of stem borer incidence on rice*

Varma (1993) stated that above average summer monsoon rainfall over India was associated with cooler temperature during the concurrent season over the Indian sub-continent. According to the author fall in mean temperature due to the appearance of synoptic system might be due to the more clouds during daytime, which restricted solar radiation to intercept with the ground surface. In 1988 a cyclonic circulation extending upto mid-tropospheric level was observed over Tripura and neighbourhood on 15th August. Under its influence a low pressure area was formed over northwest Bay and adjoining West Bengal and north Orissa coast on 17th. This system caused excess rainfall amounting 244 mm from 16th to 31st August at Puri. Cloudy condition and heavy rainfall caused fall of mean temperature by 1.5° C and ultimately severe to moderate outbreak of stem borer was observed at Puri, In 1989 low pressure area formed over east central Arabian Sea off south Maharashtra coast

with associated cyclonic circulations extending upto 3.1 km a.s.l. on 21st September. Under its influence Aurangabad received 82 mm rainfall from 19th to 22nd September. This heavy rainfall favoured drop in mean temperature by 1.1° C, which triggered low to moderate incidence of stem borer. In 1991 a cyclonic circulation extending upto 4.5 km a.s.l. was observed over central parts of Bihar on 5th September. It lied over Bihar plains extending upto 3.1 km a.s.l. on 10th and moved over Sub-Himalayan West Bengal and neighbourhood Fig. 5(a). Besides monsoon was active for couple days in West Bengal and neighbouring states. As a result there was a good amount of rainfall in West Bengal during the period of incidence of the pest. Besides there a was fall in both maximum and minimum temperature for number of days in the states. These weather conditions created an ideal condition for stem borer incidence in the state. Panagarh in West Bengal reported moderate incidence of the pest during this period. Similar situation prevailed during the first fortnight of July in 1991 in Assam where incidence of pest was also reported in moderate to severe condition Fig. 5(b). According to Dubey and Balakrishnan (1989) a station may register fall in temperature if it is under the influence of monsoon depression or other well marked weather system from the Bay of Bengal.

Incidences of stem borer in winter months may be attributed to drop of mean temperature caused by the eastward passage of western disturbance over the north of the country under the favourable weather condition (Dubey and Balakrishnan 1989). Reduction in temperature in Kakinada in coastal Andhra Pradesh during 6 to 23 February was due to the cold wave advection during the eastward passage of western disturbance over the northern latitude of the country. This caused sizeable occurrence of stem borer on rice at this station.

During the monsoon season, in general, there is a gradual decrease of mean temperature from north to south in the country. For instance, July isotherms of mean temperature ranges from 32.5° to 27.5° C from north western part to west coast of India. As the stern borer incidence is very much sensitive to the temperature fall, any further decrease of mean temperature, especially in southern peninsula, along with continuous rainfall due to synoptic features may cause more incidence of the pest.

From the above discussion it may be mentioned that it is possible to forewarn the incidence of stem borer on rice based on the prevailing weather condition and also real time data of temperature and rainfall. Weather based guidelines generated from this study will ultimately help agro meteorologists / agricultural scientists to forewarn the farmers about the possible attack of stem borer in the rice growing areas of the country.

3.5. *Validation*

The results emerged out from the study were validated with the observation made in November and December 1998 in the states of Orissa and Kerala [Figs. 6(a&b)].

The stem borer appeared in moderate intensity at Kakatpur block of Puri district of Orissa during 16-19 November when the rice was in milky to maturity stage. It was observed that there was drop a in both maximum and minimum temperature in number of stations in the state from 10-15 November. Mean temperature decreased from 27.4° C to 22.8° C and 27.3° C to 22.7° C respectively at Cuttack and Bhubaneswar from 10th to 16th November. A depression has formed on 13th and intensified into severe cyclonic storm and persisted upto 18th in Andhra Pradesh and neighbourhood As a result the state Orissa received excess rain in the week ending 18 th November (12th -18th November). Cuttack and Bhubaneswar recorded substantial rainfall for 3 consecutive days (15th - 17th November) during this period. Thus decrease in mean temperature coupled with rainfall due to the presence of rain bearing system (depression/severe cyclonic storm) favoured stem borer incidence in Puri district of Orissa.

Moderate attack of stem borer was also reported at Ankamali in Ernakulam district of Kerala during the survey conducted on 10th December in the same year when the rice was at tillering to heading stage. Decrease in maximum and minimum temperature was observed from 4th to 9th December in both the agromet observatories *i.e.* Kayamkulam (28.1° C to 26.4° C) and Vellayani (28.0° C to 24.5° C) in the state. Fall in maximum and minimum temperature was also observed at a number of stations on several occasions during this period. A trough in the easterlies extending upto 0.9 km a.s.l. lay off Kerala coast on 3rd December. Extending upto the lower levels it persisted there upto 8th and merged with a low pressure area off Kerala coast on 9th. These systems caused excess rainfall over the state in the week ending 9th December (4th - 9th December). Thus fall in mean temperature in association with rainfall in the presence of trough and low pressure encouraged stem borer incidence in moderate level in parts of Ernakulam district in Kerala.

4. Conclusion

(*i*) Stem borer incidence on rice was reported from almost all the rice growing states of the country during tillering to maturity stage of the crop.

(*ii*) Intensity of occurrence of the pest on rice was more in *kharif* than *rabi/summer* season.

(*iii*) More frequent incidences of the pest was observed in Orissa, Andhra Pradesh and Karnataka.

(*iv*) The pest appeared moderate to severe level in more number of stations in Gujarat, Orissa, Andhra Pradesh, Assam, Haryana and Punjab.

(*v*) Drop in mean temperature (< 28° C) in association with continuous rain was found to be the congenial weather condition for outbreak of stem borer on rice.

(*vi*) Forewarning of the incidence on rice can be issued well in advance by the appearance of synoptic situation which causes rainfall as well as drop in maximum and minimum temperature.

(*vii*) The above information can be used as tool for operational plant protection of stem borer on rice through Agromet Advisory Services.

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