551.586 : 632.11 : 633.511

FOREWARNING INCIDENCE OF AMERICAN BOLLWORM (*Heliothis Armigera* Hubner) ON COTTON THROUGH DIAGNOSTIC APPROACH

1. Cotton, an important fibre crop, is extensively grown in the dry farming tract of India. An erratic monsoon and post monsoon and also unseasonal weather conditions in these seasons were attributed to unusually high rate of pestilence on cotton. Among the various pests of cotton, American bollworm (*Heliothis armigera* Hubner) inflicts heavy losses every year (Tedas *et al.* 1994). In 1998, cotton grown in southern sector of Punjab was damaged substantially and 59% of the loss of the crop was reported. Widespread *heliothis* infestation was also reported in Andhra Pradesh from December 1997 and continued upto second week of January of the succeeding year. *Heliothis armigera* has also been reported to cause

Fig. 1. Locator map of stations reporting *Heliothis* incidence

heavy loss to the chickpea, pigeon pea, sorghum and cotton during the last few decades in the country (Singh and Singh 1974, Saharia and Dutta 1975, Lal *et al*. 1981, Dhaliwal and Arora 1998). Kaushik *et al.* (1969) had also reported the yield loss of cotton to the extent of 41.5 % due to bollworm attack.

Available literature show that in spite of heavy inputs of insecticides, the control of *heliothis* incidence on cotton continues to be grave. Thus timely plant protection measures before the commencement of the destructive stage of the pest would possibly save the cotton crop from such damage. Literature also suggest that the incidence of *heliothis* is sensitive to the prevailing weather condition. In view of this, an attempt has been made to explore the possibilities of forewarning the incidence of *heliothis* on cotton based on the interrelation between pest incidence and meteorological parameters and also prevailing

TABLE 1

Frequency of occurrence of *Heliothis* in different states

State	Intensity of occurrence				
	T	L	M	S	Total incidences
Andhra Pradesh	29	13	–	4	46
Madhya Pradesh	18	1	4	1	24
Maharashtra	11	9	1	–	20
Rajasthan	16	3	1	–	20
Punjab	10	2	–	1	13
Haryana	11	1	1	1	14
Gujarat	13	1	–	–	14
Karnataka	11	1	1	–	13
Tamil Nadu	5	–	–	–	5

T - Trace, L - Low, M - Moderate, S - Severe

synoptic situation which has triggered pest incidence by influencing favourable weather parameters. The aim of this study is to find crop-pest-weather interrelationship for use in forewarning of *heliothis* incidence on cotton. These forewarning may be suitably incorporated in Agromet Advisory Service (AAS) bulletins issued from different AAS units of India Meteorological Department and National Centre for Medium Range Weather Forecasting.

2. The quantitative pest data of *heliothis* were collected for 14 years (1979-92) from the Department of Entomology, Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola (24° 42′N, 77° 02′E) and for 6 years (1990-95) from Marathwada Agricultural University (MAU), Parbhani (19° 16′N, 76° 47′E). Observation of *heliothis* on cotton was recorded from the untreated experimental plot of the university. The observations were taken at weekly interval on plant, randomly selected in the cotton field. The qualitative pest data alongwith the date, place of attack and stage of the crop when the damage was caused by the pest in different parts of the country for a period of 13 years (1988-2000) were also collected from the monthly Rapid Roving Survey Report issued by the Central Integrated Pest Management Centre, Directorate of Plant Protection Quarantine and Storage (PPQ&S), Faridabad. Based on the collected information, the pest prone areas, time and frequency of pest occurrence in different intensities were delineated. Meteorological parameters such as rainfall (RFL), maximum (TMAX) and minimum(TMIN) temperature, relative humidity [0300 UTC (RH I) and 1200 UTC (RH II)], bright hours of sunshine (SSH), cloud amount [0300 UTC (CLI) and 1200 UTC(CLII)] recorded at different stations during the period of pest incidence were obtained from the National Data Centre, India

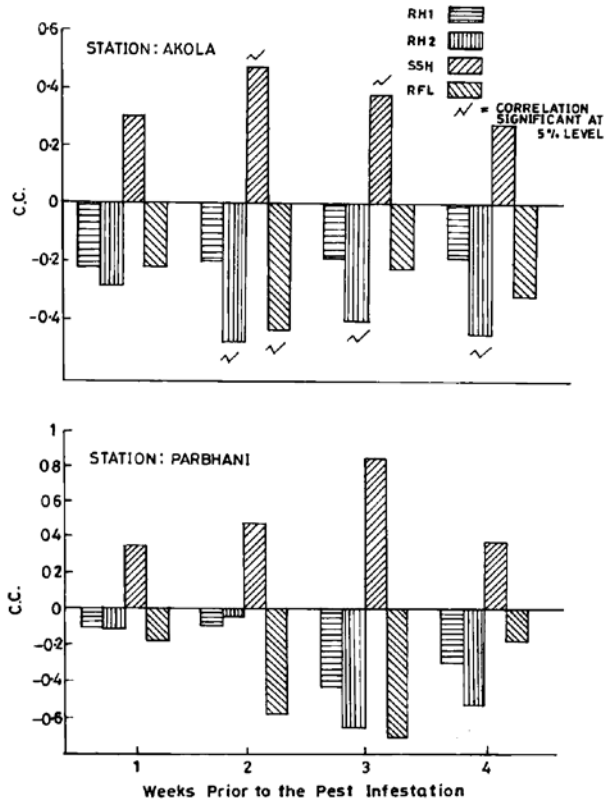

Fig. 2. Correlation coefficient between the *Heliothis* infestation and different meteorological parameters

Meteorological Department (IMD), Pune. Information on synoptic situation were collected from the weekly weather reports and synoptic charts prepared by the Office of the Deputy Director General of Meteorology (Weather Forecasting), IMD, Pune.

Both statistical tools and graphical superimposition techniques were used to workout the interrelationship between the pest population and meteorological variables. Using Sigma Statistical Software Version 2.0 for Windows 95 developed by Jandal Scientific Software, USA, statistical studies were made. Using Pearson's method, simple correlation was worked out between pests population and meteorological parameters. '*t*' test was applied to test the significance of these correlations at 5% level. Graphical superimposition of pest data and meteorological parameters were also made to workout the critical values conducive for increase in population of the pest. Synoptic situations prevailed during the period of pest incidence and its influence on the development of the pest were also critically examined.

3.1. The occurrence of *heliothis* in different intensities (low to moderate, moderate and moderate to

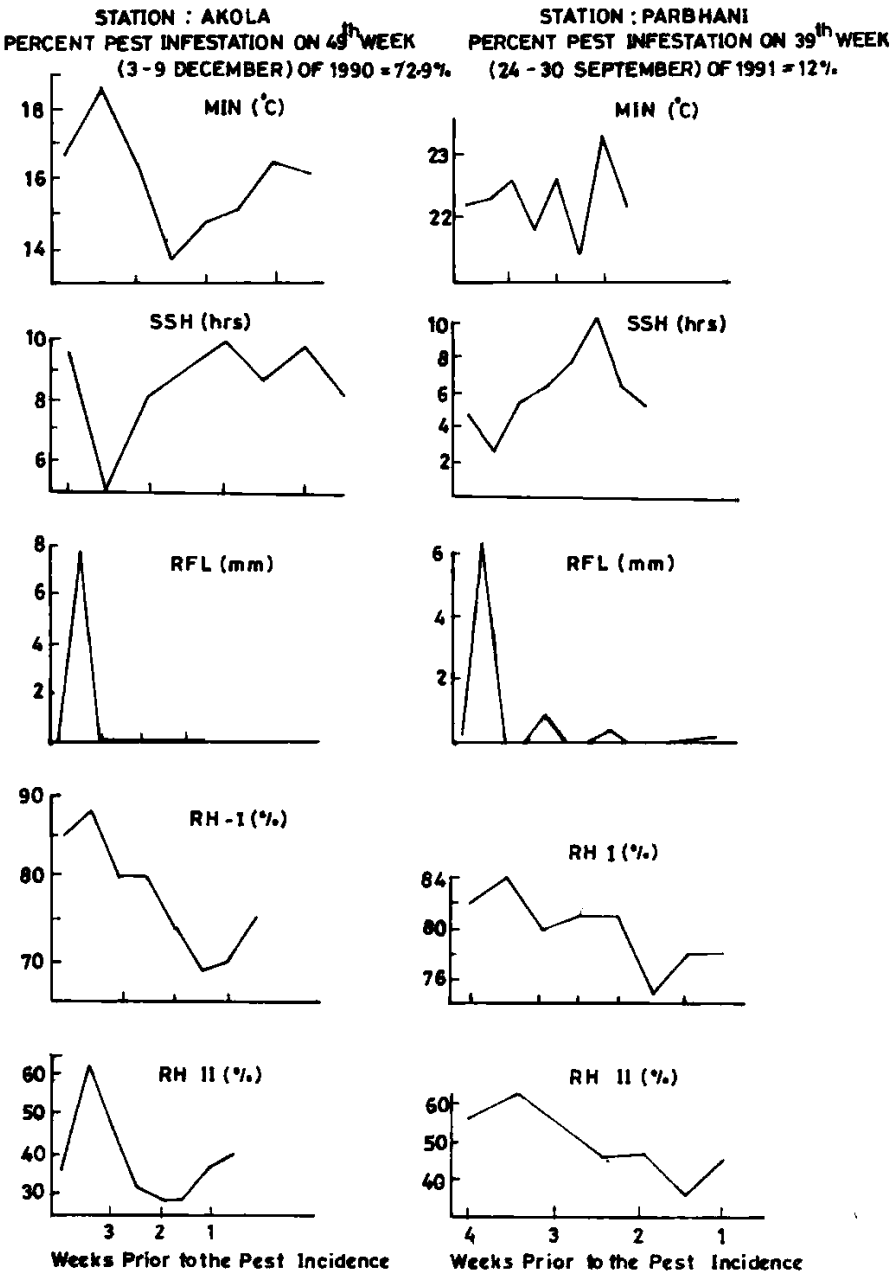

Fig. 3. Variation of different meteorological parameters in the month preceding to the incidence of *Heliothis*

severe) reveals that the pest appeared in the northern, peninsular and south Indian states in different intensities (Fig. 1 and Table 1). The pest occurred in epidemic form *i.e.* moderate to severe intensities in Andhra Pradesh and Madhya Pradesh. Except in Tamilnadu and Maharashtra, the pest appeared covering the entire cotton growing regions of the states of Punjab, Haryana, Gujarat, Andhra Pradesh, Madhya Pradesh and Karnataka. These observations are in agreement with Simat (1994). Moderate to severe intensity of the pest was mainly

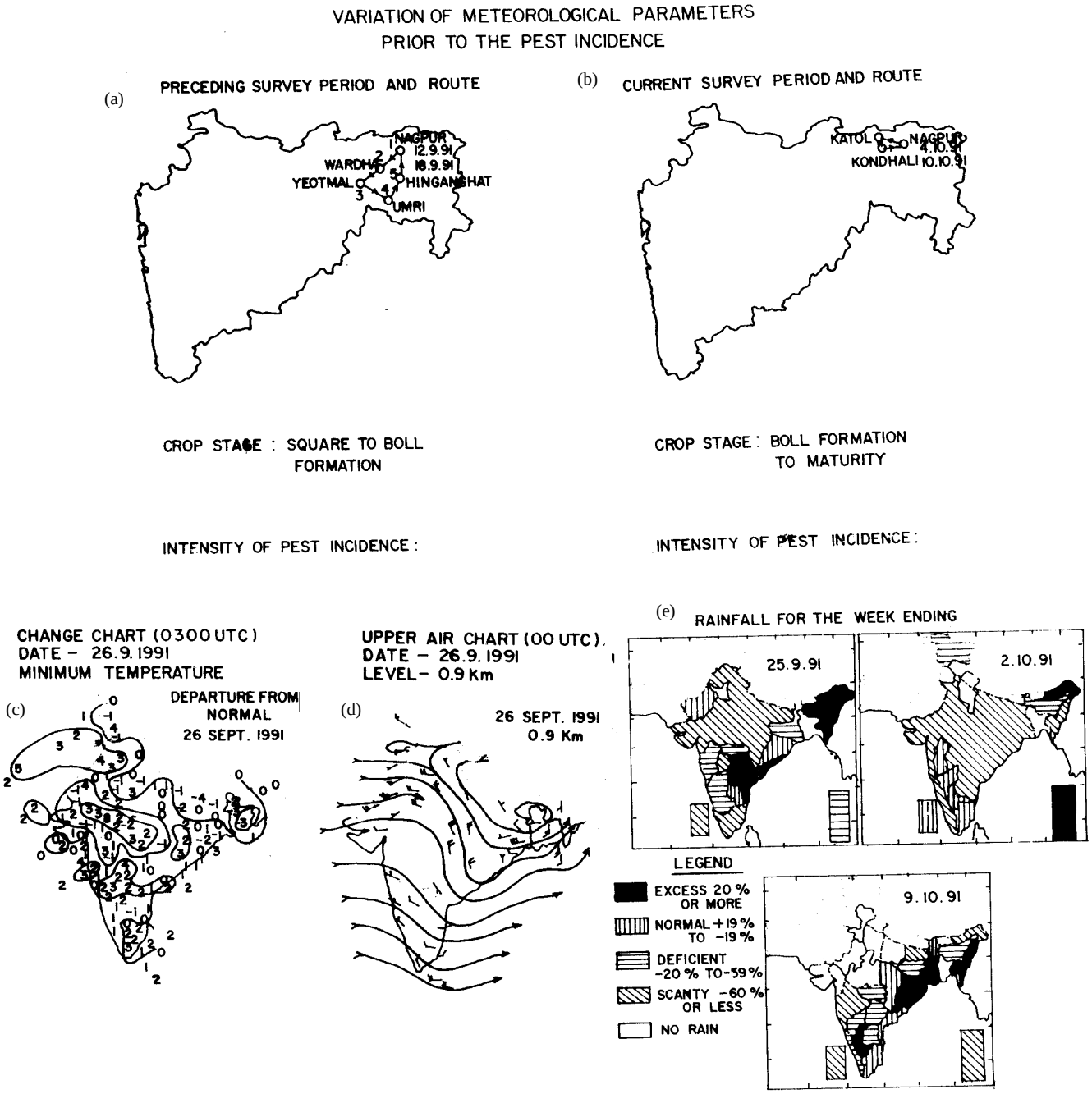

Fig. 4. Weather and *Heliothis* information prior to the pest incidence

reported from September to December corresponding to the flowering to boll formation stages of the crop. Tedas *et al.* (1994) also observed the maximum pheromone catches of the *heliothis armigera* on cotton field at Akola, Maharashtra from middle of August to end of September.

3.2. Weekly data on *heliothis* from the cotton field of PDKV, Akola and MAU, Parbhani showed that the pest appeared in sizeable population *i.e.* above economic threshold level [>10% incidence (Sundaramurthy and Basu 1985)] at both the stations during flowering to boll formation stages. Correlation studies indicated that the different meteorological variables influenced the population of the pest differently (Fig. 2). Both morning and afternoon relative humidity prior to the infestation were negatively correlated (significantly at Akola) with

TABLE 2

Variation of meteorological parameters prior to the pest incidence

	Station : Nagpur			Station : Pusad		
Date	T MIN (°C)	RH I	RH II	T MIN (°C)	RH I	RH II
23 Sep 1991	24.3	67	71	25.1	71	63
24 Sep 1991	24.5	77	51	24.5	77	50
25 Sep 1991	24.8	61	34	24	55	25
26 Sep 1991	20	55	38	24.1	68	28
27 Sep 1991	21.2	50	41	23.1	59	27
28 Sep 1991	21.4	58	44	20	58	25
29 Sep 1991	21.3	54	42	20.8	51	29
30 Sep 1991	24.8	74	82	25	47	35
1 Oct 1991	22.2	70	54	22.5	62	30
2 Oct 1991	22.3	69	49	22.2	56	34
3 Oct 1991	25	56	37	24.5	62	62
4 Oct 1991	22.7	61	38	23.6	66	27
5 Oct 1991	21	50	39	21.5	50	22
6 Oct 1991	22.5	48	49	19.5	39	27
7 Oct 1991	23.6	74	63	21.4	58	37
8 Oct 1991	23	82	57	20.9	79	38
9 Oct 1991	21.2	72	55	21.3	73	32

the percentage of pest incidence. In the present study rainfall was found to be negatively correlated, whereas bright hours of sunshine were positively correlated with the pest incidence. Negative correlation of *heliothis armigera* with relative humidity was also reported by Singh and Singh (1978), Vaishampayam and Veda (1980) and Chattopadhyay *et al*. (2001). Singh and Singh (1978) and Tedas *et al.* (1994) also observed negative correlation of *heliothis* population with rainfall and also positive correlation with bright hours of sunshine. Minimum temperature did not show any correlation with the pest population at both the stations under study. A critical examination of variations of meteorological parameters (Fig. 3) showed that pest population increased substantially when the weather was dry with more hours of bright sunshine (> 7 hrs/ day) alongwith the reduction of relative humidity (RH I < 80 % and RH II < 60 %) . Minimum temperature was below 23° C during the period of pest incidences.

3.3. In 1991, no *heliothis* attack was observed in Nagpur, Yeotmal districts of Maharashtra in the survey conducted from 12th to 18th September [Fig. 4(a)]. Moderate attack of *heliothis* was reported at Nagpur, Wardha and Yeotmal districts of Maharashtra during the survey conducted at 2nd week of October when the cotton was at boll formation to maturity stages [Fig. 4(b)]. During this time minimum temperature at Nagpur was 20° C on 26 September and it varied in narrow range between 21.2° C to 21.4° C up to 29 September (Table 2). Many other stations also showed negative departure of minimum temperature from normal in parts of Maharashtra and adjoining areas [Fig. 4(c)]. The fall in minimum temperature during this period was due to the presence of western disturbance as an upper air system which lay over north Pakistan and adjoining Punjab from 26th September to 2nd October [Fig. 4(d)]. Due to this, morning relative humidity ranged from 54 to 58% and afternoon relative humidity from 34 to 44%. Rainfall for the week ending 25th September, 2nd October and 9th October showed dry weather condition over Vidarbha region for a longer period [Fig. 4(e)]. No rainfall over Nagpur was reported from 20th to 29th September. Pest incidence was also reported for the station Pusad in Yeotmal district of Maharashtra, where minimum temperature decreased to 20° C on 20th and RH I and RH II decreased to 47% and 25% respectively during this period. Similar synoptic condition and aberration of weather was noticed in different parts of the country in other years also during the moderate to severe incidence of the pest.

3.4. A critical analysis of the meteorological parameters during the period of occurrence of the pest at

different stations indicated that drop in minimum temperature below 23° C under prolonged dry conditions resulting in decrease of morning and afternoon relative humidity below 80% and 60% during squaring to boll formation of the crop particularly from September to December are the favourable weather conditions for the out-break of *heliothis* on cotton.

3.5. The results emerged out from this study were validated with the observations made in 1998. In 1998, the pest appeared on cotton in moderate to severe intensity at Ganganagar and Hanumangarh district of Rajasthan during 14 to 17 September. By this time southwest monsoon withdrew from western parts of west Rajasthan and cotton was at boll formation stage. At Ganganagar, minimum temperature decreased from 28.2° C to 23° C. Here also there was a drop of minimum temperature in Rajasthan and neighbouring areas. The fall in minimum temperature was attributed to the presence of western disturbance in upper level in Jammu and Kashmir during this period. Dry conditions prevailed during 26 August to 16 September in western Rajasthan. There was no rain from 1 September to 17 September at Ganganagar and morning and afternoon relative humidity were observed below 80% and 60% respectively during this period. Thus the observed findings validated fairly well with the observation made in 1998.

3.6. From the foregoing discussion, it appears that there is a reasonable scope of forewarning the incidence of *heliothis* on cotton operationally based on the prevailing synoptic situation. It is seen that the following conditions need to be satisfied for the incidence of the pest on cotton.

(*i*) Deficient/scanty/ no rainfall condition at least for two consecutive weeks during September to December which corresponds to flowering to boll formation stages of the crop.

(*ii*) Passage of western disturbance causing drop in minimum temperature under strong northerly to north-westerly wind direction.

Thus by monitoring the rainfall condition, appearance of western disturbance and subsequent drop in minimum temperature during September to December alongwith the population density of *heliothis armigera* from the field, farming community could be advised to spray 0.05% endosulfan or 0.1% carbaryl at appropriate time for eradication of the pest. For successful implementation of the control measures against this pest on real time basis, active participation would be required from the workers from the extension wing of the State Agricultural Department.

Agricultural Universities, National Meteorological Services like India Meteorological Department, National Centre for Medium Range Weather Forecasting (NCMRWF), Department of Science and Technology. Dissemination of such information through TV/Radio/ Telephone/Fax/Personal contact on real time basis would help to protect the crop from infestation of *heliothis*.

4. It is thus concluded that :

(*i*) Madhya Pradesh, Andhra Pradesh, Maharashtra, Punjab, Haryana, Rajasthan, Gujarat, Karnataka and Tamil Nadu are prone to *heliothis* attack under favourable weather condition. Pest appeared in moderate to severe intensity in more number of stations in Andhra Pradesh and Madhya Pradesh during flowering to boll formation stages of the crop.

(*ii*) Bright hours of sunshine showed positive correlation with pest incidence whereas relative humidity (RH I and RH II) and rainfall were negatively correlated with pest incidence.

(*iii*) Prolonged dry conditions leading to the decrease in relative humidity (RH I < 80% and RH II < 60%) and fall in minimum temperature below 23° C were found congenial for the out- break of *heliothis* on cotton. Absence of rain due to withdrawal of southwest monsoon or break monsoon situation along with the fall in minimum temperature due to the passage of western disturbance as an upper air system in north India are the favourable synoptic situations for this outbreak of *heliothis.*

(*iv*) These information could be used as a tool to frame advisories for timely operational crop protection from *heliothis* attack on cotton through the Agromet Advisory Service bulletin.

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