

## Forewarning of incidence of Tikka disease on groundnut and operational crop protection using weather information in Gujarat

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**सार** – इस शोध पत्र में गुजरात क्षेत्र में होने वाले मूँगफली की फसल में टिकका रोग की घटना के लिए मौसम पर आधारित पूर्व चेतावनी निदर्शों को विकसित करने के लिए अध्ययन किए गए। इसमें यह देखा गया है कि क्रमशः 34° से. और 22° से. से नीचे के अधिकतम और न्यूनतम तापमान में कमी आने तथा क्रमशः 82 प्रतिशत और 78 प्रतिशत से ऊपर की सुबह और अपराह्न की सापेक्षिक आर्द्रता में वृद्धि होने की परिस्थितियाँ इस रोग के पनपने के लिए अनुकूल पाई गई हैं। इस रोग के फसल में लगने से पूर्व की सिनॉप्टिक मौसम की अवस्थाओं से यह पता चला है कि नम और शीत वायु के कारण अधिकतम और न्यूनतम तापमान में आई कमी तथा सुबह और अपराह्न की आर्द्रता में हुई वृद्धि इस रोग के पनपने के लिए अनुकूल पाई गई है। इस रोग से बचाव की पादप संरक्षण कार्रवाई के लिए यह सूचना उपयोगी होगी।

**ABSTRACT.** Studies were made to develop weather based forewarning models for the incidence of tikka disease on groundnut grown in Gujarat region. It was found that decrease in maximum and minimum temperature below 34° C and 22° C respectively and increase in morning and afternoon relative humidity above 82% and 78% respectively favoured the infestation of the disease. Synoptic weather conditions prior to the disease incidences showed that incursion of moist and cold air causing drop in maximum and minimum temperature and increase in morning and afternoon humidity were favourable for the disease infestation. This information would be useful for operational plant protection from the disease.

**Key words** – Tikka disease, Groundnut, Weather parameters, Forewarning models.

### 1. Introduction

Groundnut (*Arachis hypogea.*) is one of the most important oilseed crops grown in over 100 countries of the world. Groundnut production has an important role in the economy of many countries including India. Total area under groundnut cultivation in the world is about, 21.7 million ha with production of over 28.4 million tones. India accounts for 40 percent of the world area under groundnut cultivation and 30 percent of the world production. World average yield is around 1308 kg/ha (Desai *et al.* 1999). Compared to the other groundnut producing countries, the productivity in India is very low (988 kg/ha) which is attributed to environmental stress *viz.*, soil infertility, rainfall deficiency, pest and disease incidence and use of low yield cultivars.

Pest and disease incidences on groundnut occur throughout the growing season. In many occasions entire groundnut plant is subjected to pest and diseases attack causing reduction in quantity and quality of pods, seeds and forage. Crop losses due to some pest and disease may be negligible whereas some are devastating. *Cercospora*

*Arachidicola Hori* and *Cercosporidium Personatum* (Berk and Curt) cause leaf spot or tikka disease as it is locally known. *Deighton* pathogens occur in imperfect state whereas the perfect state of these fungi is *Mycosphaerella Arachidis Deighton* and *M. berkekeyi W. A. Jenlins* (early and late leaf spot pathogens respectively).

Studies undertaken in the past (Sundaram 1965, McDonald and Flower 1977 and Subramanyam and Ravindranath 1988) revealed that the tikka disease is one of the most dreaded disease which cause infestation, almost in the entire groundnut producing regions of India. Yield loss due to tikka is estimated to be 50-60 percent in some susceptible varieties (Subramanyam, *et al.* (1980b). Some researchers (Sulaiman and Agashe 1965, Ramakrishna and Apparao 1968, Chohan 1974, Venkatraman and Kazi 1979, and Dubey *et al.* 1995) reported the relationship between meteorological parameters and tikka disease incidence. Forewarning model for leaf spot incidence on groundnut was entirely based on meteorological parameters *viz.*, temperature, relative humidity and hours of bright sunshine. An attempt has been made in the present study to develop weather

TABLE 1

## Tikka disease index

S. No.	Tikka disease intensity	Tikka disease index
1	Trace	1
2	Trace to low	2
3	Low	3
4	Low-moderate	4
5	Moderate	5
6	Moderate-severe	6
7	Severe	8

based forewarning models for tikka disease in the areas of Gujarat state.

Lyle (1964) observed that the greatest number of conidia appeared during a period of abundance rainfall and high minimum ( $22^{\circ}$  C) and high maximum ( $35^{\circ}$  C) temperature. Jensen and Boyle (1965) reported that leaf spot severity was correlated with periods of high relative humidity during which temperatures were above  $20^{\circ}$  C. Literatures suggest that the leaf spot caused severe damage to the crops in the coastal region of India in the post rainy season because of favourable climatic conditions. A disease forecasting method for groundnut leaf spot disease was developed in 1966 for the groundnut crop grown in Georgia. The system was based on the effect of daily minimum air temperature on duration of relative humidity more than 90% on development of leaf spot epidemics. The system was computerized and daily spray of advisories was issued to groundnut growers in SE, USA beginning in 1971 (Smith 1986). Attempt has also been made to explore the feasibility of operational crop protection based on prevailing synoptic situation.

## 2. Materials and methods

The qualitative data of tikka disease incidence reported by PPQ&S, Faridabad was used in the present study. The qualitative tikka disease data was converted to quantitative tikka disease indices based on the intensity of the tikka disease incidence *viz.*, trace, low, low to moderate, moderate, moderate to severe and severe (Table 1). The data was collected from the Rapid Roving Survey Report published bimonthly by the Central Integrated Pest Management Center, Directorate of Plant Protection Quarantine and Storage (PPQ&S), Faridabad. PPQ&S in collaboration with State Department of Agriculture and Indian Council of Agricultural Research (ICAR) conducts periodic survey to monitor the crop situation in the country and publishes a report which is effectively used for planning integrated pest management operations.

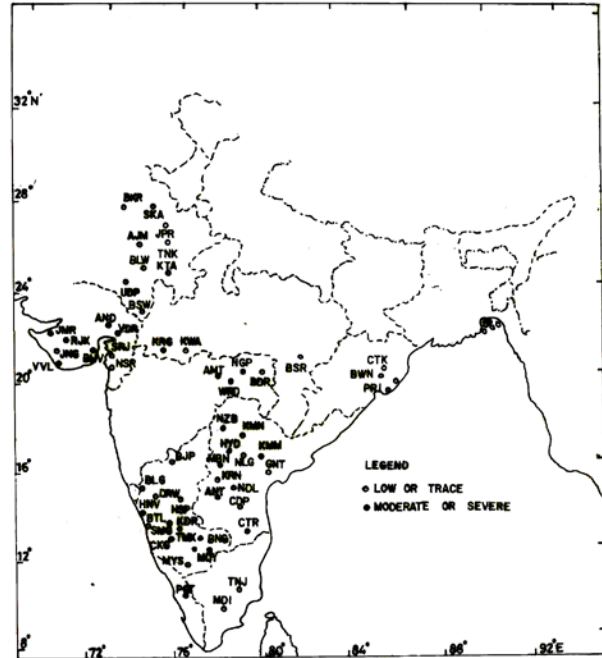


Fig. 1. Geographic distribution of Tikka disease incidence on groundnut

Data of six stations namely Ahmedabad ( $23^{\circ} 04' N$   $72^{\circ} 38' E$ ), Anand ( $22^{\circ} 55' N$   $75^{\circ} 00' E$ ), Bhavnagar ( $21^{\circ} 45' N$   $72^{\circ} 12' E$ ), Jamnagar ( $22^{\circ} 22' N$   $69^{\circ} 05' E$ ), Junaghad ( $21^{\circ} 29' N$   $70^{\circ} 19' E$ ) and Veraval ( $22^{\circ} 18' N$   $70^{\circ} 47' E$ ) in Gujarat were taken up in the present study along with the daily meteorological parameters *viz.*, maximum temperature ( $T_{max}$ ), minimum temperature ( $T_{min}$ ), morning relative humidity (RH 1), afternoon relative humidity (RH2), bright hours of sunshine (SSH) and rainfall (RFL).

Sigma Statistical Software developed by Jandel Scientific Software Inc. USA was used to study the statistical significance between the two parameters *viz.*, tikka disease indices and meteorological parameters. Pearson's method was applied to compute the simple correlation coefficient. This technique was used to ascertain the degree of relationship between tikka disease indices and meteorological parameters. The Pearson Product moment correlation measures the strength of association between Pearson's variables with regard to which variable is dependent or independent, The Pearson Product moment correlation Coefficient does not required the variables to be assigned as independent and dependent. It is a parametric test that assumes the residuals (Distance of the data points from the regressing line) are normally distributed with constant variance (Caty and Ulrich 1995). Multiple linear regression technique was applied to develop the regression model. Stepwise regression technique was applied to eliminate the insignificant

TABLE 2

Simple correlation coefficient of tikka disease on groundnut at 1% level

S. No.	Station	Period	N	Intensity	Tmax	Tmin	RH1	RH2
1	Ahmedabad	21 Sep 1991 to 11 Oct 1991	21	Severe	-0.819	-0.524	0.692	0.399
2	Anand	24 Sep 1988 to 10 Oct 1988	17	Moderate	-0.619	-0.602	0.708	0.779
3	Bhavnagar	11 Sep 1991 to 11 Oct 1991	31	Severe	-0.605	-0.858	0.627	NA
4	Jamnagar	9 Aug 1991 to 11 Oct 1991	56	Severe	-0.156	-0.640	0.736	0.767
5	Junaghad	25 Aug 1991 to 11 Oct 1991	47	Severe	NA	-0.838	0.569	0.734
6	Veraval	21 Sep 1991 to 11 Oct 1991	21	Severe	-0.852	-0.526	0.823	0.780

TABLE 3

Multiple linear regression coefficient (R and R<sup>2</sup>) and regression equation for predicting tikka disease outbreak

S. No.	Station	R	R <sup>2</sup>	Regression equation
1	Ahmedabad	0.859	0.738	$Y = 19.28 - 0.044 \text{ max} - 0.002 \text{ min} + 0.043 \text{ RH1}$
2	Anand	0.867	0.752	$Y = 1.84 - 0.033 \text{ Tmax} + 0.087 \text{ RH1} + 0.069 \text{ RH2}$
3	Bhavnagar	0.887	0.788	$Y = 17.2 + 0.002 \text{ Tmax} - 0.072 \text{ Tmin} + 0.044 \text{ RH1}$
4	Jamnagar	0.875	0.766	$Y = 2.07 - 0.043 \text{ Tmin} + 0.087 \text{ RH1} + 0.069 \text{ RH2}$
5	Junaghad	0.889	0.790	$Y = 15.35 - 0.044 \text{ Tmin} - 0.017 \text{ RH2}$
6	Veraval	0.876	0.768	$Y = -7.34 - 0.002 \text{ Tmax} + 0.12 \text{ RH1} + 0.05 \text{ RH2}$

meteorological parameters from the regression model. Daily meteorological and tikka disease data for all the stations under study for the years 1988 and 1991 when moderate to severe attack was reported were utilized to develop the weather based regression model for the outbreak of the disease. Synoptic charts were also critically examined to find out whether there is any association between the tikka disease incidence and weather prevailing during the diseases incidence in the State of Gujarat.

### 3. Results and discussion

The geographic distribution of the tikka disease incidence over Gujarat state is presented in Fig. 1. It is seen that groundnut grown in stations located in south Gujarat are more prone to the disease incidence compared to other parts of the state. Though groundnut crop was affected by this disease both in kharif and rabi seasons, yet data received from PPQ&S, Faridabad showed that frequency of disease occurrence was more in kharif season. The severity of the incidence of the disease was also more in kharif. Peak infestation period of the disease was mainly confined between August and October during the pod formation stage of the crop.

The meteorological parameters having significant correlation coefficient (CC) with respect to tikka disease indices on groundnut are presented in Table 2. CCs between tikka disease indices and meteorological parameters for the years 1988 and 1991 revealed that SSH and RFL did not show significant correlation for the stations under study. The positive CCs between tikka disease incidence and RFL and positive and significant CCs between the tikka disease incidence and RH1 and RH2 indicated that rainfall associated with high humidity played a very important role for the development of the disease. However, maximum and minimum temperature showed negative correlation which ranged between -0.15 to -0.85 and -0.52 to -0.86 and morning and afternoon relative humidity showed positive correlation coefficients which ranges between 0.57 to 0.82 and 0.40 to 0.82 respectively. The study revealed that fall in temperature both maximum and minimum and increase in morning and afternoon relative humidity helped to the multiplication of the fungi causing tikka disease incidence on groundnut at all the six stations. Based on the statistical studies, the regression models developed for each of the six stations are presented in Table 3. Tikka disease infestation in association with the change in meteorological parameters for each of the six stations is represented in Table 4.

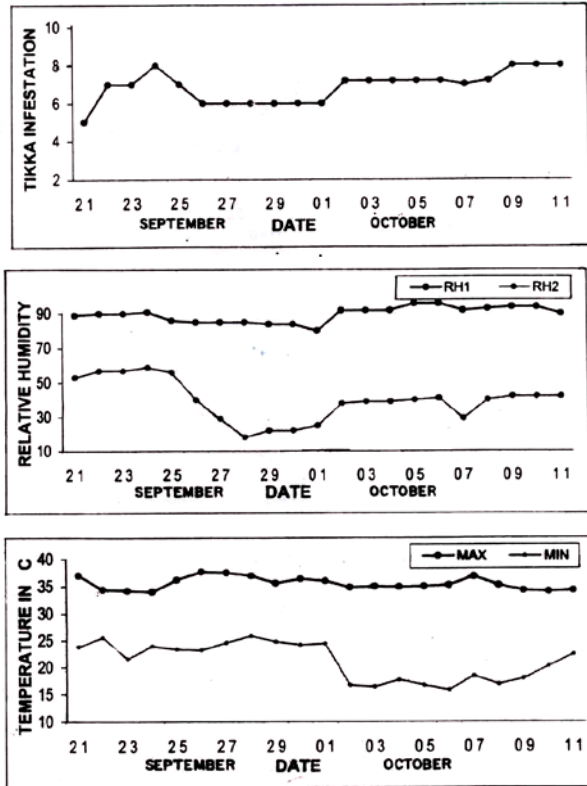


Fig. 2. Tikka infestation, relative humidity and temperature at Ahmedabad

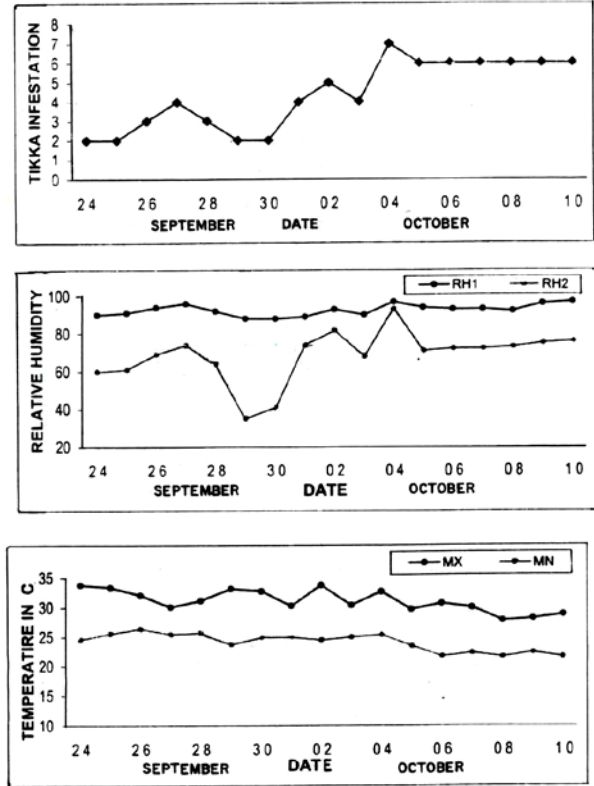


Fig. 3. Tikka infestation, relative humidity and temperature at Anand

TABLE 4

Variation in the meteorological parameters favouring tikka disease incidence on groundnut

S. No.	Station	Variation in temperature				Variation in RH			
		Tmax		Tmin		RH1		RH2	
		Actual fall	Range	Actual fall	Range	Actual rise	Range	Actual rise	Range
1	Ahmedabad	-3.5	37-34	-6.0	24-17	13	80-93	Na	Na
2	Anand	-4.0	34-30	-4.0	25-21	10	86-96	40	40-80
3	Bhavnagar	-4.0	37-33	-5.0	25-20	37	45-82	Na	Na
4	Jamnagar	-3.0	37-34	-3.0	25-22	11	80-91	28	50-78
5	Junaghad	Na	Na	-7.0	25-18	12	80-92	15	70-85
6	Veraval	-5.0	36-31	-3.0	20-17	8	85-93	10	75-85
	Avg. variation	-4.0	36-32	-5.6	25-19.4	15	76-91	22	59-81
	Normal		34.2		22.9		86		54

Station-wise studies on tikka disease incidences in relation to meteorological parameters are presented below :

*Ahmedabad*

CCs were worked out between tikka disease indices and meteorological parameters. The CCs obtained were

negative for maximum temperature (-0.81) and minimum temperature (-0.52) whereas it was positive for morning relative humidity (0.69) and afternoon relative humidity (0.39). Stepwise regression analysis carried out with these parameters indicated that afternoon relative humidity has not contributed much thus RH2 was eliminated from the regression model. Multiple regression coefficient (*R*) and

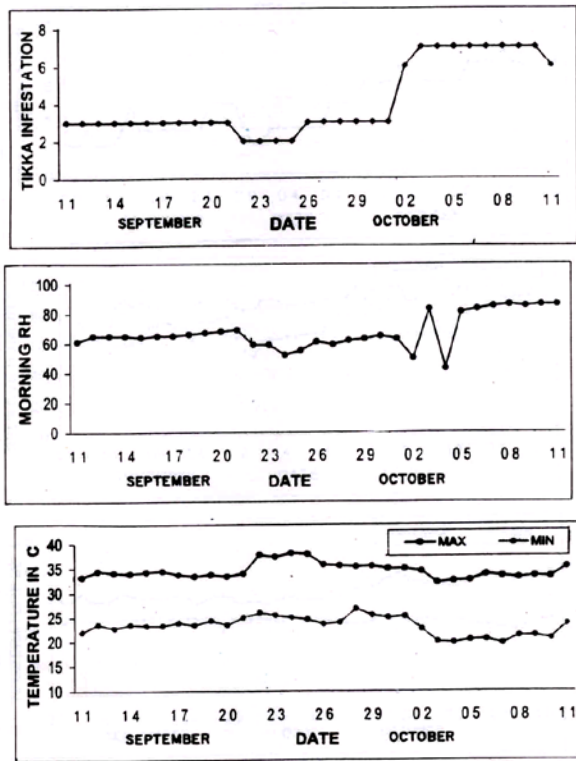


Fig. 4. Tikka infestation, relative humidity and temperature at Bhavnagar

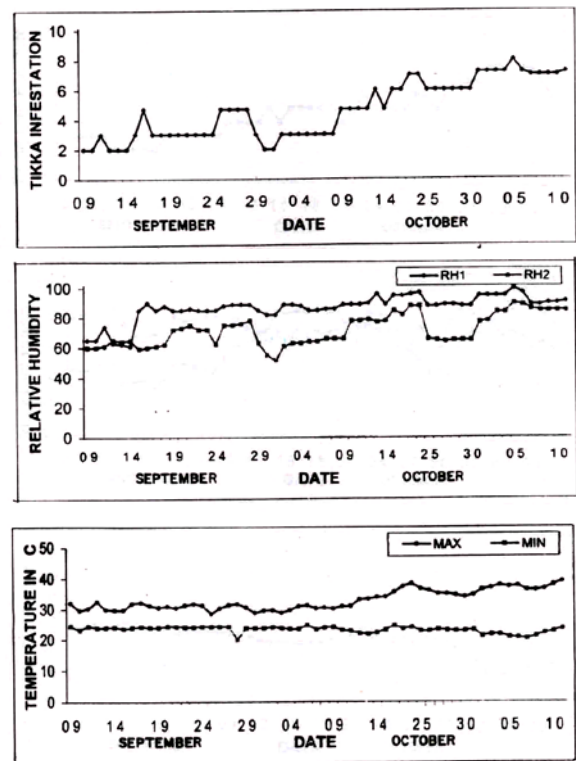


Fig. 5. Tikka infestation, relative humidity and temperature at Jamnagar

$R^2$  were 0.859 and 0.738 respectively. Since the regression model was tested for 95% confidence level, tikka disease outbreak could be predicted from the linear combination of meteorological parameters namely maximum and minimum temperatures and morning relative humidity. Graphical analysis (Fig. 2) also indicates that decrease in maximum and minimum temperatures from  $\leq 34^\circ\text{C}$  and  $\leq 17^\circ\text{C}$  respectively in combination with increase in morning relative humidity  $\geq 93\%$  favoured tikka disease outbreak at Ahmedabad.

*Anand*

CCs were negative for both maximum and minimum temperature (-0.62) and (-0.60) respectively and positive for morning (0.71) and afternoon (0.78) relative humidity respectively. Applying stepwise regression technique minimum temperature was found to be insignificant and it was eliminated from the regression model.  $R$  and  $R^2$  were 0.87 and 0.75 respectively. Thus disease outbreak could be predicted from the linear combination of meteorological parameters namely maximum temperature, morning and afternoon relative humidity. Graphical analysis (Fig. 3) reveals that decrease in maximum temperature from  $\leq 30^\circ\text{C}$  and increase in morning and

afternoon relative humidity from  $\geq 96\%$  and  $\geq 80\%$  respectively favoured tikka disease infestation.

*Bhavnagar*

At Bhavnagar CCs were found to be negative for maximum temperature (-0.61) and minimum temperature (-0.86) and positive for morning relative humidity (0.63).  $R$  and  $R^2$  were 0.89 and 0.79 respectively. Stepwise regression confirmed that maximum and minimum temperatures and morning relative humidity contributed significantly for predicting the tikka disease incidence. From the graphical analysis (Fig. 4) it may be seen that decrease in maximum and minimum temperature from  $\leq 33^\circ\text{C}$  and  $\leq 20^\circ\text{C}$  respectively along with rise in morning relative humidity from  $\geq 82\%$  favoured tikka disease incidence.

*Jamnagar*

CCs for maximum and minimum temperatures were -0.16 and -0.64 respectively and CCs were 0.74 and 0.77 for morning and afternoon relative humidity respectively.  $R$  and  $R^2$  were 0.87 and 0.76 respectively. Stepwise regression analysis eliminated insignificant variable

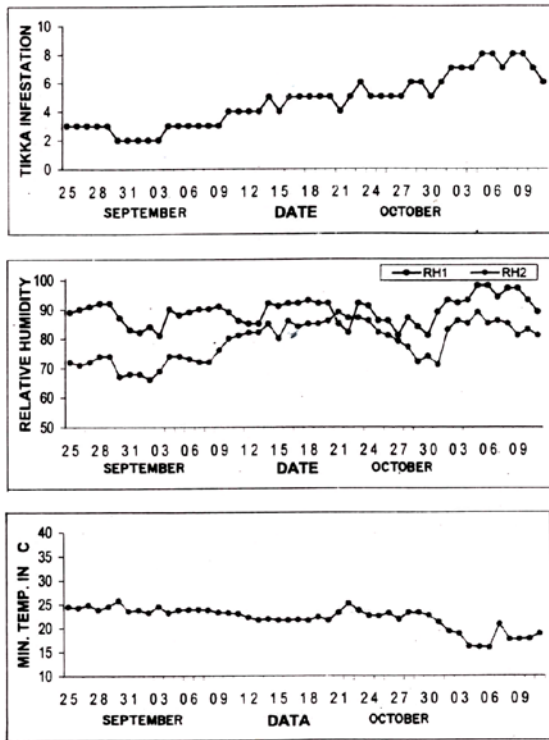


Fig. 6. Tikka infestation, relative humidity and temperature at Junaghad

maximum temperature from the multiple regression models. Graphical analysis (Fig. 5) reveals that decrease in minimum temperature from  $\leq 22^{\circ}\text{C}$  together with rise in morning and afternoon relative humidity from  $\geq 91\%$  and  $\geq 78\%$  contributed significantly to tikka disease incidence.

#### Junaghad

CCs for minimum temperature, morning and afternoon relative humidity were -0.84, 0.57 and 0.73 respectively.  $T_{\text{max}}$  could not be included in the model due to non-availability of data.  $R$  and  $R^2$  were 0.89 and 0.79 respectively. Stepwise regression analysis showed that all the above mentioned meteorological parameters have contributed significantly towards infestation of tikka disease. Graphical analysis (Fig. 6) reveals that decrease in minimum temperature from  $\leq 18^{\circ}\text{C}$  together with rise in morning and afternoon relative humidity from  $\geq 92\%$  and  $\geq 85\%$  contributed significantly to tikka disease incidence.

#### Veraval

CCs for maximum and minimum temperature were -0.85 and -0.53 respectively and for morning and afternoon relative humidity were 0.82 and 0.78 respectively.  $R$  and  $R^2$  were 0.88 and 0.77 respectively. Stepwise regression

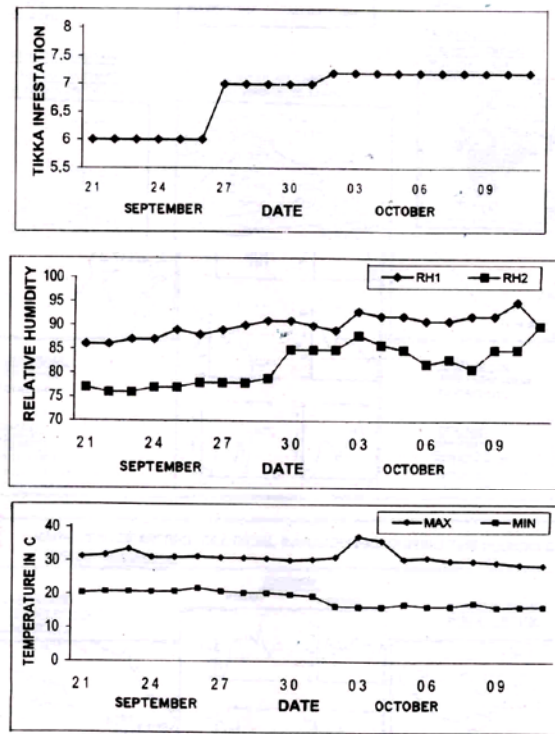


Fig. 7. Tikka infestation, relative humidity and temperature at Veraval

analysis eliminated the insignificant parameters minimum temperature from multiple regression models. Graphical analysis (Fig. 7) also reveals that decrease in maximum temperature from  $\leq 31^{\circ}\text{C}$  together with rise in morning and afternoon relative humidity from  $\geq 93\%$  and  $\geq 80\%$  contributed significantly to tikka disease incidence.

#### 4.1. Synoptic situation and tikka disease incidences in Gujarat state

In 1988, moderate to severe incidences of the disease was observed on groundnut during 1<sup>st</sup> to 10<sup>th</sup> October in the pod development to maturity stages of the crop. On 18<sup>th</sup> September, a low-pressure area was formed over east central Arabian Sea and adjoining north Maharashtra coast. It became well marked over east central Arabian Sea and adjoining north Maharashtra - south Gujarat coast in the evening of 20<sup>th</sup>. It merged with the other low pressure area over west Madhya Pradesh and persisted there for a few days (end of September) (Fig. 8). These caused rainfall and clouding and drop in temperature and increase in relative humidity in different parts of the state. Under the favourable weather conditions, disease appeared in moderate to severe intensities on groundnut grown in different parts of the state.

Tikka disease appeared in moderate to severe intensities pod formation stage of groundnut at Jamnagar,



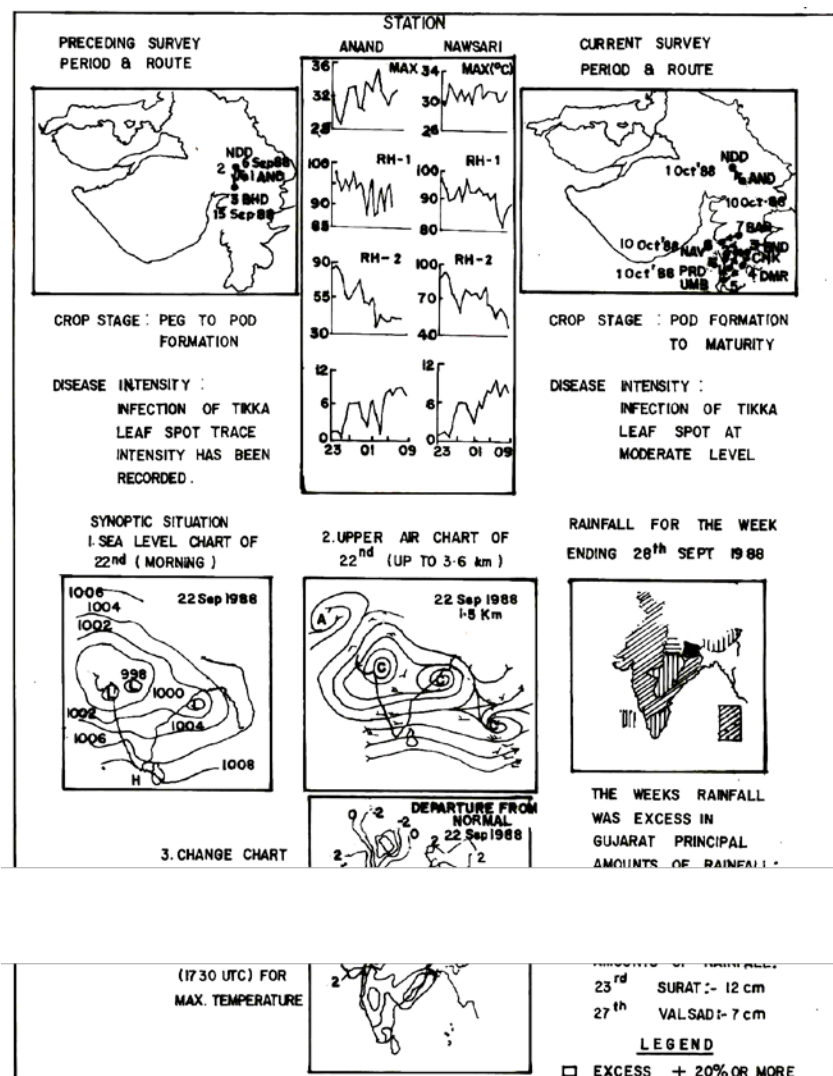


Fig. 8. Variation of meteorological parameters during the period of disease incidence

TABLE 5

Variation of meteorological parameters during the period of incidence of leaf spot disease

Station	Period of disease incidence	Tmax (°C) dropped		RH1 increased		RH 2 increased	
		From	To	From	To	From	To
Khammam (A.P.)	1-13 Feb 1998	32.0 (Jan17)	29.0 (Jan 20)	80 (Jan 18)	90 (Jan 20)	40 (Jan 17)	60 (Jan 20)
Nizamabad (A.P.)	1-13 Feb 1998	34.0 (Jan16)	29.0 (Jan 20)	65 (Jan 18)	80 (Jan 20)	15 (Jan 16)	60 (Jan 19)
Ramagundam (A.P.)	1-13 Feb 1998	33.0 (Jan16)	29.0 (Jan 21)	80 (Jan 17)	85 (Jan 21)	50 (Jan 16)	65 (Jan 19)

Junaghad and Bhavnagar during the first week of October 1991. Prior to the disease incidence, a western disturbance as an upper air system persisted over north Pakistan and adjoining Punjab on 26<sup>th</sup> September. It moved eastwards on 27<sup>th</sup>. Another western disturbance as an upper air

system was observed over north Pakistan and neighbourhood on 27<sup>th</sup>. Moving northeastwards it remained over northern parts of Jammu and Kashmir on the last day of the week. From the synoptic charts it is observed that strong northerly current brought the cold air

causing decrease in temperature in Gujarat region. Besides moisture incursion from cyclonic circulation increased the relative humidity over the Gujarat region. Thus upper air systems resulted the favourable weather conditions for the disease to appear in moderate to severe intensities.

#### 4.2. Validation of disease incidence in Andhra Pradesh using synoptic charts

The results emerged out from the above study were validated with the observation made in 1998. Incidence of disease was reported at Khammam, Nizamabad and Ramagundam of Andhra Pradesh districts by the survey carried out from 1-13 February 1998. During this period too a sudden drop in maximum temperature and increase in relative humidity and clouding during the period, (Table 5) was reported. During this period a severe cold wave condition prevailed in west Madhya Pradesh, Marathwada and Vidarbha regions of Maharashtra. Under the influence of cold wave there was a decrease in temperature in parts of Andhra Pradesh. Besides, embedded cyclonic circulation over Telangana and neighbourhood caused rainfall in different places of Andhra Pradesh. Thus, observed findings from this study validate fairly well with the observations made in 1998.

### 5. Conclusion

Groundnut grown in south Gujarat is more prone to tikka disease incidence. The crop was affected by tikka disease incidence both in kharif and rabi seasons, however the severity of the attack was more in kharif season. Peak infestation period of tikka on groundnut was mainly confined between August and October months when the crop is in the pod formation to maturity stages. The weather parameters favourable for the outbreak of tikka disease incidence are :

- (i) Decrease in maximum and minimum temperatures  $\leq 34^{\circ}\text{C}$  and  $\leq 22^{\circ}\text{C}$  respectively.
- (ii) Increase in morning and afternoon relative humidity  $\geq 82\%$  and  $\geq 78\%$  respectively.
- (iii) Synoptic weather conditions alongwith the economic threshold value of the disease from the field can be used as a guiding tool for forecasting the incidence of the disease.
- (iv) Forewarning models developed for each of the six locations alongwith synoptic situations would be useful for operational crop protection of tikka disease.
- (v) This information can effectively be utilized through AAS units of IMD and NCMRWF to issue forewarning of tikka disease incidence for operational disease management.

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