MAUSAM, **68**, 2 (April 2017), 299-308

633.852.52 : 632.11

Role of weather factors in development of late leaf spot (*Phaeoisariopsis personata*) on groundnut (*Arachis hypogaea*)

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(*Received 10 July 2015, Accepted 22 August 2016*)

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सार – मूंगफली की चार फसलों अर्थात JL-24, LGN-1, TAG-24 और TG-26 में पछेती पर्ण चित्ती रोग और विपत्रण की तीव्रता में मौसम प्राचलों नामत: तापमान, सापेक्षिक आर्द्रता, वर्षा, वर्षा के दिनों और पवन वेग के प्रभाव का पता लगाने के लिए 2012 और 2013 की फसल के दौरान फील्ड परीक्षण किए गए। प्रबल मौसम की स्थितियों नामत: 30.92 °C (अधिकतम) और 22.31°C (न्यूनतम) के औसत तापमानों, 89.67% (सुबह) ओर 64.25% (शाम) के औसत RH, 50.33 मि. मी. की सुवितरित औसत वर्षा, 2.67 की औसत वर्षा के दिन और 4.24 कि. मि./ प्रति घंटा के औसत पवन वेग सुग्राहय मूंगफली C_V. JL-24, TAG-24 और सहनशील C_V. LGN-1, TG-26 में पछेती पर्ण चित्ती रोग के लगने, विकसित होने और फैलने के लिए सहायक पाए गए है। परिणामत: JL-24 और TAG-24 में क्रमश: 33.97 (21.96 से 46.37%) और 29.06 (18.62 से 39.01%) प्रतिशत की कुल औसत अधिकतम रोग की तीव्रता रिकार्ड की गई। मूंगफली C_V. JL-24 और TAG-24 (सुग्राहय) से क्रमश: 6.65 से 14.05 (औसत 10.29%) और 5.64 से 11.82% (औसत 8.80%) की रेंज में अपेक्षाकृत अधिकतम औसत विपत्रण पाया गया है। दोनों वर्षों में मौसम परिवर्तिताओं ओर रोग की तीव्रता के मध्य सहसंबंध गुणांक से पता चला है कि सभी मूंगफली की फसलों में अधिकतम तापमान का नकारात्मक ओर गैर महत्वपूर्ण प्रभाव रहा है जबकि सभी मूंगफली की फसलों में न्यूनतम तापमान का सकारात्मक और महत्वपूर्ण प्रभाव रहा है। मूंगफली की सभी फसलों में रोग की तीव्रता में सापेक्षिक आर्द्रता (सुबह और शाम) ने महत्वपूर्ण भूमिका निभाई है।

ABSTRACT. The field experiment was conducted during *Kharif* 2012 and 2013 to find out the influence of weather parameters *viz*., temperature, relative humidity, rainfall, rainy days and wind velocity on the intensity of late leaf spot disease and defoliation in four groundnut cultivars *viz*., JL-24, LGN-1, TAG-24 and TG-26. The prevailing weather condition *viz.*, average temperatures of 30.92 °C (max.) and 22.31 °C (min.), average RH of 89.67 % (morning) and 64.25 % (evening), well distributed average rainfall of 50.33 mm, average rainy days of 2.67 and average wind velocity of 4.24 km/hr were found to be conducive for the initiation, development and spread of late leaf spot disease in susceptible groundnut Cv. JL-24, TAG-24 and tolerant Cv. LGN-1, TG-26. As a result, overall average maximum disease intensity of 33.97 (21.96 to 46.37 %) per cent and 29.06 (18.62 to 39.01 %) per cent, were recorded in JL-24 and TAG-24, respectively. Groundnut Cv. JL-24 and TAG-24 (susceptible) exhibited comparatively maximum average defoliation in the range of 6.65 to 14.05 (Av. 10.29 %) and 5.64 to 11.82 per cent (Av. 8.80 %), respectively. The correlation coefficient between weather variables and disease intensity in both the years indicated that maximum temperature had negative and non significant effect in all the groundnut cultivars; whereas, minimum temperature had positive and significant effect on the disease intensity in all the groundnut cultivars. Relative humidity (morning and evening) played significant positive role on the disease intensity in all the groundnut cultivars.

Key words – *Arachis hypogaea*, Defoliation, Late leaf spot, PDI, *Phaeoisariopsis personata*, Weather factors.

1. Introduction

Groundnut (*Arachis hypogaea* L.), is an oilseed crop of global importance because of its high protein and oil content. Groundnut hay (vine) is a nutritious animal feed, particularly for the subsequent dry season when green forage is not available. Despite of its importance, one of the major constraints in the production and productivity of the crop is the disease. The crop is affected by several biotic factors (fungi, bacteria, viruses, nematodes) and abiotic factors and among the biotic factors the major fungal diseases are early leaf spot (*Cercospora*

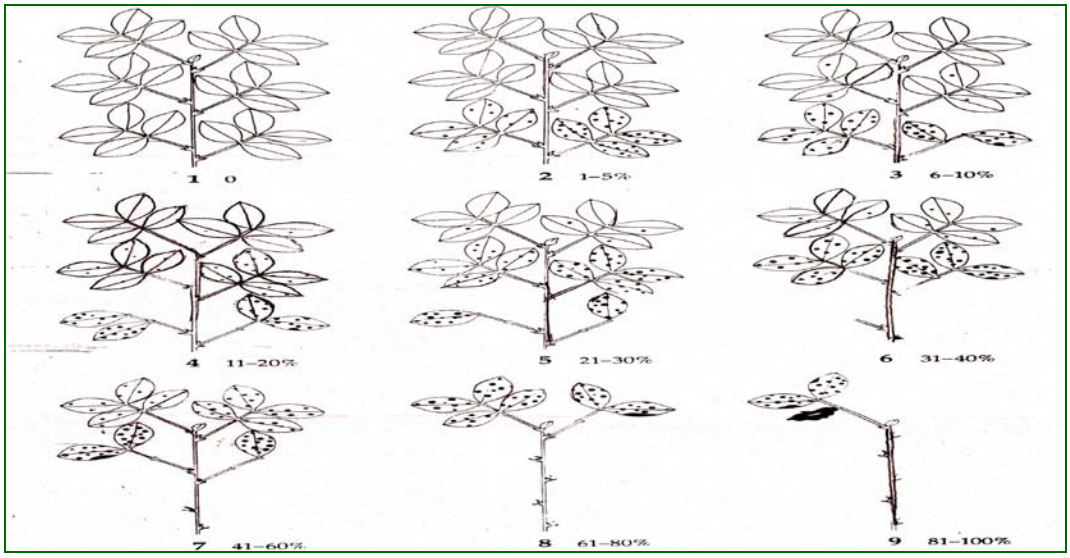

Fig. 1. Modified 9 point standardized pictorial chart

arachidicola Hori), late leaf spot (*Phaeoisariopsis personata* (Berk and Curtis) Arx and rust (*Puccinia arachidis* Speg.). Late leaf spot which is both air and seed born in nature, is one of the most destructive disease incurring both qualitative and quantitative losses (Naab *et al*., 2005), going up to the extent of 50-80 per cent losses in yield (Hegde *et al*., 1995; Grichar *et al*., 1998; Nutsugah *et al*., 2007). In Maharashtra state, the disease was reported to be more intense during *kharif* season, moderate during *rabi* (Dey, 2014) and to a lesser extent during summer seasons. Rational disease control practices should reduce the use of fungicide in developed countries and substantially augment the yield in the tropics. Ideally, management strategies for groundnut foliar diseases should include resistant varieties with good agronomic characteristics. Smith (1980) pointed out the need for further studies on the epidemiology of groundnut foliar pathogens to develop disease management strategies. An understanding of the relationships between groundnut plants, pathogens and their environment interactions is fundamental for disease control measures. Climate not only affects crops but also affects the pathogens, insect pests and weeds that reduces crop yield (Anderson *et al.*, 2004). Therefore, weather conditions play a predominant role in determining the course and severity of epidemics. The disease triangle recognizes the role of environmental factors influencing significantly in disease etiology, as no virulent pathogen can induce disease on a highly susceptible host if weather parameters are not favorable (Agrios, 2005; Ziska and Runion, 2007). Hence, an endeavor was accomplished to study the role of different weather parameters *viz.*, rainfall, rainy days, relative humidity, temperature and wind velocity on infection and development of the late leaf spot disease and then subsequently develop forecasting model that will be helpful for future strategy for controlling the disease.

2. Materials and method

The experiment was conducted on the research farm of the V. N. M. K. V., Parbhani during *kharif* 2012 and *kharif* 2013 to find out the influence of weather parameters *viz*., temperature (maximum and minimum), relative humidity (mor. and eve.), rainfall (mm), rainy days and wind velocity on the intensity of late leaf spot disease and defoliation in four groundnut cultivars *viz*., JL-24, LGN-1, TAG-24 and TG-26. Data on weather parameters during crop period (June to October) was obtained from the Meteorological Observatory, Department of Meteorology, Parbhani. Three blanket sprays of the fungicide, Tridemorph (@ 0.2%) were applied to inhibit rust (*P. arachidis*) infection and maintain the crop free from rust. The first spray was applied at 30 days after sowing of the crop and subsequent sprays at 15 days interval.

Observations on the progressive development, intensity of late leaf spot disease and defoliation were recorded at 8 days interval starting from first appearance of disease till 15 days before harvest of the crop. Before appearance of the disease, five plants were selected randomly per cultivar per replication from the crop sown on 25th June (26th Meteorological Week). Observations on late leaf spot disease were recorded on three quadruplet leaves (bottom, middle and top) from main branch of selected plants applying modified 9 point disease rating scale (Subba Rao *et al.*, 1990) (Fig. 1).

TABLE 1

Epidemiological factors (weather parameters) during *Kharif*, 2012 and *Kharif*, 2013

MW	*Kharif*, 2012							*Kharif*, 2013							Av.						
	Temp °C		RH (%)		RF (mm)	RD	WV (km/hr)	Temp °C		RH (%)		RF (mm)	RD	WV (km/hr)	Temp °C		RH (%)		RF (mm)	RD	WV (km/hr)
	Max	Min	Mor.	Eve.				Max	Min	Mor.	Eve.				Max	Min	Mor.	Eve.			
33	31.0	21.5	86	65	4.8	1	4.7	30.2	22.7	91	65	50.2	3	4.3	30.60	22.10	88.50	65.00	27.5	2	4.50
34	31.1	22.2	92	60	35.4	3	4.3	28.5	21.6	89	71	9.3	2	7.1	29.80	21.90	90.50	65.50	22.35	2.5	5.70
35	31.7	23.0	90	67	40.6	3	3.7	31.2	23.0	83	60	0.0	0	3.7	31.45	23.00	86.50	63.50	20.3	1.5	3.70
36	30.2	22.3	95	72	108.4	5	4.3	33.1	22.5	85	51	29.8	1	4.3	31.65	22.40	90.00	61.50	69.1	3	4.30
37	31.2	22.1	90	62	28.4	1	3.9	31.6	22.2	92	63	84.5	5	2.8	31.40	22.15	91.00	62.50	56.45	3	3.35
38	30.8	22.2	90	68	61.9	3	3.9	30.4	22.4	93	67	150.6	5	3.9	30.60	22.30	91.50	67.50	106.25	4	3.90
Av	31	22.22	90.5	65.67	46.58	2.67	4.13	30.83	22.4	88.83	62.83	54.07	2.67	4.35	30.92	22.31	89.67	64.25	50.33	2.67	4.24

MW : Meteorological week, Av: Average, Min = Minimum, Max = Maximum, Mor. = Morning, Eve. = Evening, RH = Relative humidity, RF = Rainfall, RD = Rainy days, WV = Wind velocity,

TABLE 2

Influence of weather parameters on late leaf spot disease intensity in groundnut cultivars

MW	Mean PDI								Av. PDI			
	Kharif, 2012				*Kharif*, 2013							
	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26
33	21.35	13.98	17.8	15.85	22.56	15.82	19.44	18.55	21.96	14.90	18.62	17.20
34	27.12	18.17	23.66	22.05	27.75	19.98	24.15	23.86	27.44	19.08	23.91	22.96
35	30.78	20.88	26.34	25.25	31.57	22.75	27.95	27.16	31.18	21.82	27.15	26.21
36	36.56	25.35	29.92	27.95	36.98	26.67	31.75	30.56	36.77	26.01	30.84	29.26
37	39.80.	28.78	34.65	32.78	40.45.	29.58	35.05	34.45	40.13	29.18	34.85	33.62
38	45.95	34.67	38.25	36.45	46.78	35.16	39.76	39.03	46.37	34.92	39.01	37.74
Av	33.59	23.64	28.44	26.72	34.35	24.99	29.68	28.94	33.97	24.32	29.06	27.83
SEm (±)	1.31	1.51	1.77	1.78	1.40	1.64	1.98	1.57	1.31	1.12	1.12	1.46
CD (*p = 0.05*)	4.13	4.77	5.56	5.62	4.41	5.18	6.23	4.95	4.12	3.52	3.53	4.60

MW : Meteorological week, PDI : Per cent disease index, Av. : Average

2.1. *Standard modified disease rating scale (9 grade)*

1 = No symptoms (0% leaf area infected), 2 = Lesions present largely on lower leaves; no defoliation (necrotic spots covering 1-5% area), 3 = Lesions present largely on lower leaves, very few on middle leaves, defoliation of some leaflets evident on lower leaves (necrotic spots covering 6-10% area), 4 = Lesions on lower and middle leaves but severe on lower leaves; defoliation of some leaflets evident on lower leaves (necrotic spots covering 11-20% area), 5 = Lesions present on all lower and middle leaves; over 50 per cent defoliation of lower leaves (necrotic spots covering 21-30% area), 6 = Severe lesions on lower and middle leaves; lesions present but less severe on top leaves; extensive defoliation of lower leaves; defoliation of some leaflets evident on middle leaves (necrotic spots covering 31-40% area), 7 = Lesions on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves (necrotic spots covering 41-60% area), 8 = Defoliation of all lower and middle leaves; severe lesions on top leaves;

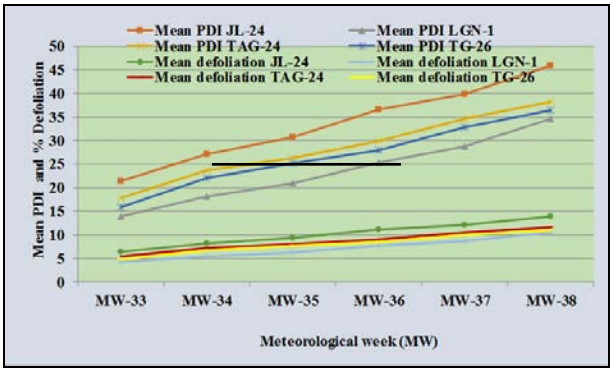

Fig. 2. Effect of weather parameters on PDI and % defoliation during *Kharif* 2012

some defoliation of top leaves evident (necrotic spots covering 61-80% area), 9 = Almost all leaves defoliated, leaving bare stems; some leaflets may remain but show severe leaf spots (necrotic spots covering 81-100% area).

Based on numerical rating scores observed, per cent disease index (PDI) was calculated by applying the formula (Mc Kinney, 1923) as given below:

$$PDI = \frac{\text{Summation of numerical ratings}}{\text{No.of leaves/plants observed} \times \text{maximum rating}} \times 100$$

Observations on defoliation were recorded on five randomly selected plants at 60, 75 and 90 days after sowing of the crop at various dates and per centage defoliation was worked out (Naab *et al*., 2005) using the following formula:

$$\text{Defoliation (\%)} = \frac{\text{number of leaves fallen}}{\text{Total number of leaves formed}} \times 100$$

3. Results and discussion

3.1. *Effect of weather parameters on the disease intensity and defoliation due to late leaf spot during Kharif, 2012*

Late leaf spot disease of groundnut appeared at 50 days after sowing (33rd MW) and the symptoms appears as small orbicular brown colored lesion on lower leaves. Later the lesions become dark brown to black and may or may not have yellow halo. Late leaf spot spores (conidia) are formed on the lower surface giving a carbon black, rough and tufted appearance. Under favourable conditions, the lesions coalescing each other leading to the intense defoliation. Under microscope 3-4 septate conidia with rounded apex and conidium with distinct hilum at base were observed. Spores (conidia) are hyaline and conidiophores are dark in color. Results (Table 1, Fig. 2) revealed that the weather variables *viz*., temperature (maximum and minimum), relative humidity (morning and evening), rainfall, rainy days and wind velocity influenced late leaf spot disease intensity and defoliation in all groundnut cultivars planted on 25th June, 2012. From the first appearance of the disease during 33rd meteorological week (MW), its intensity was found to be increased steadily in both the cultivars up to the last observation recorded during 38th MW.

During the observation period from 33rd to 38th MW, the weekly weather parameters prevailed were temperature (max), 30.8 to 31.7 °C (Av. 31 °C); temperature (min), 21.5 to 23.0 °C (Av. 22.22 °C); relative humidity (mor.), 86 to 95 per cent (Av. 90.50%); relative humidity (eve.), 60 to 72 per cent (Av. 65.67%); total rainfall, 4.8 to 108.4 mm (Av. 46.58 mm per week and total 279.5 mm); well distributed rainy days, 1 to 5 days (Av. 2.67 days and total 16 days) and wind velocity, 3.7 to 4.7 km/hr (Av. 4.13 km/hr.). The above conditions favored the initiation and further development of late leaf spot disease in all the groundnut cultivars during *Kharif* 2012. However, groundnut Cv. JL-24 and TAG-24 (susceptible) exhibited comparatively maximum average disease intensity in the range of 21.35 (33rd MW) to 45.95 (38th MW) and 17.80 (33rd MW) to 38.25 (38th MW) per cent, respectively with an overall maximum average disease intensity of 33.59 and 28.44 per cent, respectively (Table 2). Nevertheless, groundnut Cv. LGN-1 and TG-26 showed minimum average disease intensity in the range of 13.98 (33rd MW) to 34.67 (38th MW) and 15.85 (33rd MW) to 36.45 (38th MW) per cent, respectively and with an overall minimum average disease intensity of 23.64 and 28.44 per cent, respectively.

Groundnut Cv. JL-24 and TAG-24 (susceptible) showed the maximum average defoliation to the tune of 6.47 (33rd MW) to 13.92 (38th MW) and 5.39 (33rd MW) to 11.59 (38th MW) per cent, respectively, with an overall maximum average defoliation of 10.18 and 8.61 per cent, respectively (Table 3). Nevertheless, groundnut Cv. LGN-1 and TG-26 exhibited comparatively minimum average defoliation in the range of 4.23 (33rd MW) to 10.50 (38th MW) and 4.80 (33rd MW) to 11.04 (38th MW) per cent, respectively and with an overall minimum average defoliation of 7.16 and 8.09 per cent, respectively.

3.2. *Correlation between weather parameters, late leaf spot disease intensity and defoliation*

Simple correlation between major weather parameters, late leaf spot disease intensity and defoliation was worked out and the results (Tables 4 and 5) revealed that in all the groundnut cultivars, *viz*., Cv. JL24, LGN-1,

TABLE 3

Influence of weather parameters on defoliation in groundnut cultivars due to late leaf spot disease

MW	Mean defoliation (%)								Av. defoliation (%)			
	Kharif, 2012				*Kharif*, 2013							
	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26
33	6.47	4.23	5.39	4.8	6.83	4.79	5.89	5.62	6.65	4.51	5.64	5.21
34	8.21	5.5	7.17	6.68	8.41	6.05	7.31	7.23	8.31	5.78	7.24	6.96
35	9.32	6.32	7.98	7.65	9.56	6.89	8.47	8.23	9.44	6.61	8.23	7.94
36	11.07	7.68	9.06	8.47	11.2	8.08	9.62	9.26	11.14	7.88	9.34	8.87
37	12.06	8.72	10.5	9.93	12.25	8.96	10.62	10.43	12.16	8.84	10.56	10.18
38	13.92	10.5	11.59	11.04	14.17	10.65	12.04	11.82	14.05	10.58	11.82	11.43
Av	10.18	7.16	8.61	8.09	10.4	7.57	8.99	8.76	10.29	7.37	8.80	8.43
SEm (±)	1.79	1.43	2.00	1.00	1.77	1.58	2.53	1.03	1.78	1.50	2.26	1.00
CD (p=0.05)	5.65	4.51	6.30	3.15	5.58	4.99	7.96	3.24	5.61	4.72	7.12	3.14

MW : Meteorological week, Av : Average

TABLE 4

Correlation coefficient between late leaf spot intensity and weather parameters

Weather parameters	Mean PDI								Av PDI			
	Kharif, 2012				*Kharif*, 2013							
	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26
Temp (Min)	0.230	0.237	0.169	0.127	0.398	0.366	0.407	0.375	0.314	0.3015	0.288	0.251
Temp (Max)	-0.362	-0.313	-0.388	-0.431	-0.042	-0.050	-0.031	-0.060	-0.202	-0.1815	-0.2095	-0.2455
RH (Mor)	0.598	0.549	0.619	0.633	0.285	0.307	0.256	0.272	0.4415	0.428	0.4375	0.4525
RH (Eve)	0.363	0.347	0.286	0.284	0.164	0.130	0.173	0.139	0.2635	0.2385	0.2295	0.2115
Rainfall	0.638	0.598	0.598	0.596	0.732	0.749	0.707	0.708	0.685	0.6735	0.6525	0.652
Rainy days	0.373	0.325	0.343	0.355	0.513	0.528	0.491	0.504	0.443	0.4265	0.417	0.4295
Wind velo	-0.652	-0.624	-0.687	-0.722	-0.482	-0.467	-0.493	-0.474	-0.567	-0.5455	-0.59	-0.598

Av: Average, PDI: Per cent disease index, Min = Minimum, Max = Maximum, Mor = Morning, Eve = Evening, Velo = Velocity

TAG-24 and TG-26, the disease intensity and defoliation were influenced mostly by temperature, relative humidity, rainfall, rainy days and wind velocity.

On the basis of the weather parameters, maximum temperature was found to be non-significant and negatively correlated with the disease intensity in JL-24 (-0.362) and TAG-24 (-0.388), but it was significant and negatively correlated in LGN-1 (-0.313) and TG-26 (-0.431), at 5 per cent levels of significance. A non-significant and negative correlation was obtained between maximum temperature and the defoliation in JL-24 (-0.363) and TAG-24 (-0.390), but it was significant and negatively correlated in LGN-1 (-0.316) and TG-26 (-0.433), at 5 per cent level of significance. Minimum temperature was observed to be significant and positively correlated with the disease intensity and defoliation in all four groundnut cultivars.

Relative humidity (mor. and eve.) also played a major role in late leaf spot disease in all the four groundnut cultivars. Morning RH was found to be significant and positively correlated with the disease intensity in all four groundnut cultivars, JL-24 (0.598), TAG-24 (0.619), LGN-1(0. 549) and TG-26 (0.633) at 1 and 5 per cent levels of significance, respectively. Also, a significant and positive correlation between evening relative humidity and the disease intensity was recorded in all four groundnut cultivars, JL-24 (0.363), TAG - 24 (0.286), LGN - 1 (0.347) and TG - 26 (0.284)

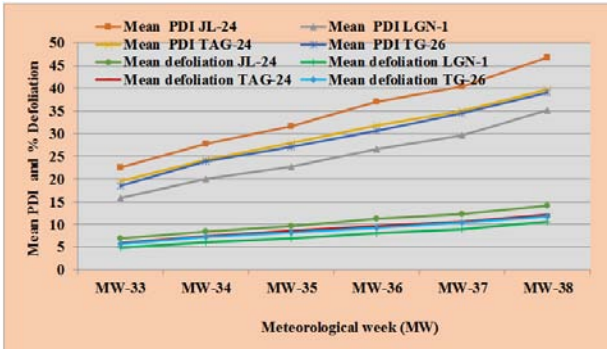

Fig. 3. Effect of weather parameters on PDI and % defoliation during *Kharif* 2013

at 1 and 5 per cent levels of significance, respectively. Morning relative humidity was found significant but positively correlated with the defoliation in all groundnut cultivars, JL-24 (0.621), TAG-24 (0.628), LGN-1(0.568) and TG-26 (0.637) at 1 and 5 per cent levels of significance, respectively. Nevertheless, evening RH was found significant and positively correlated with the disease intensity in all groundnut cultivars JL-24 (0.414), TAG-24 (0.325), LGN-1(0.385) and TG-26 (0.318) at 1 and 5 per cent levels of significance. It was found significant and positively correlated with the defoliation in all groundnut cultivars JL-24 (0.414), TAG-24 (0.325), LGN-1(0.385) and TG-26 (0.318) at 1 and 5 per cent levels of significance.

Total rainfall and rainy days also influenced the late leaf spot disease development, intensity and defoliation. In JL-24, total rainfall: 0.638 mm, rainy days: 0.373 and TAG-24, total rainfall: 0.598 mm, rainy days: 0.343 were significant and positively correlated with the disease intensity at 5 % levels of significance. Similarly, in LGN-1, total rainfall: 0.598 mm, rainy days: 0.325 and TG-26, total rainfall: 0.596 mm, rainy days: 0.355 were found significant and positively correlated with the disease intensity. In JL-24, total rainfall: 0.627, rainy days: 0.420 and TAG-24, total rainfall: 0.572, rainy days: 0.373 were significant and positively correlated with the defoliation at 5% levels of significance. The trend for the remaining groundnut cultivars, *viz.*, LGN-1 and TG-26 was similar to the above results where total rainfall (0.580), rainy days (0.366) and total rainfall (0.564), rainy days (0.378), respectively were observed to be significant and positively correlated with the disease intensity.

3.3. *Effect of weather parameters on the intensity and defoliation due to late leaf spot during Kharif, 2013*

During the observation period from 33rd to 38th MW, (Table 1, Fig. 3) the weekly weather parameters prevailed were: temperature (maximum) in the range of 28.5 to 33.1 °C (Av. 30.83 °C), temperature (minimum) in the range of 21.6 to 23.0 °C (Av. 22.40 °C), relative humidity (mor.) in the range of 83 to 93 per cent (Av. 88.83 %), relative humidity (eve.) in the range of 51 to 71 per cent (Av. 62.83 %), total rainfall in the range of 0.00 to 150.6 mm (Av. 54.07 mm and total 324.4 mm), well distributed rainy days in the range of 0 to 5 days (Av. 2.67 days and total 16 days) and wind velocity in the range of 2.8 to 7.1 km/hr (Av. 4.35 km/hr.). Weather parameters favoured the initiation as well as further development of late leaf spot disease in all the groundnut cultivars. The cultivars, Cv. JL-24 and TAG-24 (susceptible) exhibited comparatively maximum average disease intensity in the range of 22.56 (33rd MW) to 46.78 (38th MW) and 19.44 (33rd MW) to 39.76 (38th MW) per cent, respectively with an overall maximum average disease intensity of 34.35 and 29.68 per cent, respectively (Table 2). A comparatively minimum average disease intensity in the range of 15.82 (33rd MW) to 35.16 (38th MW) per cent was recorded in Cv. LGN-1 and TG-26 and 18.55 (33rd MW) to 39.03 (38th MW) per cent, respectively and with an overall minimum average disease intensity 24.99 and 28.94 per cent.

Groundnut Cv. JL-24 and TAG-24 (susceptible) showed comparatively maximum average defoliation in the range of 6.83 (33rd MW) to 14.17 (38th MW) and 5.89 (33rd MW) to 12.04 (38th MW) per cent, respectively with an overall maximum average defoliation of 10.40 and 8.99 per cent, respectively (Table 3). Whereas, groundnut Cv. LGN-1 and TG-26 recorded comparatively lower average defoliation in the range of 4.79 (33rd MW) to 10.65 (38th MW) and 5.62 (33rd MW) to 12.04 (38th MW) per cent, respectively and with an overall minimum average defoliation 7.57 and 8.76 per cent.

3.4. *Correlation between weather parameters, late leaf spot disease intensity and defoliation during Kharif, 2013*

Correlation between major weather parameters, late leaf spot disease intensity and defoliation was worked out and the results (Tables 4 and 5) revealed that in all the groundnut cultivars, Cv. JL24, LGN-1, TAG-24 and TG-26, the disease intensity and defoliation were found to be influenced mostly by the temperature, relative humidity, rainfall, rainy days and wind velocity.

Of the weather parameters, maximum temperature was observed to be non-significant and negatively correlated with the disease intensity in JL-24 (-0.042) and TAG-24 (-0.031), but it was significant and negatively correlated in LGN-1 (-0.050) and TG-26 (-0.060), at 5 per cent levels of significance. Maximum temperature was recorded to be non-significant and negatively correlated

TABLE 5

Correlation coefficient between defoliation and weather parameters

Weather parameters	Mean defoliation (%)								Av defoliation (%)			
	Kharif, 2012				*Kharif*, 2013							
	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26	JL-24	LGN-1	TAG-24	TG-26
Temp (Min)	0.304	0.293	0.228	0.187	0.398	0.366	0.408	0.375	0.351	0.3295	0.318	0.281
Temp (Max)	-0.363	-0.316	-0.390	-0.433	-0.043	-0.050	-0.030	-0.060	-0.203	-0.183	-0.21	-0.2465
RH (Mor)	0.621	0.568	0.628	0.637	0.285	0.306	0.255	0.271	0.453	0.437	0.4415	0.454
RH (Eve)	0.414	0.385	0.325	0.318	0.164	0.131	0.174	0.139	0.289	0.258	0.2495	0.2285
Rainfall	0.627	0.580	0.572	0.564	0.732	0.749	0.706	0.700	0.6795	0.6645	0.639	0.632
Rainy days	0.420	0.366	0.373	0.378	0.513	0.528	0.491	0.503	0.4665	0.447	0.432	0.4405
Wind velo	-0.608	-0.589	-0.655	-0.692	-0.484	-0.467	-0.495	-0.474	-0.546	-0.528	-0.575	-0.583

Av : Average, Min = Minimum, Max = Maximum, Mor = Morning, Eve = Evening, Velo = Velocity

with the defoliation in JL-24 (-0.043) and TAG-24 (-0.030), but it was significant and negatively correlated in LGN-1 (-0.050) and TG-26 (-0.060), at 5 per cent levels of significance. A significant and positive correlation was obtained between minimum temperature with the disease intensity and defoliation in all four groundnut cultivars.

Relative humidity (mor. and eve.) also played a major role in late leaf spot disease. Morning RH exerted a significant and positive correlation with the disease intensity in all four groundnut cultivars JL-24 (0.285), TAG-24 (0.256), LGN-1(0.307) and TG-26 (0.272) at 1 and 5 per cent levels of significance, respectively. Similarly, evening RH was found to be significant and positively correlated with the disease intensity in all four groundnut cultivars JL-24 (0.164), TAG-24 (0.173), LGN-1(0.130) and TG-26 (0.139) at 1 and 5 per cent levels of significance, respectively. Morning RH was found to be significant and positively correlated with the defoliation in all four groundnut cultivars JL-24 (0.285), TAG-24 (0.255), LGN-1(0.306) and TG-26 (0.271) at 1 and 5 per cent levels of significance, respectively. Also, evening relative humidity was observed to be significant and positively correlated with the disease intensity in all four groundnut cultivars JL-24 (0.164), TAG-24 (0.173), LGN-1(0.130) and TG-26 (0.139) at 1 and 5 per cent levels of significance. The trend for evening RH was similar as in the case of morning RH where a significant and positive correlation was recorded with the defoliation in all four groundnut cultivars JL-24 (0.164), TAG-24 (0.174), LGN-1(0.131) and TG-26 (0.139) at 1 and 5 per cent levels of significance.

Total rainfall and rainy days also influenced the late leaf spot disease. In JL-24, total rainfall: 0.732, rainy days: 0.513 and TAG-24, total rainfall: 0.707, rainy days: 0.491 were significant and positively correlated with the disease intensity at 5% levels of significance. Whereas, in LGN-1, total rainfall: 0.749, rainy days: 0.528 and TG-26 it was 0.708 and 0.504 which were found significant and positively correlated with the disease intensity. In JL-24 and TAG-24, total rainfall (0.732), rainy days (0.513) and total rainfall (0.706), rainy days (0.491) were significant and positively correlated with the defoliation at 5% levels of significance. Whereas, in LGN-1 and TG-26, total rainfall and rainy days were 0.749, 0.528 and 0.700 and 0.503 respectively which were found significant and positively correlated with the disease intensity.

Average epidemiological parameters (Table 1) observed during the period of 33rd to 38th MW, the weather parameters prevailed were: temperature (maximum) in the range of 29.8 to 31.65 °C (Av. 30.92 °C), temperature (minimum) in the range of 21.9 to 23.0 °C (Av. 22.31 °C), relative humidity (mor) in the range of 86.50 to 91.50 per cent (Av. 89.67%), relative humidity (eve.) in the range of 61.50 to 67.50 per cent (Av. 64.25 %), total rainfall in the range of 20.3 to 106.25 mm (Av. 50.33 mm), well distributed rainy days in the range of 1.5 to 4 days (Av. 2.67 days) and wind velocity in the range of 3.35 to 5.7 km/hr (Av. 4.24 km/hr.).

Cv. JL-24 and TAG-24 (susceptible) exerted comparatively maximum average disease intensity to the tune of 21.96 (33rd MW) to 46.37 (38th MW) and 18.62 (33rd MW) to 39.01 (38th MW) per cent, respectively with an overall maximum average disease intensity of 33.97 and 29.06 per cent, respectively (Table 2). Whereas, groundnut Cv. LGN-1 and TG-26 exhibited comparatively minimum average disease intensity in the range of 14.90

(33rd MW) to 34.92 (38th MW) and 17.20 (33rd MW) to 37.74 (38th MW) per cent, respectively and with an overall minimum average disease intensity 24.32 and 27.83 per cent, respectively.

Groundnut Cv. JL-24 and TAG-24 (susceptible) showed comparatively maximum average defoliation in the range of 6.65 (33rd MW) to 14.05 (38th MW) and 5.64 (33rd MW) to 11.82 (38th MW) per cent, respectively with an overall maximum average defoliation of 10.29 and 8.80 per cent, respectively (Table 3). Whereas, groundnut Cv. LGN-1 and TG-26 recorded a comparatively minimum average defoliation in the range of 4.51 (33rd MW) to 10.58 (38th MW) and 5.21 (33rd MW) to 11.43 (38th MW) per cent, respectively and with an overall minimum average defoliation 7.37 and 8.43 per cent, respectively.

Of the weather parameters, maximum temperature was observed to be non-significant and negatively correlated with the disease intensity in JL-24 (-0.202) and TAG-24 (-0.2095), but it was significant and negatively correlated in LGN-1 (-0.1815) and TG-26 (-0.2455), at 5 per cent level of significance (Table 4). Maximum temperature was recorded to be non-significant and negatively correlated with the defoliation in JL-24 (-0.203) and TAG-24 (-0.21), but it was significant and negatively correlated in LGN-1 (-0.183) and TG-26 (-0.2465), at 5 per cent level of significance (Table 5). Minimum temperature was found significant and positively correlated with the disease intensity and defoliation in all four groundnut cultivars.

Relative humidity (mor and eve) played a key role in late leaf spot disease. Morning RH exerted significant and positive correlation with the disease intensity in all four groundnut cultivars, JL-24 (0.4415), TAG-24 (0.4375), LGN-1(0.428) and TG-26 (0.4525) at 1 and 5 per cent level of significance, respectively. Similarly, evening RH was found to be significant and positively correlated with the disease intensity in all four groundnut cultivars JL-24 (0.2635), TAG-24 (0.2295), LGN-1(0.2385) and TG-26 (0.2115) at 1 and 5 per cent level of significance, respectively. A significant and positive correlation was found between morning RH with the defoliation in all four groundnut cultivars JL-24 (0.453), TAG-24 (0.4415), LGN-1(0.437) and TG-26 (0.454) at 1 and 5 per cent level of significance, respectively. In the case of evening RH, it was found to be significant and positively correlated with the disease intensity in all four groundnut cultivars JL-24 (0.289), TAG-24 (0.2495), LGN-1(0.258) and TG-26 (0.2285) at 1 and 5 per cent level of significance, respectively.

Total rainfall and rainy days also influenced the late leaf spot disease. In JL-24, total rainfall (0.865), rainy days (0.443) and in TAG-24 total rainfall (0.6525), rainy days (0.417) were significant and positively correlated with the disease intensity at 5 % level of significance. Similarly, in LGN-1 and TG-26, total rainfall (0.6735), rainy days (0.4265) and total rainfall (0.652), rainy days (0.4295) were found to be significant and positively correlated with the disease intensity. In JL-24 and TAG-24, total rainfall (0.6795), rainy days (0.4665), and total rainfall (0.639), rainy days (0.432), were significant and positively correlated with the defoliation at 5% level of significance. Whereas, in LGN-1 and TG-26, total rainfall (0.6645), rainy days (0.447) and total rainfall (0.632), rainy days (0.4405) were found significant and positively correlated with the defoliation. In JL-24 and TAG-24, total rainfall, rainy days and total rainfall, rainy days were significant and positively correlated with the defoliation at 5% level of significance. Whereas, in LGN-1 and TG-26, total rainfall, rainy days and total rainfall, rainy days were found significant and positively correlated with the disease intensity. However, in JL-24, TAG-24, LGN-1 and TG-26 wind velocity (-0.567), (-0.59), (-0.5455), (-0.598) were significant and negatively correlated with the disease intensity at 5 % level of significance. Cultivars JL-24, TAG-24, LGN-1 and TG-26 wind velocity (-0.546), (-0.575), (-0.528), (-0.583) were significant and negatively correlated with the defoliation at 5% level of significance. These observations were in accordance with the findings of Sachidanadhan and Muthusamy (1992).

The results obtained in respect of the influence of weather parameters on the intensity and defoliation was non-significant. But positive and significant correlations between the intensity of late leaf spot and weather parameters *viz*., temperature, relative humidity (>90%), adequate rainfall and leaf wetness duration were reported earlier by several workers (Hazarika *et al*., 2000; Dubey, 2005; Sood and Dohrao, 2005; Klareskog *et al*., 2006; Ijaz *et al*., 2011). Butler *et al*. (1994) reported that production of conidia by *P. personata* was maximum at high RH (94%) coupled with intermittent leaf wetness; inhibited with high light intensity and enhanced by continuous darkness and temperature of 10-28 °C. Smith *et al*. (1995) reported that high RH (>90%) and low temperature (20 °C) favored the development of late leaf spot of groundnut.

Day temperatures of 24 °C to 35 °C and night temperatures of 20 °C to 32 °C, RH ≥95% influenced significantly the number of lesions, infectious frequency and lesions diameter and were inversely proportional to the temperature (Venkataraman and Kazi, 1979; Shew *et al.*, 1988; March *et al*., 1993; Alderman and Nutter, 1994; Wadia and Butler, 1994; Waliyar *et al*., 1994; Pande *et al*., 2004).

4. Conclusions

Accurate spatio-temporal weather information is crucial for monitoring the progression of favourable conditions and determining the potential threat of the disease. In field conditions, rainfall is the main source of humidity that makes leaves wet. Generally, during the growth period of groundnut, temperature is favourable for host as well as for pathogen. Infection favors at temperature of 22-30^{0}C, relative humidity 89%, adequate rainfall and leaf wetness. The congenial epidemiological determinants prevailing during the cropping period resulted in severe defoliation. The disease intensity increased with the age of crop and reached peak at the time of harvesting. The above results indicated that weather has a pivotal role in disease development. By knowing the relation between the weather parameters and disease development, forecasting models can be developed that will go long way in effective management strategies of the foliar disease.

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