Original Research Article

Elucidating late leaf spot Disease Progression and Resistance Components in Different Groundnut (*Arachis hypogaea* L.) Cultivars towards *Phaeoisariopsis personata*

ABSTRACT

Late Leaf Spot (LLS) disease is caused by *Phaeoisariopsis personata*, a devastating disease that significantly affects groundnut (*Arachis hypogaea* L.) production worldwide. This research aimed to investigate the disease progress in resistant and susceptible groundnut genotypes under green house conditions with artificial inoculations. The four popularly growing groundnut cultivars in Andhra Pradesh *i.e.,* Kadiri-6 (K6), Dharani, Harithandra and Lepakshi (K-1812) were evaluated in this study. The disease severity scale, percent disease index (PDI), Area under disease progression curve (AUDPC) and the epidemic rate (rate) were estimated by using the linear model. Highest disease severity was observed in K6 (88.19 %) and Dharani (85.19 %) with greater disease progression rate was highest for K6 (0.13) and Dharani (0.12) cultivars. However, the lowest disease progression was observed in Lepakshi (0.04) and Harithandhra (0.08) cultivars. Enhanced resistance to LLS was reported with Harithandhra and Lepakshi cultivars due to slower epidemic rate, longer incubation and latent periods with smaller lesions.

Keywords: Late leaf spot, groundnut, epidemiology, disease progression, AUDPC, epidemic rate (r)

1. INTRODUCTION

Late Leaf Spot (LLS), caused by *Phaeoisariopsis personata* (Berk. & M. A. Curtis) Deighton, (teleomorph: *Mycosphaerella berkeleyi* Jenk.), is a serious foliar disease affecting groundnut crops globally (Shokes and Culbreath, 1997). The secondary spread of the disease is due to enormous production on conidia on the abaxial surface of the leaves. The conidia of *P. personata* were 3-4 septate, olivaceous brown, cylindrical and 43.2 x 5.6 µm in size (McDonald *et al*. 1985). LLS disease is still predominant in groundnut cultivated areas of Andhra Pradesh and also increased its prevalence throughout India.

Host resistance is considered the most effective and sustainable approach to manage this disease. It is critical to evaluate the resistance against LLS disease. Variation exists for nearly all resistance components investigated for late leaf spot includes, infection frequency, incubation period (time from inoculation to symptom appearance), latent period (time from inoculation to first sporulating lesion), lesion size, percent necrotic leaf area, percent lesions with sporulation, spore production, and time to defoliation. Infection frequency is highly dependent upon temperature and relative humidity (Shew *et al.,* 1989; Waliyar *et al.,* 1995). While latent period, lesion size and spore production have been the components most commonly associated with genetic resistance (Chiyembekeza *et al.,* 1993; Walls *et al.,* 1985).

The cultivar Kadiri-6 (K6) and Dharani are currently the predominant cultivars grown in Southern part of India. Recently a new groundnut cultivar *i.e.,* Lepakshi (K-1812) released from ARS Kadiri, which gained a significant response for its better yielding and disease resistance capabilities. The disease progress in resistant and susceptible groundnut genotypes under controlled conditions with artificial inoculation can provide critical information for disease management strategies (Tshilenge-L *et. al.,* 2012). This study aims to compare the disease progression response of various groundnut cultivars to LLS and identify the factors influencing disease development.

2. MATERIAL AND METHODS

2. 1. Plant Material Selection:

Four popularly grown groundnut cultivars were selected for the study. These genotypes were known for their contrasting responses to LLS based on previous studies and preliminary screenings.

2.2. Preparation of *Phaeoisariopsis personata* Inoculum:

Conidia of *P. personata* collected from infected leaves were suspended in sterile distilled water containing a few drops (0.01 %) of Tween 20 (polyoxyeythlene sorbitan minolaurate). The concentration of conidia was measured under light microscope using a haemocytometer and adjusted to desired level of 40,000 conidia/ml using sterilized distilled water (Subrahmanyam and McDonald *et. al*., 1982).

2.3. Artificial Inoculation:

Healthy, uniform groundnut plants at the early vegetative growth stage were chosen for the experiment. The prepared conidial suspensions of *P. personata* was sprayed by using hand atomizer on 35 days old green house plants evenly on the leaves and covered with polythene bags. Healthy, uninoculated plants were maintained for comparision.

2.4. Controlled Conditions:

The experiment was conducted in a glass house chamber, maintaining a temperature of 25°C ± 2°C, and relative humidity of 80% ± 5% by covering the pots with polythene covers. Adequate measures were taken to prevent cross-contamination between cultivars.

2.5. Disease Assessment:

Disease symptoms were monitored daily after inoculation till its first visible symptoms appeared i.e., the incubation period, was observed and recorded for each cultivar. Disease severity was assessed on a 1-9 scale of Subramanyam *et al*., 1995. However the scale was modified by subtracting -1 as a common factor for all the numerical scale values in order to obtain 0 % PDI for no disease instead and PDI values were calculated based on the following formula. **(Table 1)**

$$PDI = \frac{[x1\,(1-1) + x2\,(2-1) + \ldots + x9\,(9-1)]}{N \times (9-1)} \times 100$$

Where, x is number of samples in each score and N is the total samples scored

2.6 Statistical Analysis:

Effects of cultivars on resistance variables and transformations of variables were tested using the IBM SPSS software linear model. One factor analysis of completely randomized design was done and the figures were plotted in Microsoft Excel using the analyses tables. Due to unbalanced data, whenever the standard errors were reasonably similar, the greater standard error was used for means comparisons.

3. RESULTS AND DISCUSSION

3.1 Symptomatology of Late leaf spot:

Disease appeared as small dark brown lesions with very light yellow halo on adaxial surface whereas on the abaxial surface of the leaves, the spots were deep black in colour with clusters of conidiophores bearing conidia, arranged in concentric manner without a definite chlorotic halo. Leaf spots were recorded on stipules, petioles and stems at later stage of plant growth. Severely diseased leaves dried up and resulted in heavy defoliation. The symptoms produced by LLS infection on groundnut in the present investigation were in agreement with LLS symptoms described by Woodroof (1933) and Jenkins (1938); Mehrotra and Agarwal (2003).

3.2 Incubation Period:

The incubation periods varied significantly among the groundnut cultivars. Resistant cultivars Lepakshi and Harithandhra exhibited longer incubation periods *i.e.,* 10 and 08 days respectively after inoculation compared to susceptible ones *i.e.,* 4 DAI for both k6 and Dharani cultivars, indicating slower disease development.

3.3 The Per cent Disease Index (PDI):

Four groundnut cultivars *viz.,* K6, Dharani, Harithandhra and Lepakshi were screened (against *Phaeoisariopsis personata* under green house conditions. The data on late leaf spot index in different groundnut cultivars were presented in Table 2 and Figure 1. These results revealed that the late leaf spot terminal PDI in cultivar Lepakshi was 29.65 per cent followed by cultivar Harithandhra (33.33 %). Severe LLS incidence was observed in case of cultivar, K6 (88.89 %) followed by Dharani 85.19 per cent **(Table 2 & Figure 1).**

Disease symptoms in susceptible cultivars (K6 and Dharani) developed rapidly and spread extensively across the leaves. In contrast, resistant cultivars (Harithandhra & Lepakshi) showed limited lesion development and slower disease progression

3.4 Area Under Disease Progress Curve:

The AUDPC values were calculated for LLS per cent disease severity recorded at seven days interval for four cultivars and the results are furnished in the Table 3. by following (Wilcoxson *et al.,* 1975). These results revealed that the Lepakshi cultivar showed lowest AUDPC (557.38) value with less disease severity followed by Harithandhra (570.36). Whereas K6 cultivar recorded the highest AUDPC value (1762.95) with high disease severity followed by Dharani (1477.78). The results stated that the severity of leaf spot shows decreasing trend with Lepakshi and FDR cultivars. **(Table 3 & Figure 2)**

3.5 The epidemic rate (r):

The epidemic rate (r) unit's day^{-1} showed a decreased trend. The highest recorded epidemic rate was in cultivar K6 (0.13) followed by Dharani (0.12) and the disease progression was very fast compared to the resistant cultivars Lepakshi (0.04) and Harithandra (0.08). **(Table 3 & Figure 3).**

3.6 Discussion:

The results of this study provide valuable insights into the symptomatology, incubation period, disease severity, and progression of late leaf spot (LLS). The results of this study demonstrate that groundnut genotypes exhibit varying responses to LLS under controlled conditions with artificial conidial infections. The incubation period, an important indicator of disease dynamics, exhibited significant variability among different groundnut cultivars. The extended incubation period in resistant cultivars indicates slower disease development, which could be attributed to the effectiveness of their defense mechanisms against the pathogen (E.G. Cantonwine , A.K. Culbreath, *et. al.,* 2008).

Disease severity assessments revealed substantial differences among the four groundnut cultivars studied. These results corroborate the susceptibility, evidenced by their rapid lesion development and extensive spread across leaves. On the other hand, the resistant cultivars, displayed limited lesion development and slower disease progression, validating their resistance mechanisms against LLS (Shew *et al.,* 1989; Waliyar *et al.,* 1995). The calculation of the AUDPC provides a quantitative measure of disease progression over time. In this study, Lepakshi and Harithandra cultivars exhibited lower AUDPC values, indicating less disease severity and slower progression. Additionally, the epidemic rate (r) further elucidates disease dynamics. The susceptible cultivars, displayed higher epidemic rates, indicative of rapid disease spread. In contrast, the resistant cultivars, exhibited lower epidemic rates, suggesting a slower rate of disease propagation (Aquino *et al.,* 1995).

These observations highlights the complexity of host-pathogen interactions in LLS and reinforces the significance of resistant cultivars in managing LLS outbreaks.

Table1. Modified Disease Rating Scale for Late Leaf Spot Disease (Subrahmanyam *et. al*., 1995)

Disease score	Description	Disease severity (%)
1	No disease	0
2	Lesions present largely on lower leaves; no defoliation	1-5
3	Lesions present largely on lower leaves ,very few on middle leaves, defoliation of some leaflets evident on lower leaves	6-10
4	Lesions on lower and middle leaves but severe on lower leaves; defoliation of some leaflets evident on lower leaves	11-20
5	Lesions present on all lower and middle leaves; over 50% defoliation of lower leaves	21-30
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	31-40
7	Lesions on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves	41-60
8	Defoliation of all lower and middle leaves; severe lesions on top leaves; some defoliation of top leaves evident	61-80
9	Almost all leaves defoliated, leaving bare stems; some leaflets may remain, but show severe leaf spots	81-100

Table 2. The Per cent Disease Index (PDI) for late leaf spot of groundnut in four cultivars under green house conditions

Weeks after inoculation	Days After Inoculation (DAI)	Percent Disease Index (PDI %)* in different cultivars			
		K6	Dharani	Harithandhra	Lepakshi
1	7 DAI	7.41 (15.789)**	3.70 (11.09)	0.00 (0.0)	0.00 (0.0)
2	14 DAI	18.52 (25.48)	14.81 (22.62)	3.7 (11.085)	3.7 (11.085)
3	21 DAI	44.44 (41.79)	25.93 (30.596)	11.11 (19.46)	11.11 (19.46)
4	28 DAI	62.96 (52.49)	55.56 (48.172)	22.22 (28.11)	18.52 (25.48)
5	35 DAI	77.78 (61.86)	70.37 (57.00)	25.93 (30.60)	23.33 (25.25)
6	42 DAI	88.89 (70.54)	85.19 (67.35)	33.33 (37.47)	29.65 (32.96)
	C.D.	2.549	2.239	0.89	0.872
	SE(m)	0.818	0.719	0.286	0.28
	SE(d)	1.157	1.016	0.404	0.396
	C.V.	2.834	2.923	2.969	3.021

*Means of three replications

** Values in parenthesis are angular transformed values

Table 3. Terminal PDI, AUDPC values and Epidemic rate of late leaf spot of groundnut in different cultivars under green house conditions

S. No.	Cultivars	Terminal disease severity of late leaf spot (PDI %)*	AUDPC ($Units^2$)	Epidemic Rate (r) ($Units\ day^{-1}$)
1	K6	88.89	1762.95	0.13
2	Dharani	85.19	1477.78	0.12
3	Harithandhra	33.33	557.38	0.08
4	Lepakshi	29.65	233.05	0.04

*Means of three replications

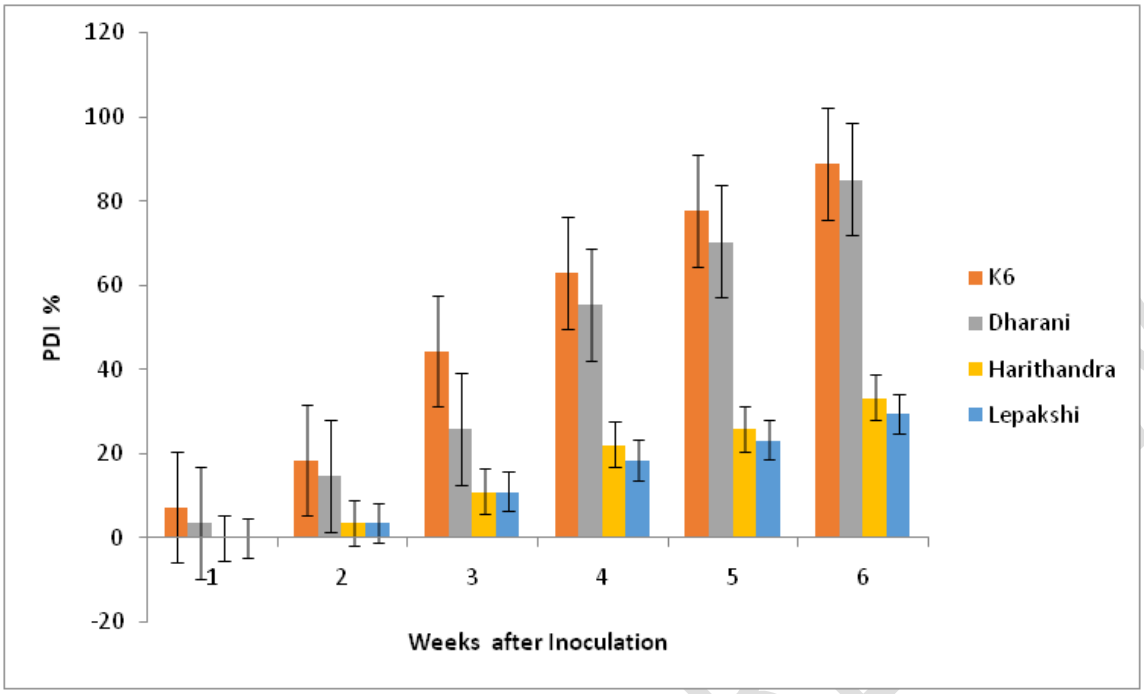

Figure 1. The per cent disease index (PDI) for late leaf spot of groundnut in four groundnut cultivars under green house conditions

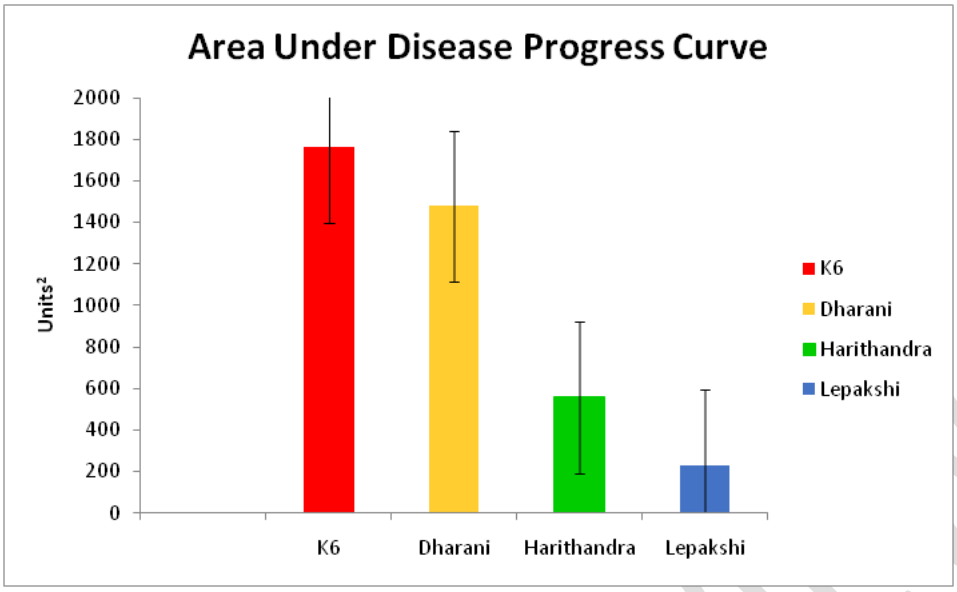

Figure 2. AUDPC values of late leaf spot of groundnut in different groundnut cultivars under green house conditions

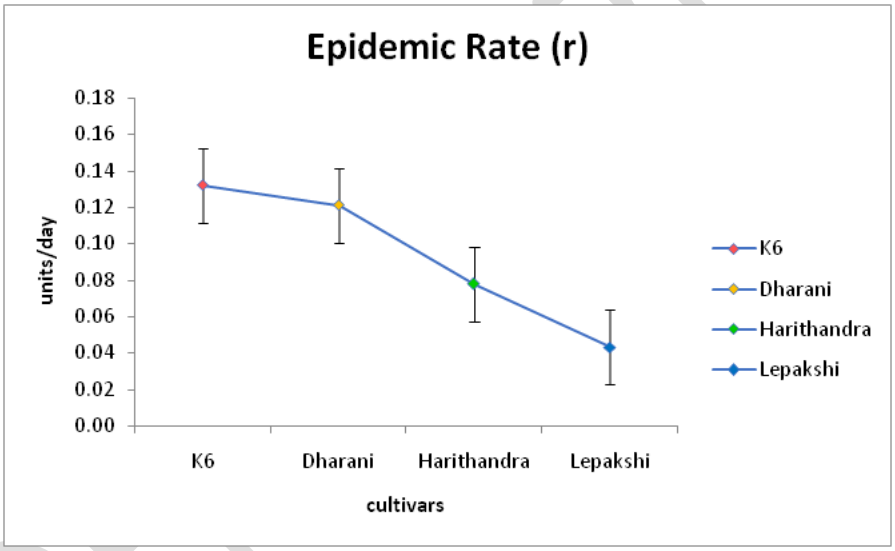

Figure 3. Epidemic rate (r) of late leaf spot of groundnut in different groundnut cultivars under green house conditions

4. CONCLUSION

In conclusion, this research provides valuable insights into variation in Disease Development. The groundnut varieties exhibited varying levels of disease development in response to LLS infection. Some varieties showed early and extensive disease symptoms, while others displayed delayed or limited lesion development. Resistant varieties as indicated by slower disease progression and lower disease severity. These varieties showed potential for further evaluation as potential sources of resistance in breeding programs. On the other hand, susceptible varieties exhibited rapid and widespread disease development, with higher disease severity scores, making them susceptible to LLS infection.

REFERENCES

1. Aquino, V.M., F.M. Shokes, D.W. Gorbet, and F.W. Nutter Jr. 1995. Late leaf spot progression on peanut as affected by components of partial resistance. *Plant Disease.* 79:74-78.

2. Chiyembekeza, A.J., D.A. Knauft, and D.W. Gorbet. 1993. Comparison of components of resistance in peanut to late leaf spot in different environments. *Crop Science*. 33:994-997.

3. E.G. Cantonwine, A.K. Culbreath, C.C. Holbrook and D.W. Gorbet (2008). Disease Progress of Early Leaf Spot and Components of Resistance to *Cercospora arachidicola* and *Cercosporidium personatum* in Runner-Type Peanut Cultivars. *Peanut Science*. 35(1). 1-10.

4. Gaur, P. M., Pande, S., Sharma, H. C., Rao, B. V., & Rao, J. N. (1998). Inheritance of resistance to late leaf spot and rust in groundnut. *Annals of Applied Biology,* 133(3), 429-437.

5. Janila, P., Nigam, S. N., Abhishek, R., Anil Kumar, V., Manohar, S. S., Venuprasad, R., & Varshney, R. K. (2018). Groundnut improvement: use of genetic and genomic tools. *Frontiers in Plant Science*. 9, 998.

6. Jenkins, A. E. (1938). *Diseases of cultivated plants and trees in India*. Pioneers.

7. Mehrotra, R. S., & Agarwal, H. P. (2003). *A textbook of plant pathology*. Tata McGraw-Hill Education.

8. Nigam, S. N., & McDonald, D. (1996). Breeding for resistance to rust and late leaf spot in groundnut. *Groundnut rust and late leaf spot: Proceedings of the Workshop*, 14-15 Oct 1996, ICRISAT Asia Center, Patancheru, India. 52-61.

9. Pande, S., Rao, J. N., & Sharma, M. (2006). Factors contributing to variability in host resistance to late leaf spot and rust diseases of groundnut (*Arachis hypogaea* L.). *European Journal of Plant Pathology*. 114(1), 77-85.

10. Reddy, P. M., & McDonald, D. (2001). Factors contributing to late leaf spot epidemics in groundnut during the post-rainy season in Andhra Pradesh, India. *Journal of Phytopathology.* 149(1), 27-34.

11. Shanmugasundaram, S., & Palaniswami, M. S. (1996). Epidemiology of groundnut rust and late leaf spot in relation to environment. *Tropical Agricultural Research*. 8, 301-310.

12. Sharma, M., Ghosh, R., Telangre, R., Pande, S., & Rao, M. S. (2012). Studies on inheritance of resistance to foliar diseases in groundnut (*Arachis hypogaea* L.). Field Crops Research, 134, 184-189.

13. Sharma, M., Pande, S., & Rao, J. N. (2003). Effect of temperature and leaf wetness duration on infection of groundnut by conidia of *Mycosphaerella berkeleyi*, the causal agent of late leaf spot. *Annals of Applied Biology*. 142(2), 177-183.

14. Shew, B.B., T. Sommartya, and M.K. Beute. 1989. Components of partial resistance in peanut genotypes to isolates of *Cercosporidium personatum* from the United States and Thailand. *Phytopathology*. 79:136-142.

15. Shokes, F.M. and A.K. Culbreath. 1997. Early and late leaf spots, pp. 17-20. In N. Kokalis-Burelle, D.M. Porter, R. RodriguezKabana, D.H. Smith, and P. Subrahmanyam (eds.). *Compendium of Peanut Diseases*, 2nd Ed. APS Press.

16. Subrahmanyam, P., McDonald, D., Gibbons, R. W., Nigam S. N. and Nevill, D.L. 1982. "Resistance to Rust and Late Leaf Spot Diseases in Some Genotypes of *Arachis Hypogaea*," *Peanut Science*. 9(1). 6-10. Subrahmanyam, P., & McDonald, D. (1984). A critical analysis of the techniques for screening groundnut for resistance to rust and late leaf spot. *Peanut Science*. 11(2), 74-78.

17. Tshilenge-Lukanda, Nkongolo, K. K. C., A. Kalonji-Mbuyi, Kizungu, R. V. 2012. Epidemiology of the Groundnut (*Arachis hypogaea* L.) Leaf Spot Disease: Genetic Analysis and Developmental Cycles. *American Journal of Plant Sciences*. 3(5). 582-588.

18. Walls, S.B., J.C. Wynne, and M.K. Beute. 1985. Resistance to late leaf spot of peanut of progenies selected for resistance to early leaf spot. *Peanut Science*. 12:22-27.

19. Waliyar, F., B.B. Shew, R. Sidahmed, and M.K. Beute. 1995. Effects of host resistance on germination of *Cercospora arachidicola* on peanut leaf surfaces. *Peanut Science.* 22:154-157.

20. Wilcoxson, R.D., Skovamand, B and Atif, A.H. 1975. Evaluation of wheat cultivars for ability to retard development of stem rust. *Annuals of Applied Biology.* 80: 275-281.

21. Woodroof, J. G. (1933). Leaf Spots of Peanut. *Journal of Agricultural Research*, 46(2), 139-163.