Research Article

Relationship between Components of Resistance to Late Leaf Spot in Groundnut Botanical Genotypes

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Abstract | Late leaf spot (LLS) is the most destructive, widespread, and consistent in occurrence disease of groundnut worldwide. LLS is the imperative factor while developing resistance varieties along with agronomic characteristics. In total, 153 groundnut botanically different genotypes namely Virginia, Spanish, and Valencia were screened under filed conditions and detached leaf assay against LLS pathogen. Most of genotypes during three years of study at early assessments under field conditions showed resistant response whereas, at late assessments most of genotypes were susceptible. In pathogen-host relationship several components of partial resistance have been proposed. Under detached leaf assay Virginia type groundnut showed minimum spots per leaf, sporulation, and product of spots per leaf and sporulation, spots per leaf and percent area diseased per leaf and spots per leaf and defoliation indices. Correlation between defoliation and spots per leaf are negative in Virginia (-0.12 to 0.22) and Spanish (-0.39 to 0.01), whereas positive in Valencia (0.17 to 0.78) were calculated. While positive correlation between multiple of spots per leaf and sporulation were computed.

Received | September 26, 2018; **Accepted** | April 20, 2019; **Published** | May 02, 2019
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Citation | Ijaz, M., S.R.A. Shah, M.I. Haq and A. Afzal. 2019. Relationship between components of resistance to late leaf spot in groundnut botanical genotypes. *Pakistan Journal of Agricultural Research,* 32(2): 390-397.
DOI | http://dx.doi.org/10.17582/journal.pjar/2019/32.2.390.397
Keywords | Defoliation, Leaf spot reaction indices, Pathogen-host relationship, Rainfed, Sporulation

Introduction

Groundnut (*Arachis hypogaea* L.) is an important monoecious legume in the world mainly grown for oil seed, food and animal feed (Upadhyaya et al., 2006). Among fungal foliar diseases, late leaf spot caused by *Cercosporidium personatum* (Berk. and Curt.), is very important diseases on groundnut causing quality and yield losses. (Pretorius, 2006). The LLS pathogen causes severe defoliation and ultimately affects yields. The disease development is optimal at 20°C and high relative humidity lasting for more than 12 hours per day. (Kokalis-Burelle et al., 1997). Lesions are roughly circular, darker brown without a definite chlorotic halo. On the adaxial side of the leaflets, lesions are almost black. LLS usually occur later in the season and is often seen as a complex with other leaf spots. Most of the late leaf spot spores are formed on the lower surface giving it a rough and tufted appearance, whereas upper leaf surface is generally smooth. Leaf spot can cause yield losses up to 50% worldwide (Tshilenge et al., 2012)

Arachis hypogaea ssp. *Hypogaea*, the Virginia and the Peru Types for instance, have a low growth habit (runner type) with growth period of four to five months or more and seeds exhibiting marked dormancy. Whereas, *A. hypogaea* ssp. *Fastigiata*, for example the

Valencia and Spanish types, has an upright-growth habit (bunch type) with a growth period of three to four months and seeds without dormancy. Seeds of running types are usually used for direct consumption and confectionary purposes, whereas those of the Valencia and Spanish types are generally grown for oil extraction. (De Waele and Swanevelder, 2001).

Pixley et al. (1990) compared LLS epidemic rates and leaf area dynamics on the susceptible cv Florunner and three other partially resistant lines. Percent necrotic area in three leaf canopy layers (estimated by using a modified Horsfall-Barratt diagram), defoliation of the main stem (determined by counting missing leaflets) and leaf area index were recorded at seven to 10 day intervals. The leaf area index (LAI) was calculated as: LAI = specific leaf area x fraction leaf x biomass. This technique assumes that specific leaf area and the ratio of leaf weight to total aboveground plant weight (fraction leaf) are similar for neighboring plants of the same age and genotype. The specific leaf area is the ratio of leaf area to leaf mass. Leaf spot induced defoliation of Florunner progressed more rapidly on the other three partially resistant lines. Maintenance of higher LAI by the partially resistant lines was associated with sustained leaf production until maturity.

Objective of improvements in varieties of groundnut have included resistance to diseases especially leaf spot and other agronomic desirable characteristics. In last 60 years of groundnut production in Pakistan about 12 lines have been released for commercial cultivation. The groundnut varieties like B-4, Accession No. 45 and Accession No. 334 released before 1980 were developed under irrigated ecological conditions. These varieties were released for cultivation in all over the Pakistan but their responses to diseases had not been studied (Hussain and Ahmed, 1984). Later on variety BARI-11 (Naeem et al., 2012), was developed at Barani Agricultural Research Institute Chakwal which is drought tolerant, has more shelling percentage and has resistance against leaf spot and root rot diseases.

The aim of present study was to evaluate groundnut germplasm to sort out sources of resistance against LLS disease under field and lab conditions in semiarid tropics of Pakistan.

Materials and Methods

Screening under field conditions

In total, 153 groundnut genotypes were collected from different sources to investigate the sources of multivariate resistance against LLS under field conditions and detached leaf assay (Table 7). Among these 103 genotypes are Virginia, 45-Spanish and 5- Valencia botanical type. The experiment primarily was laid out in completely randomized design. All the genotypes were sown in plots of size measuring 1m × 0.3m (single row of 1m length) across the fertility and slop gradient. The sowing was done in already infested fields (Coffelt and Porter, 1986) and additionally LLS diseased leaves were collected at harvesting of previous year's crop and kept under room conditions in craft paper bags were added in soil at time of sowing (Kishor et al., 2005). LLS naturally infected leaves were collected from farmer fields and LLS spots were excised and kept under a moist chamber lined with aluminum foil for 48 hours. These sporulated excised spots were blended in Molinex to obtain spore suspension for artificial inoculation. LLS conidial suspension (2×10^4 mL^{-1}) was maintained under heamocytometer and sprayed inoculum on onset of summer rainfall.

Severity of LLS on groundnut entries was evaluated from 115 to 120 days after sowing, at 50% flowering and pod development stages according to 0-9 disease severity scale described by (Mayee and Datar, 1986) as under: where 0: No symptoms (Immune); 1: Few small necrotic spots covering 1% Or less of leaf area (Highly resistant). 3: Few small necrotic spots covering 1-5%of leaf area (Resistant). 5: Spots coalescing enlarging 6-20% of leaf area (Moderately susceptible). 7: Spots enlarging, coalescing to cover 21-50% of the compound leaf area (Susceptible) 9: Spots enlarging, coalescing to cover 51% or more of the leaf area (Highly susceptible).

Assessment of spots per leaf (SL) and defoliation (Def)

Severity of leaf spot on groundnut entries was evaluated. Numbers of spots per leaf (SL) were counted. Defoliation (Def) was assessed on 1 to 10 scale where 1 is no defoliation and 10 is 100% leaves defoliated. Degree of sporulation (S) was determined on ten leaflets with infected leaves collected from 3rd and 4th node of randomly selected 5 plants from each plot. Collected leaf lets were washed with tap water and swabbed with cotton thereafter incubated

Table 1: *Response of botanical genotype groundnut genotypes to LLS under field conditions.*

Scoring cale	Genotypes Response	First year		Second year		Third year	
		Flowering stage	Pod formation	Flowering stage	Pod formation	Flowering stage	Pod formation
0	Immune						
1	Highly resistant						
3	Moderately resistant	5	1	48	1	19	2
5	Moderately susceptible	31		79	35	76	98
7	Susceptible	100	120	23	79	58	53
9	Highly susceptible	17	32	3	38		

Table 2: *ANOVA of Leaf Spot Reaction Indices of Botanical Type Groundnut.*

SoV	DF	Sum of squares										
		Def[1]	SL[2]	S[3]	DA[4]	DA*S	SL* S	SL* DA	%Inc.[5]	Def*S	Def*SL	Def*DA
Plant Type	2	5.07^{NS}	67.29**	1.66**	0.87^{NS}	51.28^{NS}	1481**	1412*	81.07^{NS}	72.78^{NS}	3203.*	6.14^{NS}
Geno-types	150	130	940	24.11	136.	2079.	20067	34365	10867.14	2520.	68125	13812
Total	152	135	1007.	25.76	137.	2131.	21548	35777.	10948.23	2593.	71329	13818
F. Cal.		2.92	5.36	5.16	0.48	1.85	5.54	3.08	0.56	2.166	3.53	0.03
Probability		0.057	0.0056	0.0068	-	0.161	0.004	0.049	-	0.12	0.032	-

1: *Def-Defoliation%;* **2:** *SL-Spots/leaf;* **3:** *S-Sporulation;* **4:** *DA- % area diseased/leaf;* **5:** *%Inc. Incidence %.*

Table 3: *Index Means of Spots per Leaf, Sporulation, % Area Diseased per Leaf, Sporulation X % Area Diseased, Spots per Leaf X Sporulation and Spots per Leaf x % Area Diseased in Botanical Type Groundnut.*

Botanical Plant type	Def.[1]	SL[2]	S[3]	DA[4]	DA*S	SL *S	SL * DA	%Inc [5]	Def*S	Def*SL	Def*DA
Virginia	8.19	8.88	3.12	4.29	13.45	28.64	38.54	18.62	25.50	72.44	35.29
SE±	0.09	0.25	0.04	0.09	0.37	1.14	1.49	0.84	0.40	2.10	0.95
Spanish	8.15	10.20	3.32	4.34	14.43	34.91	44.31	19.35	26.97	82.40	35.60
SE±	0.14	0.37	0.06	0.14	0.56	1.72	2.26	1.27	0.61	3.18	1.43
Valencia	9.20	7.67	2.92	3.90	11.65	23.36	31.57	15.20	26.90	70.87	36.19
SE±	0.42	1.12	0.18	0.43	1.67	5.17	6.77	3.81	1.83	9.53	4.29

1: *Def-Defoliation%;* **2:** *SL-Spots/leaf;* **3:** *S-Sporulation;* **4:** *DA- % area diseased/leaf;* **5:** *%Inc. Incidence %*

at ≈100% relative humidity under continuous light for 96 hours at 25±2°C (Pande and Rao, 2001). All lesions of sample were examined under stereoscope (Swift SM80HF, Made in Japan). Disease data were recorded and sporulation assessed on 0-5 scale modified from (Melouk and Banks, 1984) described in detail where, 0; No sporulation (Immune), 1: Spars sporulation, one to two stromata sporulating (Highly Resistant) 2; More than two stromata sporulating but less than half of total stromata on a spot (Resistant) 3; Sporulation moderate, half of the total stromata sporulating (Moderately susceptible) 4; Whole of the spot sporulating, (Susceptible) and 5; Heavy sporulation. Spores long, arose looking like mycelium and sometimes stromata sporulate on both sides of leaf (Highly susceptible).

In earlier studies assessments were based on sporulated stromata out of total stromata after counting of total stromata. Whereas, present studies emphasis is on number of sporulated stromata and intensity of sporulation rather on non-sporulated stromata. Data were recorded under stereoscopic microscope at 2X and 4X magnifications according to ease of counting.

Leaf spot reaction indices (LSRI)

Leaf spot reaction indices (LSRI) like multiple of sporulation and diseases area per leaf (S × DA), spots/leaf x sporulation (SL × S), spots/leaf × %area diseased (SL × DA), defoliation x sporulation (Def × S), defoliation x spots per leaf (Def × SL) were computed (Melouk and Banks, 1984).

Statistical analysis

ANOVA-1 was used for one-way comparison of means and significant variate was correlated to study their dependency on each other.

Results and Discussion

Screening of groundnut germplasm under field conditions against LLS during consecutive three years

First year: First observation on disease severity was recorded at flowering stage and none of genotypes showed diseased symptoms. Five genotypes exhibited minimum disease severity and showed moderately resistant response. Whereas, 31 genotypes were moderately susceptible, 100 were susceptible and 17 were found highly susceptible with more than 51 % diseased leaf area. Second observation was done at pod development stage, where only one genotype i.e. Chakori showed moderately susceptible response, while others 120 genotypes were susceptible and 32 genotypes showed highly susceptible response to LLS under field conditions (Table 1).

Second year: Next year disease severity observation at flowering stage exhibited different response to disease development where 48 genotypes were showed minimal disease severity exhibiting resistant response. Whereas, 79 genotypes were moderately resistant, 23 were moderately susceptible and three were found susceptible. At pod development stage, number of genotype increased in higher severity scales. There was no genotype which showed moderately resistant response to LLS except commercial cultivar Chakori, which remained resistant. However, 35 genotypes were moderately susceptible, 79 were susceptible and remaining 38 were found highly susceptible (Table 1).

Third Year: During third year, first disease observations were recorded at flowering stage. The response of 19 genotypes against LLS was moderately resistant, whereas 76 were moderately susceptible followed by 58 which showed highly susceptible response. At pod development stage, the response of number of genotypes gradually increased from susceptible to highly susceptible. It was observed that high disease scores were observed at later stages of crop growth i.e. pod development stage. Where only two genotypes showed moderately resistant response, 98 were moderately susceptible and 53 were found susceptible (Table 1). most of times at early stages of crop growth from 110 to 130 days after sowing during three years of study lesser disease scores were observed. Only few genotypes suffered maximum at their early stages of crop growth.

Leaf Spot Reaction Index (LSRI)

Non-consistent grouping of groundnut germplasm under field plot screening necessitated to study more than one variate in addition to diseased area per leaf.

One-way analysis of variance of multiple variables for LLS expression on botanical groundnut genotypes showed that spots per leaf (SL), sporulation (S), SL × S, SL × Diseased area (DA), and Defoliation (Def) × SL variables and interactions were significant to measure the disease expression (Table 2).

Valencia botanical type groundnut plants exhibited less SL values (7.67) than Spanish (10.20) and Virginia (8.88) type plants. Valencia type plants exhibited lesser mean values of S (2.92), SL × S (23.36), SL × DA (31.57) and SL × Def (70.87) than Virginia and Spanish botanical type plants (Table 3).

Table 4: *Means of Spots per Leaf (SL), Sporulation(S) and Reaction indexes of SL × S, SL × % Area Diseased (DA) and SL × Defoliation in Botanical Type Groundnut.*

Entry No.	Genotype	Botanical Type	SL	S	S/L*S	SL*DA	Def*SL
1	Chakori	Virginia	8.11	3.02	24.49	15.81	64.89
2	BANKI	Virginia	10.08	3.33	33.55	40.32	80.64
3	GOLDEN	Virginia	9.26	3.2	29.67	42.45	74.1
4	BARI2000	Virginia	10.78	3.43	37	52.15	97.02
5	PW	Virginia	9.82	3.29	32.29	47.09	88.37
6	BARI-89	Virginia	11.58	3.55	41.1	60.2	104.26
7	PG-1018	Virginia	6.97	2.82	19.68	26.08	62.74
8	PG-1051	Virginia	6.83	2.8	19.1	30.53	47.79
9	PK-900123	Virginia	11.45	3.53	40.42	49.93	57.27
10	PK-900125	Virginia	10.91	3.45	37.65	28.86	76.36
11	PK-90061	Virginia	10.3	3.36	34.6	38.52	72.07
12	PK-90064	Virginia	9.97	3.31	33.02	37.3	49.85
13	ICGS-3	Virginia	8.28	3.05	25.24	27.22	66.26
141	BC-171-C	Spanish	5.78	2.6	15.05	14.62	52.01
142	2KCG003	Spanish	5.69	2.59	14.73	18.88	45.54
143	PG-1013	Spanish	5.51	2.55	14.07	32.62	49.62
144	HUSTA-J	Spanish	10.08	3.33	33.55	49.38	80.64
145	SUDAN	Spanish	9.82	3.29	32.29	24.05	83.46
146	NO.73-27	Spanish	9.08	3.17	28.82	28.71	72.62
147	SHANG. DONG684	Spanish	10.37	3.37	34.98	42.77	86.87
148	BC-60	Spanish	9.8	3.29	32.2	60.4	88.18
149	BC-128	Valencia	8.15	3.03	24.65	31.56	81.49
150	BC-128C	Valencia	5.83	2.61	15.24	24.74	58.31
151	BC-128D	Valencia	11.91	3.59	42.78	60.72	107.17
152	BC-128F	Valencia	7.67	2.94	22.58	28.69	69.01
153	01CG009	Valencia	4.8	2.41	11.55	12.13	38.37

Table 5: *Ranking of Peanut Botanical Types on Means of SL, S or Reaction Indexes of SL × S, SL × DA and SL × Defoliation.*

S. No	BT	SL	BT	S	BT	S/L*S	BT	SL*DA	BT	Def*SL
1	[1]Vg	ICGV88475	Vg	ICGV88475	Vg	ICGV88475	Vg	ICGV88475	Vg	ICGV88475
2	Vg	ICGV89235	Vg	ICGV89235	Vg	ICGV89235	VL	01CG009	Vg	ICGV89235
3	Vg	01CG004	Vg	01CG004	Vg	01CG004	Sp	BC-171-C	Vg	PI-13
4	Vg	ICG-485	Vg	ICG485	Vg	ICG-485	Vg	2KCG005	VL	01CG009
5	[2]VL	01CG009	VL	01CG009	VL	01CG009	Vg	Chakori	Vg	BC-170-B
6	[3]Sp	PG-1013	Sp	PG-1013	Sp	PG-1013	Vg	01CG003	Vg	01CG004
7	Vg	01CG003	Vg	01CG003	Vg	01CG003	Vg	ICGV89235	Vg	ICG-485
8	Vg	96CG008	Vg	96CG008	Vg	96CG008	Vg	2KCG010	Vg	96CG008
9	Vg	2KCG005	Vg	2KCG005	Vg	2KCG005	Sp	2KCG003	Vg	2KCG005
10	Vg	ICGV88429	Vg	ICGV88429	Vg	ICGV88429	Vg	ICGV88473	Sp	2KCG003
11	Sp	2KCG003	Sp	2KCG003	Sp	2KCG003	Vg	2KCG021	Vg	2KCG010
12	Sp	BC-171-C	Sp	BC-171-C	Sp	BC-171-C	Vg	04CG008	Vg	PG-1051
13	Vg	BC-170-B	Vg	BC-170-B	Vg	BC-170-B	Vg	01CG008	Vg	04CG008
141	Sp	ICGV88329	Sp	ICGV88329	Sp	ICGV88329	Sp	BC-60	VL	BC-128D
142	Vg	ICGV86550	Vg	ICGV86550	Vg	ICGV86550	VL	BC-128D	Vg	2KCG014
143	Sp	ICGV88398	Sp	ICGV88398	Sp	ICGV88398	Sp	ICGV86885	Vg	BC-482-A
144	Sp	ICGV88376	Sp	ICGV88376	Sp	ICGV88376	Sp	BM-36	Sp	ICGV88401
145	Vg	BM-24	Vg	BM-24	Vg	BM-24	Vg	BC-139-A	Sp	ICGV88316
146	Vg	2KCG014	Vg	2KCG014	Vg	2KCG014	Vg	BC-71	Vg	BC-139-A
147	Sp	ICGV88338	Sp	ICGV88338	Sp	ICGV88338	Vg	2KCG014	Vg	ICGV88315
148	Vg	BC-482-A	Vg	BC-482-A	Vg	BC-482-A	Vg	BM-24	Vg	01CG002
149	Sp	ICGV88362	Sp	ICGV88362	Sp	ICGV88362	Vg	BC-482-A	Vg	BC-9
150	Sp	BC-124C	Sp	BC-124C	Sp	BC-124C	Sp	ICGV88362	Sp	ICGV88338
151	Sp	ICGV88401	Sp	ICGV88401	Sp	ICGV88401	Sp	BC-124C	Sp	ICGV88362
152	Vg	ICGV88394	Vg	ICGV88394	Vg	ICGV88394	Vg	01CG002	Vg	ICGV86128
153	Sp	ICGV88316	Sp	ICGV88316	Sp	ICGV88316	Sp	ICGV88316	Sp	BC-124C

Vg: *Virginia;* **Sp:** *Spanish;* **VL:** *Valencia;* **BT:** *Botanical type.*

Table 6: *Correlation between Spots/Leaf, Diseased Area/Leaf, Sporulation, Defoliation, Reaction Indexes of Defoliation*Spots/Leaf, Spots/Leaf x Diseased Area/Leaf, Spots/Leaf x Sporulation in Botanical Type Groundnut Germplasm. Cell contents correlation coefficient in every first row against the groundnut botanical type. Probability values in every second row against the groundnut botanical type.*

Sr. No.	Botanical Type	SL &DA	SL &S	Def& SL	Def*SL &Def	Def*SL &SL	SL*DA &SL	SL*DA &DA	SL*S &S
1	Virginia	0.20	0.99	-0.12	0.33	0.89	0.83	0.69	0.99
		0.04	0.00	0.22	0.00	0.00	0.00	0.00	0.00
2	Spanish	0.03	0.99	-0.39	-0.02	0.93	0.73	0.68	0.99
		0.86	0.00	0.01	0.88	0.00	0.00	0.00	0.00
3	Valencia	0.82	0.99	0.17	0.35	0.98	0.98	0.89	0.99
		0.06	0.00	0.78	0.55	0.00	0.00	0.02	0.00
4	Polled	0.17	0.99	-0.19	0.22	0.90	0.81	0.69	0.99
		0.03	0.00	0.01	0.01	-0.00	0.00	0.00	0.00

SL: *Spots/Leaf,* **DA:** *% Area Diseased/Leaf,* **S:** *Sporulation,* **Def:** *Defoliation.*

Among Virginia type plants accession No. ICGV88475 exhibited minimum SL (2.45), S (1.86), SL×S (4.55), SL × DA (6.1) and SL × Def (22.05) values (Table 5) and it ranked highly resistant genotype to LLS disease of groundnut.

Table 7: *Sources of Groundnut Germplasm.*

S.No	Identification	Description	Donor agency	Origin
1	ICGS	ICRISAT groundnut selection.	NARC, Islamabad	ICRISAT
2	ICGV	ICRISAT groundnut cultivar.	NARC, Islamabad	ICRISAT
3	00CG00	Year -Chakwal groundnut-	BARI, Chakwal	BARI, Chakwal
4	BC	BARI Cross.	BARI, Chakwal	BARI, Chakwal
5	BM	BARI Mutant.	BARI, Chakwal	BARI, Chakwal
6	PTGS	Pak. trainee's groundnut Selection.	BARI, Chakwal	BARI, Chakwal
7	PG	Pakistan groundnut.	NARC, Islamabad	NARC, Islamabad
8	PK	Pakistan groundnut (NARC).	NARC, Islamabad	NARC, Islamabad
9	HUSTA-J	-	NARC, Islamabad	ICRISAT
10	LICN	-	NARC, Islamabad	USA
11	NC	North Carolina	NARC, Islamabad	USA
12	S-25	-	NARC, Islamabad	Not known
13	SUDAN	-	NARC, Islamabad	Sudan
14	NO-73-27	-	NARC, Islamabad	Not Known
15	PI	Groundnut Introduction	NARC, Islamabad	USA
16	Shang.dong-684	-	NARC, Islamabad	China
17	PW	Pink white	BARI, Chakwal	BARI, Chakwal
18	BARI-188	Approved cultivar	BARI, Chakwal	BARI, Chakwal
19	BARI-89	Approved cultivar	BARI, Chakwal	BARI, Chakwal
20	BARI-2000	Approved cultivar	BARI, Chakwal	BARI, Chakwal
21	Chakori	Approved cultivar	BARI, Chakwal	BARI, Chakwal
22	No.334	Approved cultivar	BARI, Chakwal	BARI, Chakwal
23	Banki	Approved cultivar	BARI, Chakwal	BARI, Chakwal
24	Golden	Approved cultivar	BARI, Chakwal	BARI, Chakwal

Among Valencia type accession No. 01CG009 showed minimum SL (4.8), S (2.41), SL × S (11.5), SL × DA (12.13) and SL × Def (38.37) reaction indices (Table 4). Minimum SL × DA (14.62) reaction indices among Spanish type plants showed by BC-171-C but PG-1013 exhibited minimum SL (5.51), S (2.55), and SL × S (21.52) reaction index values. Among commercial cultivars only Chakori showed lesser values of SL x DA (15.81) then other commercial cultivars. (Table 4)

Among highly resistant ten genotypes under SL, S, and SL × S indices eight entries were of Virginia group and one is from both Valencia and Spanish group. Under SL × DA seven entries were from Virginia, two from Spanish and one from Valencia group. Under SL × Def eight entries were from Virginia and one was from each of Valencia and Spanish group. Most of Spanish botanical type groundnut plants have higher values of SL, S and SL × S. Higher values of SL × DA and SL × Def encountered both, in Spanish and Virginia type groundnut plants. (Table 4).

Correlation between SL and DA values showed increase in number of infections resulted in increase in diseased area per leaf in Virginia, Valencia and pooled analysis of genotypes but in case of Spanish type plants number of infection lesion did not cause increase in diseased area per leaf significantly. It may be concluded that lesion size was smaller in Spanish type plants. Correlation between SL and S has same trend in all plant types. There was a negative correlation between Def and SL. Correlation between interaction of SL × S and S are significant and positive (Table 6). Previous studies showed that amount of SL, Def, S and reaction between amount of SL and S showed a significant difference in wild and cultivated groundnut entries. Groundnut genotypes were grouped on bases of more or less sporulation (Melouk and Banks, 1984; Pensuk et al., 2003).

To obtain maximum sporulation necrotic area of LLS on groundnut leaves was removed. It is thought that more necrotic area results in more sporulation of fungus under optimum humidity and temperature conditions (Creen and Wynne, 1986; Nova et al., 1989). In general number of conidia per lesion was significantly higher in susceptible genotypes than in resistant genotypes (Rao et al., 1995).

Selection of genotypes with low sporulation levels could be expected to identify genotypes with desirable levels of other resistance components. A high level of resistance to LLS was identified in groundnut lines derived from interspecific crosses with *A. durenensis*. These homozygous lines were used as parents to incorporate resistance into high yielding breeding lines and to produce a segregating population for molecular marker studies (Anderson et al., 2000).

In Late groundnut host pathogen system (Nova et al., 1989) obtained sporulation by incubating necrotic area of groundnut leaves under high humidity moist chamber conditions. Resistance to LLS could be associated with low partitioning, late maturity and undesirable pod and seed characteristics (Nigam and Dwivedi, 2000). Luo et al. (2005) identified genes for resistance to LLS using micro array and real-time polymerase chain reaction (PCR). They detected 56 genes in several functional categories which could be used for marker-assisted selection in breeding programs.

In present study number of spots (necrotic areas) x sporulation was significant rather than diseased area (necrotic area + yellow hallo). The susceptibility of plant organ was also affected by the age of leaves; older leaves were more susceptible than younger ones. More resistant varieties, which were affected on their younger leaves, can suffer severe damage on their older leaves (Raymond et al., 1985). High defoliation scores after monsoon season left only few leaves on upper nodes on some genotypes so fluctuated results are observed due to younger leaves on upper nodes.

Conclusions and Recommendations

The graduation in the susceptibility of genotypes to toxin producing pathogens were purely quantitative. Absolute resistance i.e. incompatibility, cannot be found in such quantitative resistance responses. In the absence of quantitative resistance two main strategies are advocated to keep LLS of peanut under some limits. The first is to reduce the level of inoculum during the intercrop period, which will reduce the amount of inoculums available to start an epidemic after the peanut crop emerges and second strategy is to reduce the rate of increase during the cropping period.

Author's Contribution

M. Ijaz conceived the idea of this study, designed experimental layout, did data analysis, and provided technical inputs at every step of this study. S.R.A. Shah wrote manuscript and formatted according to journal keeping in view authors guidelines. A. Afzal worked on data recording, and reviewed the manuscript. M. I. Haq critically reviewed the manuscript and contributed in formatting.

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