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REGULAR ARTICLE

Screening of Indian peanut genotypes for resistance to *Cercospora* leaf-spot under savanna conditions

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ABSTRACT

The objective was to evaluate the Indian and Venezuelan peanut cultivars (PC) for agronomic performance and resistance to *Cercospora* leaf-spot (CLS) diseases for selection. The study covered three experiments: In the first one, 15 PC were evaluated (13 from India classified as resistant to CL and two native, Desconocida-36 and Americano Chico (AC)) in a RBD. In the second one, 15 PC (12 from India classified as early maturing) and three native (Rojo, Rosado and AC) in a RBD. In the third experiment, 25 PC were evaluated (22 from India classified as confectionery) and three native (Rojo, Rosado and AC) in a triple lattice design. In all experiments, three replications were used and probability level was 5%. Fungicide aspersions were not carried out. The two species of *Cercospora* identified were *Cercospora arachidicola* and *Cercosporidium personatum*. Peanut cultivars found to be high yielding were Desconocida-36 with 1944.6 kg/ha and cv. 86325 with 2035.3 kg/ha, both with intermediate tolerance. Cultivars 88401 and 88395 were classified as tolerant because of restricting fungicide application in the experiments.

Keywords: *Arachis hipogaea*; Disease damage; Pythopathogen fungi; Resistant plants

INTRODUCTION

Yield losses in peanut cultivars are produced by diverse causes, one of the more important is due to diseases, mainly *Cercospora* leaf spots ones and the recognition of peanut genotypes being tolerant to them and simultaneously having higher production potentials should benefit growers and breeders to carried out the proper variety for sowing or for further breeding (Gaikpa et al., 2015). The cultivation of resistant and tolerant peanut varieties does not only eliminate the crop losses caused by disease, it also contributes to reduce costs related to fungicide sprayings and other control methods. The hazard of pollution of the environment with toxic chemical compounds can also be discarded, that otherwise would have to be used in the crop for diseases control. In Venezuela, the control of disease in peanut cultivation is a serious problem. The high expense associated with 8 to 10 fungicide sprayings during the crop cycle, is economically not feasible but serve as a challenge to develop resistance/tolerant varieties against foliar diseases such as early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*). The early and late spots are foliage disease more common and more destructive of peanut. Leaf spot diseases produced by *C. arachidicola* and *C. personatum* are present every year on groundnut in the southeastern of the United States and can decrease seed productions over 50%, if no fungicides are applied for control (Alderman and Nutter, 1994; Ambang et al., 2011). Fungicides can be applied to control leaf spot and reduce yield loss, but fungicide utilization at recurrent periods are expensive. In Florida, a 10% reduction in yield is due to leaf spot epidemics no matter the use of six to eight chemical applications per crop cycle by most farmer (Alderman and Nutter, 1994; Pixley et al., 1990a). Thakur et al. (2012) indicated that *Cercospora* leaf spot (CLS) is a main severe disease of peanut and could produce yield reduction up to 50% or more. According to Walls and Wynne (1985), CLS are a major restriction to higher productions of groundnut and loss in yield of up to 70% has been indicated worldwide, where fungicides are not applied for LS managements. In zones where fungicides are used, a lot of money is expended every year in the

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control of these two fungus. Macedo-Nobile et al. (2008) indicated that late leaf spot, caused by *C. personatum*, is one of the most destructive diseases in groundnut and most commercial varieties are not acceptably resistant to the fungus. Although, Woodward et al. (2010) carried out trials to asses complete and diminished input fungicide plans in groundnut cultivations with several levels of hazard for groundnut LS compound (produced by *C. arachidicola* and *C. personatum*), chemical aspersions were carried out on a 14-, 21-, or 28-day periods (dp), LS level was comparable for all plans in fields contemplated as low or intermediate hazard; but, there was more LS in areas with a 28-dp for high hazard fields, pod productions were comparable among application periods for all experiments and they indicated that diminishes in chemical use can be carried out without compromising LS management or pod production.

In Venezuela, there are a few studies about the evaluation of resistance and tolerance of peanut cultivars to *C. arachidicola* and *C. personatum*. Layrisse and Borges (1984) evaluated four peanut varieties after artificial inoculations in the glasshouse and in the field for their response to *C. arachidicola;* the results showed a low association between glasshouse and field evaluations. Variety Tarapoto did not have any resistance under glasshouse experiments; but, it had the lowest percentage of foliar area infected in the field experiment. Tarapoto showed a kind of partial resistance, which is more properly assessed under field conditions. de Torres and Subero-Martínez (1992) evaluated three groundnut varieties (Red Starr, Bolivia Pintado, Tarapoto) and found that they had a differential behavior against *C. arachidicola* concerning to the period of symptom appearance at field level.

The purpose of the study was to evaluate the Indian and Venezuelan peanut cultivars for agronomic performance and resistance to *Cercospora* leaf spot diseases.

MATERIALS AND METHODS

The present study was carried out in the Estación Experimental de Sabana of Universidad de Oriente (Experimental Station of Savanna of the Universidad de Oriente), in Jusepín, Monagas State. The study consisted of three experiments Experiment 1: 15 peanut cultivars were evaluated (13 from India classified as resistant to CLS) and two native (Desconocida-36 and Americano Chico); in a randomized complete block design. Experiment 2: 15 peanut cultivars were evaluated (12 from India classified as early maturing) and three native (Rojo, Rosado and Americano Chico); in a randomized complete block design and Experiment 3: 25 peanut cultivars were evaluated (22 from India classified as confectionery) and three native (Rojo, Rosado and Americano Chico); in a triple lattice design. In all experiments, three replications were used and the level of statistical significance was $P < 0.05$.

All Indian cultivars were obtained from the ICRISAT (Patancheru, Hyderabad, India). Plots consisted of three rows (6 m long) 60 cm apart; the plants were spaced 25 cm apart. All plots were surrounded by cultivar Americano Chico (known to be very susceptible to the fungi in the savanna conditions of Jusepin) acting as an inoculum source. Only, central row was harvested. Fungicide aspersions were not carried out. The agronomic practices used were those currently utilized by farmers for commercial production excepting the fungicide use. Fungi *C. arachidicola* Hori and *C. personatum* (Bert and Curt) Deighton [*Phaeoisariopsis personata*] (Bert and Curt) V. Arx. were identified. The field was known to be endemic to leaf spot disease.

Leaf spot evaluations (infection percentages) were carried out by using measurement scale of 1-9 suggested by Rao et al. (1990) (Fig. 1).

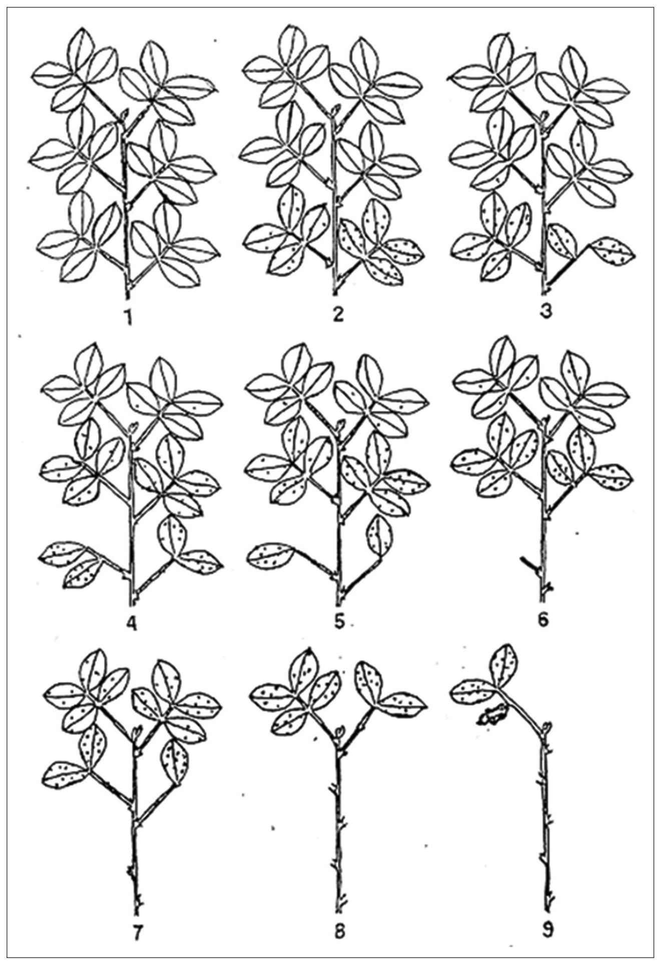

Fig 1. Modified 9-point disease scale used for assessment of peanut cultivars for resistance to late leaf spot caused by *Cercosporidium personatum* (Rao et al., 1990).

Seven leaf spot evaluations were made from 60 to 103 days after sowing each seven days and, the infection percentages were recorded. The following phytopathological traits were determined: area under disease progress curves (Shaner and Finney, 1977) and rate of disease progress, models Logits and Gompertz (Berger, 1981). Infection percentages were transformed by arc sin $\sqrt{\%I/100}$. Seed yield ha^{-1} was also determined. An analysis of variance was carried out and Duncan's Multiple Range Test was used to detect differences among cultivars. Genotypes were classified based on area under disease progress curves and rates of disease progress as the following

Susceptible(S):	$Xc > Xg + 1\ \sigma_{n-1}$	Where: Xc = Mean of the cultivar
Intermediate(I):	$Xg + 1\ \sigma_{n-1} > Xc > Xg - 1\ \sigma_{n-1}$	Xg = General mean of the trial
Resistant (R):	$Xc \leq Xg - 1\sigma_{n-1}$	$1\sigma_{n-1}$ = One standard deviation

RESULTS AND DISCUSSION

In Table 1, seed yields ha^{-1}, average infection percentage at 102 days after sowing, area under disease progress curve and rate of disease progress are shown. Duncan's multiple range test indicated that cultivar Desconocida-36 presented the biggest seed yields ha^{-1} with 1944.6 kg ha^{-1}. The cultivars with a smaller percentage of infection at 102 days after sowing were 87334, 87817 and 88248 with infection percentages up to 41%. The mean technique $\pm 1\sigma_{n-1}$ based on rate of disease progress models Logits and Gompertz allowed to classify the cultivars 87817 and 87334 as resistant to cercosporiosis leaf spot and cultivars Americano Chico and 88247 as susceptible.

In Table 2, seed yield ha^{-1}, average infection percentage at 102 days after sowing, area under disease progress curve and rate of disease progress in experiment two are shown. Duncan's multiple range tests indicated that the best yielder was cultivar 86325, followed by 88315 and 88316 (adjusted data for covariance on plants harvested ha^{-1}). Cultivars with a smaller average infection percentage at 102 days after sowing were 88307, 88308, 89322, 89328 and 86300 with infection percentages up to 38%. The mean technique $\pm 1\sigma_{n-1}$ based on rate of disease progress models Logits and Gompertz allowed to classify the cultivars 88307, 88320 and 88308 as resistant to cercosporiosis leaf spot and cultivars, Rosado, Rojo and Americano Chico as susceptible.

In Table 3, seed yield ha^{-1}, average infection percentage at 102 days after sowing, area under disease progress curve and rate of disease progress in experiment three are shown. Duncan's multiple range test indicated that cultivars 88376, 89203 and 88388 (adjusted data for covariance on plants harvested ha^{-1}) were the best yielders. Cultivars with a smaller infection percentage at 102 days after sowing were 88464 and 88401 with infection percentages up to 42%. The mean technique $\pm 1\sigma_{n-1}$ based on area under diseases progress curve and rate of disease progress model Logits

Table 1: Mean of seed yields per hectare, infection percentage to *Cercospora* leaf spot at 102 days after sowing and level of resistance according to area under disease progress curve and rate of disease progress models Logits and Gompertz of fifteen peanut (*Arachis hipogaea* L.) cultivars, under agroecological conditions of savanna in Jusepin, Monagas State, Venezuela. (Experiment 1)

Cultivars[a]	Seed yields (kg ha^{-1})	Infection percentage[b]	Test of X $\pm \sigma_{n-1}$[c]		
			AUDPC[d]	RDPML[e]	RDPMG[f]
Desc.-36	1944.6a[g]	48.07abc	I	I	I
87281	1102.2b	58.23cd	I	I	I
87160	1051.7b	54.00bcd	I	I	I
87282	1011.1bc	58.27cd	I	I	I
87867	923.8bc	44.53ab	I	I	I
87288	784.7bcd	44.53ab	I	I	I
86023	778.3bcd	42.20ab	I	I	I
88248	681.9bcd	41.00a	I	I	I
88247	665.8bcd	64.53d	I	S	S
87242	597.4bcd	48.07abc	I	I	I
Ame. Chico	459.9cd	81.00e	S	I	S
87232	438.8cd	47.67abc	I	I	I
87291	239.5d	48.07abc	I	I	I
87817	230.8d	39.67a	I	R	I
87334	216.2d	37.67a	I	R	R
Xg	741.8	50.51	821.4	0.098	0.044

[a]Cultivars Desconocida-36 (Desc.-36) and Americano Chico (Ame. Chico) are from Venezuela, the rest of cultivars are from India and classified as leaf spot resistant. [b]Average infection percentage of seven evaluations. [c]Susceptible (S) : $Xc > Xg + 1\ \sigma_{n-1}$ Where: Xc = Mean of the cultivar Intermediate (I): $Xg + 1\ \sigma_{n-1} > Xc > Xg - 1\ \sigma_{n-1}$ Xg = General mean of the trial. Resistant (R): $Xc \leq Xg - 1\ \sigma_{n-1}$ $1\ \sigma n - 1$ = One standard deviation. [d]AUDPC : Area under disease progress curve. [e]RDPML : Rate of disease progress models Logits. [f]RDPMG : Rate of disease progress models Gompertz. [g]Means followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test

Table 2: Mean of seed yields per hectare, infection percentage to *Cercospora* leaf spot at 102 days after sowing and level of resistance according to area under disease progress curve and rate of disease progress models Logits and Gompertz of fifteen peanut (*Arachis hipogaea* L.) cultivars, under agroecological conditions of savanna in Jusepin, Monagas State, Venezuela. (Experiment 2)

Cultivars[a]	Seed yields (kg ha^{-1})		Infection percentage[b]	Test of X ± σ_{n-1} [c]		
				AUDPC[d]	RDPML[e]	RDPMG[f]
86325	1711.5[g]	2035.3[h]a[i]	47.67bc	I	I	I
88315	1194.8	654.7ab	42.40abc	I	I	I
88316	1174.6	861.2ab	42.20abc	I	I	I
86300	1118.4	1098.2ab	37.67ab	I	I	I
89322	1083.0	1406.9ab	35.33ab	I	I	I
88317	1037.8	928.8 abc	47.67bc	I	I	I
88307	1027.7	1498.8abc	31.00a	I	R	R
Rosado	959.0	418.9abc	67.67ef	S	S	S
88314	914.1	1080.4abc	53.30cd	I	I	I
Rojo	901.9	361.8abc	61.00de	S	I	S
Ame. Chico	763.9	223.8bc	74.70f	S	S	S
88322	679.3	941.6bc	43.80abc	I	I	I
88320	572.1	863.5bc	39.00ab	I	R	I
88308	560.7	972.0bc	31.67a	I	R	R
89328	176.0	529.0c	37.67ab	I	I	I
Xg		925.0	46.18	774.9	0.098	0.043

[a]Cultivars Rojo, Rosado and Americano Chico (Ame. Chico) are from Venezuela, the rest of cultivars are from India and are classified as early maturing. [b]Infection percentage at 102 days after sowing. [c]Susceptible (S) : Xc > Xg + 1 σ_{n-1} Where: Xc = Mean of the cultivar. Intermediate (I) : Xg + 1 σ_{n-1} > Xc > Xg - 1 σ_{n-1} Xg = General mean of the trial. Resistant (R): Xc ≤ Xg - 1 σ_{n-1} 1 σ_{n-1} = One standard deviation. [d]AUDPC : Area under disease progress curve; [e]RDPML : Rate of disease progress models Logits; [f]RDPMG : Rate of disease progress models Gompertz; [g]Adjusted data by covariance analysis on number of harvested plant/plot. [h]Original data obtained in the trial. [i]Means followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test

allowed to classify the cultivars 88401, 88395, 88376, 89203 and 88480 as resistant to cercosporiosis leaf spot and cultivars, Rosado, Rojo y Americano Chico as susceptible.

de Torres and Subero-Martínez (1992) evaluated relatively the foliar anatomical variation of three groundnut varieties (Red Starr, Bolivia Pintado, Tarapoto) in the stages of penetration, infection, colonization and sporulation of *C. arachidicola*, after artificial inoculation, the groundnut varieties evaluated in the assay, had a differential behavior against *C. arachidicola* concerning to the period of symptom appearance at field level. This was found to associate to the anatomical facts happened during the penetration and post-penetration of *C. arachidicola* when the follicles of such varieties were inoculated. The typical symptoms of the ELS were seen faster at field level in Red Starr than varieties Bolivia Pintado and Tarapoto. In the other hand, the first anatomical response of Red Starr was seen after 72 hours post inoculation and it constituted of an increasing of cuticle thickness at the penetration places. The colonized cells of epidermis had a compact and granulated cytoplasm. In the follicles of varieties Bolivia Pintado and Tarapoto which were inoculated with the fungus, anatomical response began 96 hours after inoculation.

The seed yield ha^{-1} were higher in experiments 1 and 2 than experiment 3, the general yield means were 741.8; 925.0 and 507.1 kg ha^{-1} for the experiments 1, 2 and 3, respectively. This result could be due to that in experiments 1 and 2 smaller values of the area under disease curve progress were obtained than in experiment 3 (821.4; 774.9 and 1048.5 respectively). The rate of disease progress model Logits was superior than model Gompertz rate in the three experiments, but in each model, the values of disease progress were very similar in all experiments. These data suggest that area under disease progress curve is a phytopathological character very reliable and it allows to differentiate cultivars according to its resistance to cercosporiosis leaf spot than traits, rate of disease progress, models Logits and Gompertz, this can be explained by the fact that two cultivars (one resistant and other susceptible) can have the same rate of disease progress, but the initial fungi attack is very severe in the susceptible cultivar from this, it will have a bigger area under disease progress curve than resistant cultivar although they present similar disease progress rates. De Almeida et al. (2000) evaluated 15 and 6 groundnut lines and varieties, respectively through quantification of leaf spots produced by *C. personatum*, to screen the populations with the best behavior and suggested that all evaluated populations performed comparably to the variety Tatu, which was classified as susceptible to the disease as showed by the apparent infection rate and AUDPC. Although, all the assessed populations were classified as susceptible, the variability of AUDPC indicated genotype differences in the progress of *C. personatum* among them. These differences among populations may be related with other plant characters and with its resistance or susceptibility. The experiment confirmed previous studies that regard AUDPC as the better methodology to define the performance of the leaf spots caused by *C. personatum* in several populations.

Table 3: Mean of seed yields per hectare, infection percentage to *Cercospora* leaf spot at 102 days after sowing and level of resistance according to area under disease progress curve and rate of disease progress models Logits and Gompertz of 25 peanut (*Arachis hipogaea* L.) cultivars, under agroecological conditions of savanna in Jusepin, Monagas State, Venezuela. (Experiment 3)

Cultivars[a]	Seed yields (kg ha^{-1})		Infection percentage[b]	Test of X $\pm \sigma_{n-1}$ [c]		
				AUDPC[d]	RDPML[e]	RDPMG[f]
88376	679.6g	702.0[h]a[i]	47.67 ab	I	R	nsj
89203	635.5	677.3ab	47.67 ab	I	R	ns
88388	607.7	643.5abc	54.33 abc	I	I	ns
88429	598.2	559.6abc	67.67 cd	I	I	ns
89235	589.9	566.9abc	47.67 ab	I	I	ns
88474	548.6	593.0abcd	51.00 abc	I	I	ns
88448	545.0	566.4abcd	61.00 abc	I	I	ns
89214	544.0	576.0abcd	61.00 abc	I	I	ns
88409	543.7	501.6abcd	61.00 abc	I	I	ns
88401	543.4	588.3abcd	41.00 a	R	R	ns
88362	539.0	572.9abcd	67.67cd	I	S	ns
89211	535.6	566.0abcd	47.67ab	I	I	ns
88475	522.1	527.1abcd	51.00abc	I	I	ns
88480	520.4	510.9abcd	47.67ab	I	R	ns
88482	504.4	472.2abcd	47.67ab	I	I	ns
88406	495.1	478.0abcd	61.00abc	I	I	ns
89220	479.7	399.3bcde	61.00abc	I	I	ns
88392	465.9	449.5bcde	61.00abc	I	I	ns
88473	444.7	509.4bcde	54.33abc	I	I	ns
88464	438.3	541.1cde	41.00a	I	I	ns
88394	433.0	445.7cde	61.00abc	I	I	ns
Ame. Chico	422.7	333.7cde	81.00d	S	S	ns
Rosado	374.1	326.9de	81.00d	S	I	ns
88395	370.1	363.0de	54.33abc	R	I	ns
Rojo	299.2	210.3e	81.00d	S	S	ns
Xg		507.1	57.53	1048.5	0.092	0.049

[a]Cultivars Rojo, Rosado and Americano Chico (Ame. Chico) are from Venezuela, the rest of cultivars are from India and are classified as confectionery. [b]Infection percentage at 102 days after sowing. [c]Susceptible (S) : Xc > Xg + 1 σ_{n-1} Where: Xc = Mean of the cultivar. Intermediate (I) : Xg + 1 σ_{n-1} > Xc > Xg - 1 σ_{n-1} Xg = General mean of the trial. Resistant (R): Xc ≤ Xg - 1 σ_{n-1} 1 σ_{n-1} = One standard deviation. [d]AUDPC : Area under disease progress curve. [e]RDPML : Rate of disease progress models Logits. [f]RDPMG : Rate of disease progress models Gompertz. [g]Adjusted data by covariance analysis on number of harvested plant/plot. [h]Original data obtained in the trial. [i]Means followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range Test. [j]ns : There was not significant differences among cultivars for RDPMG

The smallest incidence of the disease and a higher seed yields ha^{-1} in the experiments 1 and 2 in comparison to experiment 3, are probably due to that in experiment 1, leaf spot resistant cultivars were evaluated and in experiment 2, the evaluated cultivars were early maturing ones, while in experiment 3, the evaluated cultivars were confectionery ones, which are generally late maturing. Singh (1994) indicated that early varieties often escape a disease since they mature before the disease epidemic occurs. For example, early peanut varieties generally escape 'tikka' disease caused by *Mycosphaerella* sp. Also, Izge et al. (2007) found that the groundnut cultivar ICGV-IS 96808 which produced the higher kernel yield also was among cultivars that registered the lower disease severity and indicated that this could suggest that precocious maturity may be positively correlated with *Cercospora* late spot tolerance in groundnut.

On the other hand, according to Wells et al. (1994) partial resistance to late and early leafspot has been registered in cultivated groundnut, in all cases the resistance diminished the intensity of the disease but production reduction still happened. Seed yields ha^{-1} obtained in experiments 1 and 2 are similar to those reported by Méndez-Natera (1995) who in a trial with 11 groundnut varieties in the savanna of Jusepín, Venezuela found that yields ranged between 485.3 and 1838.2 kg of seeds ha^{-1}, while Méndez-Natera et al. (2003) in the savanna of Jusepín, Venezuela with 24 of the 25 varieties of groundnut of experiment 3, found that seed productions ranged from 194.6 to 926.6 kg ha^{-1}. Also, Naab et al. (2005) studied the effects of sowing date, variety cycle, and fungicide applications on disease severity, biomass and pod production of groundnut cultivated under dryland conditions in Ghana and found that early sowings after onset of rains produced more biomass and pod yields in comparison to late sowings for cvs. Chinese and F-mix. The late variety F-mix yielded more than short duration variety Chinese under fungicide and nonfungicide applications, but incidence and severity of disease were comparable in both varieties and the greater yield got by late variety was not due to disease tolerance or escape but due to its longer cycle.

In this study, several peanut cultivars were detected showing different level of resistance to leafspot caused by *C. arachidicola* and *C. personatum*. However, some cultivars leveled as resistant were susceptible. In this respect, Waliyar et al. (1994) found that expression of resistance to *C. arachidicola* in some accessions, depended on the geographic place where they were evaluated, because the environment affects the expression of partial resistance in several pathosystems, and could influence stability of resistance to ELS. Pixley et al. (1990b) stated that genetic resistance to leaf spot diseases is a wanted answer to the issue of the yield reduction, but such resistance has typically been related to late maturity and low production. On the other hand, Chiyembekeza et al. (1993) indicated that resistant varieties can boost yields, decrease costs of production, and minimalize environmental hazards related to fungicide application. Waliyar et al. (1993, 1994) indicated that although efficient fungicides exist, their use is limited in many cultivation regions because of high costs and/or because fungicide-tolerant strains of the pathogen exist, subsequently, improving levels of resistance to leafspot diseases in locally adapted varieties would considerably increase groundnut productions in developing countries, elsewhere, diminished fungicide sprayings would decrease environmental effects and augment profitability.

According to Singh et al. (2011), *C. personatum* produces LLS in groundnut and causes necrotic lesions, early leaf senescence and yield reductions, two groundnut varieties were assessed, York with more and Carver with less quantitative resistance to *C. personatum* cultivated with fungicide and nonfungicide applications at Citra, Florida, United States over two years and found that disease intensity based on canopy lesion area was diminished by 30% in York compared to Carver. Reduction in total canopy photosynthesis was greater in York compared to Carver given their respective disease severity. Combining resistance with the maintenance of physiological function during LLS infection could result in improved groundnut production under diseases.

Recently, Macedo-Nobile et al. (2008) indicated that non-commercial materials cv. 850 and cv. 909 have resistance to LLS and produce symptoms comparable to hypersensitive response damage. They investigated the molecular components of the early phases of the resistance and helped to elucidate the defense approaches of groundnut and give the basis for the creation of pathogen-resistant groundnut genotypes. Also, resistant *Arachis* species have been identified. Pereira, et al. (2009) found that most of the genotypes of wild species had more resistance than genotypes of *A. hypogaea* and indicated that wild germplasm collection of genome types (AB) can be utilized for the introgression of resistance genes against *C. arachidicola* and *C. personatum*. Similar results were reported by Gremillion et al. (2011) who found some new Bolivian-derived genotypes which show promise for use in a reduced fungicide integrated disease management system with the potential to lessen fungicide use compared to standard production practices while maintaining low leaf spot levels and high yields.

There was a significant variability among peanut cultivars to CLS disease. Resistant cultivars were found in the three experiments. Similar results were reported by Thakur et al. (2013) who indicated highly significant difference among the groundnut varieties for CLS score. Li et al. (2012) compared field susceptibility of several groundnut genotypes to spot fungus for screening of genotypes for mapping population development and found that six and five accessions were resistant and susceptible, respectively to LS. Chapin et al. (2010) conducted field experiments to assess the disease reaction of 47 experimental Virginia-type breeding lines and eight varieties of peanut and found that variety Bailey, three sister lines and N03091T had steadily less susceptibility to LLS and the level of field resistance determined for this disease was similar to that of a resistant runner-type Georgia-03L. Tallury et al. (2009) assessed 26 interspecific hybrid derived breeding lines (IHDBL) with five *Arachis* species in their pedigrees, six resistant *A. hypogaea* controls and 11 susceptible varieties for leaf spot resistance in field experiments without leaf spot fungicides and found that some of the IHDBL presented levels of leaf spot resistance comparable to the resistant *A. hypogaea* controls, indicating that they have genes conditioning resistance to leaf spots.

This experiment is in agreement with the result of Thakur et al. (2012, 2014) who evaluated 25 groundnut varieties along with local controls (B-4 and Jayanti) for resistance to CLS and for yield production and found highly significant difference among the groundnut cultivars for days to 75% flowering, days to maturity, 100 kernel weight and CLS scores. The results indicated that seven cultivars presented the lowest level of CLS severity and four cultivars had the higher pod yield and also had the lowest CLS severity. Four cultivars produced higher haulm yield and presented lower CLS severity. Also, Muhammad and Bdliya (2015) found significant differences in three groundnut genotypes and indicated that this could probably to be due to difference in the inherent resistance of the cultivars to attack by the fungus. In the other hand, Izge et al. (2007) found four groundnut cultivars had lower levels of *Cercospora* leaf spot severity, suggesting that they were comparatively tolerant to CLS, but four cultivars were recognized as comparatively having higher disease severity consistently suggesting that they were susceptible to CLS. Similar results were reported by Tshilenge-Lukanda et al. (2011) who carried out an assay on the performance of nine groundnut cultivars with several levels of resistance to peanut foliar disease and found a moderate resistance in two genotypes with low levels of AUDPC. Three genotypes were moderately susceptible and four were highly susceptible. The several cultivars evaluated all have a precocious sensibility to LS but with different levels of infection.

In experiment 1, two, two and 11 cultivars were classified as resistant, susceptible and intermediate, respectively. In experiment 2, three, three and nine cultivars, respectively and in experiment 3, five, four and 16 cultivars were classified as resistant, susceptible and intermediate, respectively. Similar results were reported by Sudini et al. (2015) who evaluated the groundnut mini core collection to find possible sources of resistance to late leaf spot in two field assays under no-natural epiphytotic conditions at ICRISAT and indicated significant differences among genotypes for late leaf spot. Average of two years experiment indicated that 53 genotypes had intermediate resistance, 86 genotypes had susceptibility and 45 genotypes were highly susceptible to late leaf spot. Six superior materials according to pooled disease resistance and production were chosen. The highest productions were registered with ICG 11426 in late leaf spot. Gaikpa et al. (2015) carried out an assay to determine the yields and yield components of 20 peanut cultivars in a zone denominated as a 'hot spot' for *Cercospora* leaf spot disease in Ghana and observed significant differences in all characters including disease incidence and severity and defoliation. They reported that the top eleven high producing varieties have moderate resistance to leaf spot and should be selected for cultivation in regions where *Cercospora* leaf spot is present.

Debele and Ayalew (2015) conducted field experiment in Eastern Ethiopia to assess the effect of integrated utilization of cultivar resistance and fungicides on CLS and production of groundnut. Three peanut cultivars were used and six chemical treatments. They found that high levels of disease control were got by sprayings every week of chlorothalonil. Up to 25 and 65% intensity levels were registered on fungicide and nonfungicide treatments, Chemical sprayingsalso significantly diminished disease development and AUDPC value on the susceptible cultivar.

The fungicides are the most common strategies for controlling disease losses. Nowadays, there has been increasing concern in undiscriminating utilization of them because they are potentially risky to environment and chemical residues in the soil adding to the contamination. These facts have conducted to the pursuit of new and advanced methods for plant disease control (Nath et al., 2013). The absence of resistance in peanut cultivars to CLS still does the utilization of fungicides for controlling it (Khan et al., 2014) but the actual tendency of higher costs for them, especially the copper ones, will obligate to augment sowing regions of resistant or tolerant groundnut varieties to leaf-spots. Solving one of the most important groundnut production restraints should help to substantial enhance of its cultivation area. Thakur et al. (2013) stated that the management of leaf spot disease in groundnut has also been indicated to depend very much on many sprayings of fungicides which could produce slow erosion of disease control due to a reduction of sensibility in the target fungus population and contribute to higher production costs and environmental contamination. The creation or choice of tolerant genotypes or cultivars could therefore be an efficient approach in reducing production costs and enhancing product quality. Thakur et al. (2012, 2014) found notable levels of variation among the groundnut cultivars that is important in groundnut breeding program and suggested that creation or choice of tolerant/resistant cultivars to CLS should be based on their level of severity and stated that this will be the only efficient method in reducing production costs and safeguarding the environment from contamination. Therefore, there are potential cultivars for selection among the assessed groundnut genotypes for CLS tolerance/resistance.

High yielding peanut cultivars were identified, which could guarantee cultivation profitability for the peanut farmers of Orient savannas of Venezuela. Besides, the non-application of fungicides in the experiments, classifies these cultivars as resistant to leaf spot disease caused by *C. arachidicola* and *C. personatum*, with a decrease of cost of production due to reduced or no fungicide use, and a conservation of the environment for the no incorporation of toxic residuals from the fungicides fulfilling the principles of a sustainable agriculture economic profitability, social reason and ecological dimension.

CONCLUSION

In the experiment with peanut cultivars classified as leaf spot resistant, two cultivars (87817 and 87334) were classifies as resistant but they had the lowest yields, two cultivars (88247 and Americano Chico) were classified as susceptible and they have yields below the general mean and the rest was classified as intermediate, Desconocida 36 had the highest yield (1944.6 kg ha^{-1}).

In the experiment with peanut cultivars classified as early maturing, three cultivars (88307, 88320 and

88308) were classifies as resistant. Cultivar 88307 had a yield (1027.7 kg ha^{-1}) above of the general mean but 88320 and 88308 had the second and third lowest yield, three cultivars (Rosado, Rojo and Americano Chico) were classified as susceptible and the rest as intermediate. Cultivar 86325 had the highest yield (1711.5 kg ha^{-1}).

In the experiment with peanut cultivars classified as confectionery, five cultivars (88376, 89203, 88401, 88480 and 88395) were classifies as resistant. Cultivars 88376 and 89203 had the highest yield (702.0 and 677.3 kg ha^{-1}, respectively) and 88395 had the second lowest yield. Four cultivars (88362, Rosado, Rojo and Americano Chico) were classified as susceptible and the last three cultivars had the fourth, third and first lowest yields. The rest of cultivars were classified as intermediate,

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Author's contributions

Jesús Rafael Méndez-Natera wrote the manuscript, carried out the statistical analysis, was involved in overall planning and supervision, Jesús Rafael Cedeño was involved in overall planning and supervision of the experiments, revised, edited and approved the manuscript. Joseba Andoni Luna Tineo carried out experiment 3 and Luis Arnaldo Barrios Azócar performed experiments 1 and 2.

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