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Appraisal of the performance of peanut genotypes (*Arachis hypogaea* L.) from the ICRISAT collection in India

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ABSTRACT

Peanut (*Arachis hypogaea* L.) is a worldwide popular oilseed. In Burkina Faso, production fluctuates from year to year. This fluctuation in yield is linked to the biotic factors which constitute the major constraints of peanuts. To this end, many breeding programs have been set up to select disease-resistant varieties to improve yields. It is with this in mind that this work focused a genetic analysis of traits related to leaf spot resistance of groundnuts. This study was to evaluate the performance of groundnut genotypes of Indian origin, through field screening to identify leafs spot resistant genotypes with good performance. The experimental device was in a completely randomized Fisher block with three repetitions. After setting up the trial, severity of the disease, percentage of defoliation and yield components were noted. Data from all observations were analyzed using the XLSTAT Pro.1 static analysis software. Statistical analysis of the obtained results showed a significant difference between the obtained values in the different genotypes evaluated for all of the above parameters except the yield. At the end of this study, nineteen (19) resistant genotypes and twenty-three (23) genotypes moderately resistant to leaf spot were identified. These resistant genotypes constitute an additional list of resistant varieties and can be used as a source of resistance in a varietal improvement program.

Keywords: Performance, *Arachis hypogaea* L., ICRISAT collection, India.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a worldwide popular oilseed. It is almost grown in all the regions in Burkina Faso. It is mainly processed into oil, flour and derivatives that are part of family and industrial diet. It is then an important source of income for farmers. Groundnut also contributes to the field of agriculture in maintaining agricultural production in Saharan countries where it is grown in rotation with cereals (Faye, 2010). Peanut cultivation is practiced all over the world, with a total area of 26.89 million hectares, world production was 46.04 million hulls in 2020 (USDA, 2021). The largest non-shelled groundnut producing countries are China (17.52 million tons), India (6.26 million tons), Nigeria (3.50 million tons), the United States of America. America (2, 48 million tons) with respective areas planted in hectares of

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4.63 million, 4.83 million, 2.80 million and 0.56 million hectares.

In Burkina Faso, production fluctuates year in year out. It increased from 365,887 hull tons in 2016 to 519,345 hull tons in 2017 and in 2018 it will fall to 334,328 hull tons. It will fall slightly in 2019 to 329,783 tons; then it will rose to 334,328 tons in 2020 (MAAH / DGESS, 2020). This fluctuation of yield is linked to structural, abiotic and biotic factors: the real lack of a crop promotion policy is a serious handicap, the climate disturbances, the irregularity of the rainy events during the cropping season are abiotic factors that limit the production of peanuts. However, biotic factors are the first-order constraints that seriously hamper groundnut production. Among these factors are foliar diseases (rust, rosette and early and late leaf spot diseases). These diseases are a major cause of yield losses in the field. with this situation, various control methods were developed to combat them in order to improve production: agricultural practices, biological control, genetic control and chemical control. Among these methods, chemical control is the most used in our countries with acceptable results. But it causes serious environmental and health problems through its toxicities. I response to this situation, the search for other methods of struggle is necessary, such as the use of local plant extracts for the control of peanut leaf diseases (Koita , 2007). To this end, many breeding programs were set up to select disease-resistant varieties to improve yields. It is with this in mind that our work, whose theme is "Appraisal of the performance of peanut genotypes from the ICRISAT collection in India", focuses a genetic analysis of traits related to leaf spot resistance of groundnuts.

The overall objective of this study is to evaluate the performance of groundnut genotypes of Indian origin, through field screening to identify leafs spot resistant genotypes with good performance.

MATERIALS AND METHODS

Experimental location

The experimentation was carried out on the Gampela agricultural site in Burkina Faso. The Gampela experimental site is located about 25 km in the East of Ouagadougou, not far from national road No. 4. The Gampela experimental field extends over 450 ha between the parallels 12024.613 'and 12025.413' of north latitude and the meridians1020.464 and 1021.652 'of west longitude. It is located in the village of Gampela, administratively attached to the department of Saaba (Kagambega, 2006). The climate of the region is of Sudano-Sahelian type. It is characterized by a rainy season from June to October with the maximum rain in August. The soils of the site are very diverse. Ferruginous, hydromorphic soils, lithosols, poorly developed soils with anthropogenic contribution and brown euterotrophic soils are noted in order of importance. The pH of the soils varies from 5 to 6.3; and presents constraints which are inter alia the low organic matter content, the low retention capacity (Sankara, 1997).

Plant material

The plant material used for this study consists of seventy-six (76) groundnut genotypes including seventy-four (74) genotypes from the ICRISAT India collection and two controls, the TS32-1 genotype was used as a control susceptible to leaf spot disease originating from Burkina Faso and the PC 79-79 genotype as a resistant control originating from Senegal. The characteristics of the different genotypes used are contained in (Table 1).

Experimental design

The experiment was carried out in Gampela according to Fisher's experimental block device completely randomized with three repetitions. Each repetition was subdivided into two sub-blocks. The sub-blocks of the same repetition are spaced 0.5 m apart. The distance between repetitions was 1 m. Each genotype was sown on an elementary plot of 2 lines of 3m each by repetition at the rate of one seed per pouch. The distance between the lines was 0.50 m and that between the pockets was 0.15 m. To protect the test, we sowed three lines of the Nama variety (resistant variety) as border lines all around the test. The trial was

oriented from north to south and the first parcel started from the west by the IP196 variety.

Evaluation of the severity of leaf spot diseases

Late leaf spot disease severity scoring was done at 30 and 105 days after sowing (DAS) (at harvesting maturity) using a modified nine-point scale (Subrahmanyam et al., 1995) **(**Table 2 and Figure 2), where a score of 1 was rated as highly resistant (HR), 2 to 4 as resistant (R), 5 and 6 as moderately resistant (MR), 7 and 8 as susceptible, and 9 as highly susceptible (HS).

Evaluation of the percentage of defoliation

Defoliation is assessed at harvest, so at the stage of maximum loss of leaves. It reflects the degree of incidence of the disease on peanut plants expressed by leaf fall. Thus, on each plot, the measurement is made on the main stems of five plants selected at random. The number of fallen leaves is obtained by counting the leaf locations on the main stem. The percentage is obtained by relating the number of fallen leaves to the number of total leaves (present and absent) reduced to one hundred.

$$\%\, DE = \frac{Nbr\ of\ L\ fallen}{Total\ Nbr\ \ of\ leaves}\ x\ 100$$

% DE: Percentage of defoliation;
Nbr of L fallen: Number of fallen leaves;
Total Nbr of leaves: Total number of leaves

Measure of performance components

Pods, which are the essential components of yield, are sun-dried in sacks after harvest by variety and repetition. The pods of each genotype are then weighed and the pod yields in tons / ha are determined.

Statistical analysis

Data from all observations were analyzed using the XLSTAT Pro 7.1 statistical analysis software. A variance analysis followed by an average comparison using the Duncan test at the 5% threshold, made it possible to determine the genotypes that best resist to Sigatoka diseases. Histograms, curves and tables were constructed using the Microsoft Excel 2013 software.

Table 1: Characteristics of peanut varieties used in experimentation.

CODE	GENOTYPES	IDENTITY	ORIGIN
IP2	ICG-76	T27	India
IP4	ICG-111	C50	Unknown
IP7	ICG-156	Mungphalli13	India
IP8	ICG-163	S 42	Unknown
IP18	ICG-532	AH 6857	Unknown
IP19	ICG-721	6842	USA
IP20	ICG-862	C 121	India
IP22	ICG-928	EC 16690 (PC)	Unknown
IP26	ICG-1399	U 2-4-1; EC 21151	Malawi
IP27	ICG-1415	U 2-24-5; EC 21161; JE 59	Senegal
IP29	ICG-1668	NCAC 2730	USA
IP35	ICG-2511	C21	India
IP37	ICG-2772	Kano 50	Nigeria
IP38	ICG-2773	Kanyoma	Tanzania
IP39	ICG-2777	Limdi 219-3	India
IP40	ICG-2857	US 57	Argentina
IP41	ICG-2925	C 145-12-P-16	India

IP42	ICG-3027	HG3	India
IP43	ICG-3053	275	India
IP57	ICG-3992	Local 3	India
IP58	ICG-4156	AH7002	Unknown
IP59	ICG-4343	NG268	India
IP60	ICG-4389	IC22951	India

Table 1: Characteristics of peanut varieties used in experimentation (next steps).

CODE	Genotypes	Identity	Origin
IP61	ICG-4412	USA60	USA
IP62	ICG-4527	Teso	Uganda
IP63	ICG-4538	27-janv	India
IP66	ICG-4598	Hyderabad	India
IP70	ICG-4746	P1 298115; line 136	Israel
IP74	ICG-4955	AH7065; HG6 P1269060;NCAC9977;IN5940K	India
IP75	ICG-4998	487	China
IP78	ICG-5195	U 4-7-15; EC 21097	Sudan
IP82	ICG-5327	EC 112032; MC Fla 14	USA
IP83	ICG-5475	AH 6666	Kenya
IP84	ICG-5494	AH 7234	Malaysia
IP87	ICG-5609	AH 7144; Small Spanish	Sri Lanka
IP89	ICG-5663	AH 7325	China
IP92	ICG-5827	UF 439-16-6; NCAC 17348	USA
IP94	ICG-5891	VRR 125 P1 162859; NCAC 927; Baladibunch	India
IP96	ICG-6057	NCAC 17773	USA
IP107	ICG-6813	11	Senegal
IP109	ICG-6892	NCAC 17591	USA
IP113	ICG-7153	VRR 299	India
IP124	ICG-8490	RG 159; Somaliaali	Somalia
IP128	ICG-9037	57-295	Ivory Coast
IP135	ICG-9666	VRR 663	India
IP136	ICG-9777	RPM 13; Mative	Mozambique
IP137	ICG-9809	RPM 145; Mative	Mozambique

Table 1: Characteristics of peanut varieties used in experimentation (next steps).

CODE	Genotypes	Identity	Origin
IP138	ICG-9842	PR 5680	Tanzania
IP139	ICG-9905	ZM 2861	Zambia
IP141	ICG-9961	79-6-1	Unknown

IP145	ICG-10185	52-32	USA
IP148	ICG-10479	P1 259694;Mani aceitero	Uruguay
IP153	ICG-1109	P1 230192; EG	Taiwan
IP158	ICG-11426	CS 2414	India
IP159	ICG-11457	AMR 151	India
IP164	ICG-11855	Suweon 45; 300521	Républic of Corée
IP167	ICG-12000	RS 128-2 red ; Zorowoule	Mali
IP169	ICG-12276	BPZ 71 overo	Bolivia
IP170	ICG-12370	AKG 280 BPZ 691 purple; P1497597; Rojo del	India
IP171	ICG-12625	Oriente	Ecuador
IP172	ICG-12672	US 824; US 824-2; Pl 497404; Overo	Bolivia
IP176	ICG-12921	AMM 1452 Tan	Zimbabwe
IP177	ICG-12988	US 22	India
IP178	ICG-13099	U 118	Unknown
IP180	ICG-13525	GNAK 377	Republic of Central-African
IP184	ICG-13723	37 GG2	Niger
IP185	ICG-13787	91 GG2	Niger
IP189	ICG-13942	ICGS 76	I Costa RicaSAT
IP191	ICG-14008	AK 471	Central African Republic
IP196	ICG-14466	AON 778	Nigeria
IP197	ICG-14475	AON827	Nigeria
IP198	ICG-14482	AON 857	Nigeria

Table 1: Characteristics of peanut varieties used in experimentation (end).

CODE	Genotypes	Identity	Origin
IP199	ICG-14523	9	Unknown
IP201	ICG-14705	NFC 6; Midevia	Cameroon
TS32-1	TS32-1	TS32-1	Burkina-Faso
PC79-79	PC79-79	PC79-79	Senegal

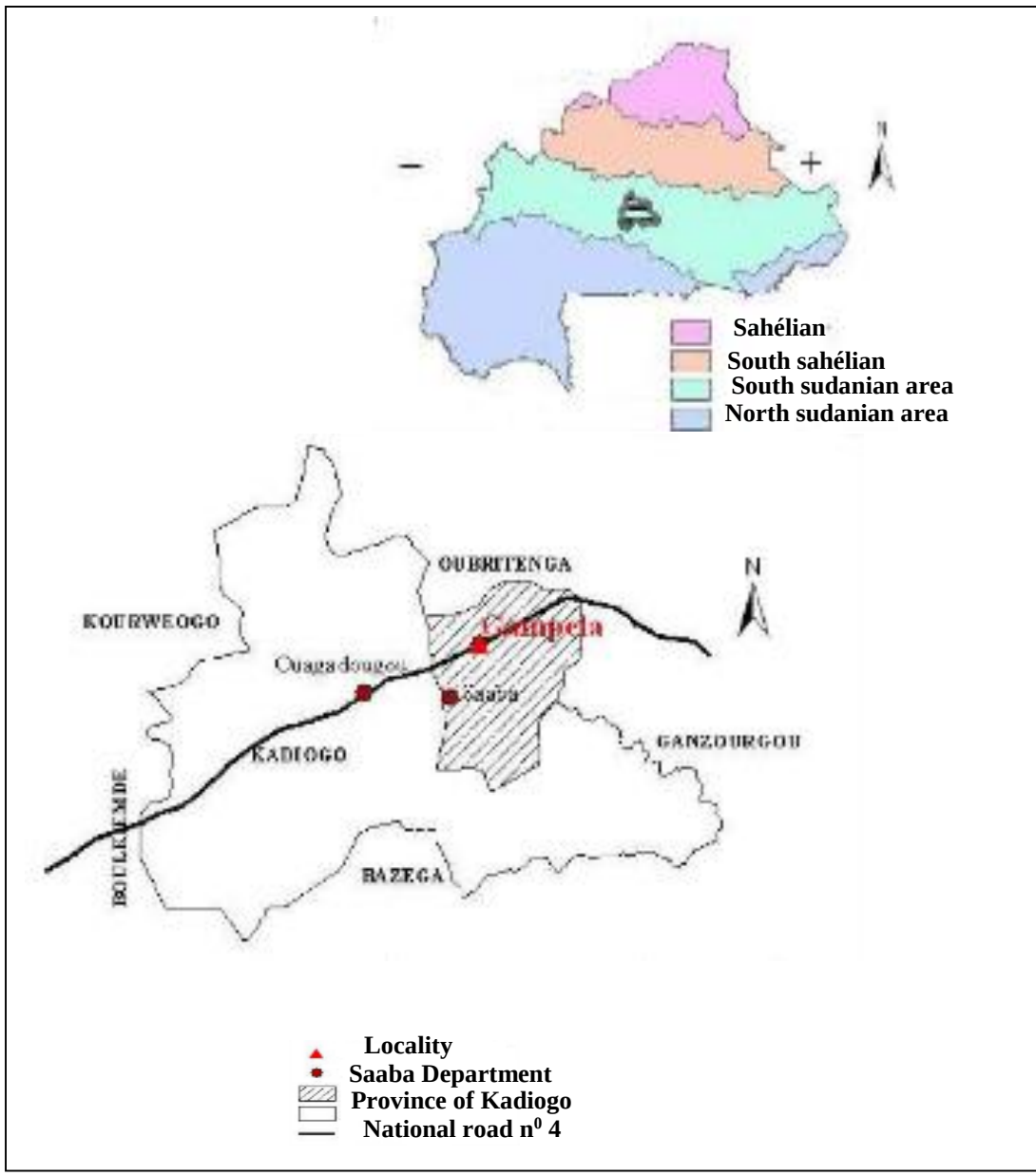

Figure 1: Gampela Research Station (Kagambega, 2006).

Table 2: Modified 9-point scale used for field screening groundnut genotypes for resistance to late leaf spot.

Disease Score	Description
1	No disease
2	Some lesions on old leaves; no defoliation
3	Some small spots mainly on old leaves, very few on middle leaves; defoliation

4	Spots on lower and middle leaves but severe on lower leaves; obvious defoliation of some leaflets on lower leaves
5	Visible spots on lower and middle leaves; yellow and moderate sporulation, fall of some basal leaves.
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
7	Lesions on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves
8	Defoliation of all lower and middle leaves; severe lesions on top leaves; some defoliation of top leaves evident
9	Almost all leaves defoliated, leaving bare stems ; some leaflets may remain, but show severe leaf spots

Subrahmanyam et al., 1995)

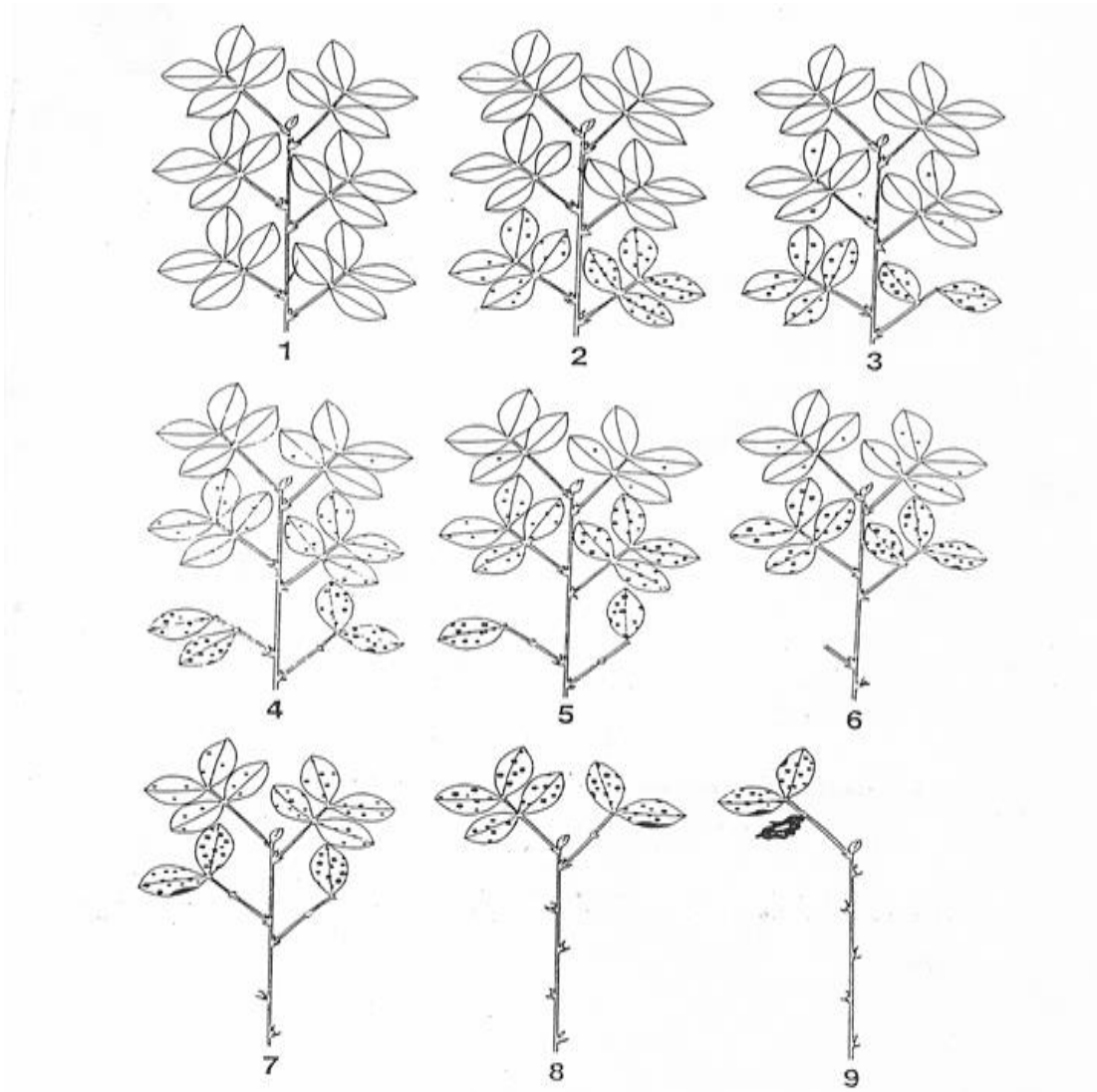

Figure 2: Modified 9-point disease scale for field evaluation of late leaf spot (Rao et al., 1990).

RESULTS

Evaluation of the severity of leaf spot diseases and the percentage of defoliation

Table 3 shows the results of the analysis of variance of the last leaf spot scores and the average percentages of defoliation at the time of harvest. Variance analysis for the severity of leaf spot showed a very highly significant difference between the different genotypes at the 5% threshold (P <0.0001). Leaf spot disease severity scores range from 2 to 7.5. The genotypes IP137, IP87, IP84, IP83, IP78, IP180, IP176, IP196, IP184, IP169, IP27, IP177, IP26, IP74, IP178 and the sensitive control TS32-1 recorded the highest leaf spot scores between 6 and 7.5. They are statistically superior to other genotypes. The PC79-79 genotype scored 3.5; it is statistically equivalent to thirteen (13) other genotypes. For the percentage defoliation character whose average is 53.77%. The genotype with the highest score is IP83 with 96, 93%, and is statistically equivalent to 13 genotypes including the susceptible genotype with defoliation percentages between 77.46 and 94.46%. The lowest rates were recorded by the IP158, IP19, IP20, IP167, IP35, IP135, IP61, IP148, IP136, IP40, IP94 genotypes and the PC79-79 control.

The yield is in t / ha

The analysis of variance in mean yields revealed a non-significant difference between genotypes. The pod yield averages 1.50 t / ha in the site. The IP63 genotype had the highest yield (2.70 t / ha). All genotypes are statistically equivalent with the letter "a" and yield between 0.64 and 2.70 tons. The lowest yield was recorded by the IP148 genotype (0.64 t / ha). The resistance control, PC 79-79 gave a yield of 1.44 t / ha and the sensitive control TS32-1 1.93t / ha.

Table 3: Average values for leaf spot, percent defoliation and yield.

Genotypes	Leaf spot	Genotypes	DF	Genotypes	Yield (t/ha)
IP137	7,50 a	IP83	96,93 a	IP63	2,70 a
TS32-1	7,50 a	IP84	94,46 ab	IP83	2,27 ab
IP87	7,33 ab	IP137	94,33 ab	IP42	2,20 ab
IP84	7,33 ab	TS32-1	92,76 ab	IP172	2,16 ab
IP83	7,33 ab	IP176	91,40 ab	IP59	2,14 ab
IP78	7,16 a-c	IP180	90,93 ab	IP82	2,14 ab
IP180	7,16 a-c	IP87	90,10 ab	IP198	2,14 ab
IP176	7,16 a-c	IP78	89,96 ab	IP201	2,06 ab
IP196	6,83 a-d	IP184	82,90 a-c	IP66	2,00 ab
IP184	6,66 a-e	IP178	80,36 a-d	IP29	1,99 ab
IP169	6,66 a-e	IP177	79,80 a-d	TS32-1	1,93 ab
IP27	6,50 b-e	IP26	78,90 a-e	IP199	1,91 ab
IP177	6,50 b-e	IP196	78,70 a-e	IP57	1,91 ab
IP26	6,33 c-f	IP169	77,46 a-f	IP178	1,83 ab
IP74	6,16 d-g	IP74	76,40 b-g	IP96	1,81 ab
IP178	6,00 d-h	IP27	76,03 b-h	IP40	1,81 ab
IP82	5,83 e-i	IP189	69,26 c-i	IP19	1,78 ab
IP171	5,83 e-i	IP109	67,66 c-j	IP145	1,76 ab
IP189	5,50 f-j	IP82	66,73 c-k	IP35	1,70 ab
IP172	5,50 f-j	IP172	64,10 c-l	IP4	1,68 ab
IP58	5,33 g-k	IP171	62,06 d-m	IP167	1,68 ab
IP89	5,33 g-k	IP66	59,03 e-n	IP124	1,65 ab
IP62	5,33 g-k	IP113	58,50 f-n	IP170	1,64 ab
IP109	5,33 g-k	IP145	58,03 f-n	IP177	1,64 ab

IP43	5,16 h-l	IP191	57,93 f-n	IP171	1,63 ab
IP201	5,16 h-l	IP159	57,76 f-n	IP94	1,62 ab
IP113	5,16 h-l	IP92	57,20 g-n	IP62	1,62 ab
IP145	5,00 i-m	IP60	56,83 g-n	IP18	1,59 ab
IP128	5,00 i-m	IP62	56,66 g-n	IP180	1,58 ab
IP92	5,00 i-m	IP58	56,13 g-o	IP184	1,57 ab
IP75	5,00 i-m	IP89	55,76 h-o	IP61	1,57 ab
IP191	5,00 i-m	IP37	55,56 i-o	IP139	1,56 ab
IP41	5,00 i-m	IP8	55,33 i-p	IP189	1,56 ab
IP66	5,00 i-m	IP141	55,16 i-p	IP7	1,54 ab
IP8	4,83 j-n	IP41	54,96 i-p	IP136	1,53 ab
IP39	4,83 j-n	IP199	54,80 i-p	IP89	1,51 ab
IP38	4,83 j-n	IP7	54,76 i-p	IP27	1,49 ab
IP70	4,83 j-n	IP59	54,73 i-p	IP87	1,48 ab
IP63	4,83 j-n	IP197	54,66 i-p	IP159	1,47 ab
IP7	4,83 j-n	IP63	54,53 i-p	IP113	1,47 ab
IP59	4,66 j-o	IP75	54,33 i-p	IP60	1,45 ab
IP159	4,66 j-o	IP124	53,83 i-p	PC79-79	1,44 ab
IP18	4,66 j-o	IP57	52,36 i-q	IP141	1,44 ab
IP37	4,66 j-o	IP201	52,16 i-q	IP37	1,43 ab
IP124	4,66 j-o	IP128	51,20 i-q	IP164	1,43 ab
IP141	4,66 j-o	IP153	50,70 i-r	IP191	1,43 ab
IP60	4,66 j-o	IP38	50,46 i-r	IP197	1,42 ab
IP170	4,50 k-p	IP170	50,13 i-r	IP169	1,40 ab
IP199	4,50 k-p	IP43	48,63 i-r	IP58	1,40 ab
IP42	4,50 k-p	IP18	48,03 j-r	IP89	1,51 ab
IP57	4,33 l-q	IP107	46,80 j-r	IP27	1,49 ab
IP198	4,33 l-q	IP22	45,73 k-s	IP87	1,48 ab
IP197	4,33 l-q	IP70	45,23 l-s	IP159	1,47 ab
IP107	4,33 l-q	IP185	45,10 l-s	IP113	1,47 ab
IP153	4,16 m-r	IP42	44,36 l-s	IP60	1,45 ab
IP29	4,00 n-s	IP39	43,20 l-t	PC79-79	1,44 ab
IP164	4,00 n-s	IP198	42,60 m-u	IP141	1,44 ab
IP139	3,83 o-t	IP164	41,06 m-u	IP37	1,43 ab
IP185	3,83 o-t	IP138	40,76 n-u	IP8	1,33 ab
IP96	3,66 p-u	IP2	35,66 o-v	IP138	1,32 ab
PC79-79	3,50 q-u	IP139	34,60 o-v	IP78	1,28 ab
IP138	3,33 r-u	IP96	32,03 q-w	IP84	1,24 ab
IP19	3,33 r-u	IP29	30,43 r-w	IP74	1,21 ab
IP2	3,33 r-u	IP4	26,16 s-w	IP158	1,19 ab
IP167	3,16 s-u	PC79-79	25,63 s-w	IP176	1,17 ab
IP20	3,00 t-u	IP94	24,20 t-w	IP2	1,10 ab
IP4	3,00 t-u	IP40	23,90 t-w	IP153	0,91 ab
IP136	3,00 t-u	IP136	23,16 t-w	IP70	0,90 ab
IP135	3,00 t-u	IP148	22,93 u-w	IP41	0,89 ab
IP94	3,00 t-u	IP61	20,50 v-w	IP185	0,87 ab
IP61	3,00 t-u	IP135	20,26 v-w	IP20	0,84 ab
IP40	3,00 t-u	IP35	19,50 v-w	IP92	0,81 ab
IP35	3,00 t-u	IP167	19,46 v-w	IP26	0,80 ab
IP22	3,00 t-u	IP20	19,40 v-w	IP128	0,78 ab

IP148	2,83 u	IP19	18,53 v-w	IP39	0,71 ab
IP158	2,00 v	IP158	13,93 w	IP148	0,64 b
LSD test	VHS	**LSD test**	VHS	LSD test	NS
SD	1,39	**SD**	18,63	**SD**	0,58
Average	4,85	**Average**	57,26	**Average**	1,50
P<LSD	0,0001	**P<LSD**	0,0001	**P<LSD**	0,16

Geno: Genotype, **Yield (t / ha)** = yield in tons per hectare; **W100GS** = weight of 100 good seeds **VHS:** Very Highly Significant, SD: Standard Deviation.
DF: Defoliation, VHS: Very Highly Significant, SD: Standard Deviation.

DISCUSSION

The average leaf spot rating was 4.85. This average is relatively low this is in line with the results of (Neya, 2007) who found that the Gampela site in the central region has low ratings. This low average will be explained by the fact that the rainfall was low with an average of 665.1 mm from our semi date. In fact, environmental conditions required for both types of leaf spot are the long periods of high humidity or leaf wetness Tshilenge Lukanda et al. (2012). The notation has shown that the genotypes TS32-1, IP137, IP87, IP84, IP83, IP78, IP180, IP176 are sensitive and the other genotypes resist (medium or strong) to leaf spot. The resistance of these could be explained by the presence of an additive gene that would control this resistance. In additionally, Khedikar et al. (2010) reported that the genetic determinism of this resistance is polygenic and is probably controlled by several recessive genes. The observation of the results of the defoliation indicates that it was very strong this year on the site of Gampela. Defoliation is a natural phenomenon related to leaf senescence and is aggravated by factors such as leaf spot attack and drought. In our case, it is very likely that it is drought. Indeed, the rainfall for this year 2016 was characterized by a dry pocket throughout the month of October. The amount of rain recorded during this month was 3mm. These repeated droughts could explain the strongest defoliation recorded in this site. Our results are similar to those of Neya et al. (2013) who worked under the same Gampela conditions and noted that defoliation accelerates at the end of vegetation (mid-October) when there is a relative drought situation. This does not exclude the fact that it may be related to the severity of leaf spot. Indeed, Hamasselbe et al. (2011); Gaikpa et al. (2015), believe that there is a strong positive (or negative) correlation between the severity of leaf spot attack and defoliation. Finally, genotypes did not all have the same percentage of defoliation. This could be explained by their intrinsic capacity to control leaf abscission (Neya, 2007). For yield, the average genotype was 1.5 t / ha which is generally satisfactory. These results are in agreement with those of (Sirima ,2013) who worked on genotypes of American origin. This situation is largely linked to the nature of the soil. Indeed, SANKARA in 1997 showed that Gampela soils are suitable for groundnut cultivation because of their richness in mineral elements. The best yields were obtained by genotypes that showed a moderate level of resistance to leaf spot but also by some sensitive genotypes. This high yield of susceptible genotypes is explained by their intrinsic ability to tolerate the disease. It is possible that these genotypes can complete their cycles before the intervention of the disease. In addition, Mendez et al. (2016) noted that early genotypes are able to dodge the disease while late genotypes are unable to dodge because of the length of their cycles. This does not rule out the decrease in yield related to the sensitivity of the disease. Indeed, Thakur et al. (2012) reported that leaf spot is the main peanut disease that causes 50% yield loss and more.

Conclusion

The appraisal of the performances of Indian genotypes went through an estimation of several parameters which allowed us to enrich our knowledge on these different

genotypes. At the end of this study, we take into account the different results obtained, that the site of Gampela is conducive to the cultivation of peanuts. The appraisal of these genotypes shows through the analysis of their performances that they have a moderate resistance to the disease. We could say that the genotypes IP158, IP148, IP22, IP35, IP40, IP61, IP94, IP135, IP136, IP4, IP20, IP167, IP2, IP19, IP138, PC79-79, IP96, IP185, IP139 have good resistance to disease. Among these genotypes are the IP35 genotypes, IP40, IP94, IP19, IP96 and moderately resistant genotypes IP63, IP42, IP172, IP59, IP198, IP201, IP66 which have obtained satisfactory yields. They can be qualified as promising genotypes for future extension in peasant environments.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

RBS managed the literature research, designed the study, wrote the protocol, participated in data collection and performed the statistical analysis, and wrote article. KMLG managed the analyses of study, and wrote article. MBZ participated in data collection, data analysis and wrote the first draft of the manuscript. SN corrected the manuscript.PS was the principal investigator.

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