Combining Ability Analysis of Late Leaf Spot Resistance and other Agronomic traits in Nine Groundnut Genotypes.

Abstract

Late leaf spot (LLS) *Phaeoisariopsis personata* (Berk. and Curtis) Deighton is one of the most important foliar diseases of groundnut worldwide including Nigeria. The genotypes were used to estimate the general combining ability (GCA) and specific combining ability (SCA) for yield components and late leaf spot (LLS) resistance. Four susceptible genotypes (SAMNUT 23, SAMNUT 24, SAMNUT 25 and SAMNUT 26) were used as females and five resistant genotypes (ICGV 12991, ICGV 7878, FDR-F7 82, FDR-F7 67 and FDR-F7 61) were used as males using line x tester mating design with three replications. The parents and progenies were evaluated for late leaf spot resistance. Highly significant negative general combing ability (GCA) effects were recorded for disease incidence in SAMNUT 25 (-0.05), indicating the genotype is a good general combiner for late leaf spot (LLS) and SAMNUT 26 (-5.90) is a good general combiner for LLS disease severity. ICGV 12991 (-12.00), FDR-F7 67 (-.68) and FDR-F7 61 (-2.23) genotypes are good general combiner for late leaf spot (LLS) disease resistance (disease incidence and severity), among the crosses, significant and negative SCA effects were obtained for most of the crosses i.e SAMNUT 24 x FDR-F7 67 and SAMNUT 24 x FDR-F7 61 for late leaf spot (LLS) resistance indicating that they are good specific combiners for late leaf spot (LLS) resistance. The ratio of the general combining ability (GCA) and specific combing ability (SCA) variances indicated the preponderance of specific combining ability (SCA) variance over general combining ability (GCA) variance for disease incidence and severity, indicating the role of non-additive gene effect and it may be due to difference in genotypes used as parents.

Introduction

LLS is a devastating fungal disease which affect groundnut in Nigeria accounting for yield loss of over 60% (Okello *et al*., 2010). The disease is caused by *Phaeoisariopsis personata* with symptoms that are seen as small necrotic flecks that enlarge and become light to dark brown. Efforts have been made to control late leaf spot disease using a combination of cultural and chemical measures with limited success (Page *et al*., 2002). Use of fungicides to control leaf spots usually increases production costs by 10% (Coffelt and Porter, 1986). Effective chemical control is heavily reliant upon multiple fungicide applications (Jordan *et al*., 2012), which are costly for resource poor farmers in Nigeria, and as well raises environmental and health concerns with significant decrease in crude protein and fiber contents with increasing disease severity (Coffelt and Porter, 1986). These factors coupled with health hazards associated with the use of insecticides suggested the use of host plant resistance as the most effective and environmentally friendly control measure for the management of LLS. The use of resistant genotypes and genetic information on inheritance of LLS will help in the development and utilization of LLS resistant cultivars which will reduce production costs; and boost groundnut production in Nigeria. It is also necessary to know about the nature and magnitude of gene action responsible for controlling the inheritance of various yield attributes along with combining ability of the parents and their cross combinations in order to make use of them in further crop improvement program. The line×tester analysis is one of the efficient methods of evaluating large number of inbred as well as providing information on the relative importance of GCA and SCA effects for interpreting the genetic basis of important plant traits (Singh and Chaudhury, 1985). The most commonly used designs for combining ability studies are line x tester (L x T) and diallel analysis. Combining ability analysis following line x tester given by Kempthorne (1957) and Arunachalam (1974) is frequently used for testing the performance of lines in hybrid combinations. It is also useful in characterizing the nature and magnitude of gene action involved in controlling the quantitative traits. The general and specific combining ability effects and variances obtained from a set of F1s would enable a breeder to select desirable parents and crosses for each of the quantitative components separately. From their results Tatum and Spargue (1942) concluded that the general combining ability was mainly the results of additive gene action while the specific combining ability due to dominance, epistasis and genotypic environment interaction. Baker‟s ratio close to unity indicates additive.

Due to different genetic control of LLS and yield associated traits in various genetic materials, the objectives of the present study were therefore to identify general and specific combining abilities estimates for yield component and LLS resistance traits in nine groundnut genotypes.

Materials and Methods

The experimental materials for this study comprised of nine early maturing groundnut genotypes representing a range of resistance levels to LLS obtained from IAR Samaru. The resistant genotypes were validated in the 2013/2014 growing season IAR at the farm, Samaru. Five of the groundnut genotypes are resistant to the LLS, these are ICGV 12991, ICGV 7878, FDR-F7 82, FDR-F7 67 and FDR-F7 61 which were used as male. The other four genotypes are the improved and released material by IAR, which are all susceptible to the LLS. These are SAMNUT 23, SAMNUT 24, SAMNUT 25 and SAMNUT 26 which were used as females. The 20 F1 along with 9 parents were evaluated for LLS in the screen house using line x tester design in a randomized complete block design (RCBD) with three replications in 2016 growing season at the Institute for Agricultural Research (IAR) of the Ahmadu Bello University, Zaria, Nigeria. Two pots were allocated for each genotype and two seed were sown per pot. All the plant protection and agronomic measures were adopted. Thirty-five days old plants were inoculated with LLS at 10^6 conidia/ml inoculum concentrations. Hand held sprayer was used for the inoculation; 0.1 ml spore suspension was dropped on the leaves. High relative humidity around the plants was maintained by covering the plants with wet polythene bags 24 hours before inoculation. Inoculated plants were covered for another 24 hours to maintain high humidity. Plants were observed weekly for development of disease after inoculation and disease score was recorded using 1-9 scale describes by Subrahmanyam *et al*., (1995). Data were recorded on four randomly selected plants of each entry of each replication for plant height, days to 50% flowering, days to maturity, number of matured pods per plant, number of seeds per pod, 100-seed weight, LLS disease severity and LLS disease incidence. Data collected on disease severity and incidences were transformed using log10 and were all subjected to analysis of variance using General Linear Model procedure of Statistical Analysis System (SAS) package (SAS, 2002). The combining abilities (GCA and SCA) estimates were carried out as per Singh and Chaudhury (1985).

Table 1: Description of Leaf Spot scale (1-9)

Leaf spot score	Description	Disease Severity (%)
1	No disease	0
2	Lesion larger on lower leaves, no defoliation	1 – 5
3	Lesion larger on lower leaves, very few lesion on middle leaves, defoliation of some leaflets evident	6 – 10
4	Lesion on the lower middle leaves, but severe on lower leaves, defoliation of some leaflets evident on lower leaves	11 – 20
5	Lesion on all lower and middle leaves, over 50% defoliation of lower leaves	21 – 30
6	Lesion severe on lower and middle leaves, defoliation of some leaflets evident on middle leaves	31 – 40
7	Lesion on all leaves but less severe on top leaves, defoliation of all lower and some middle leaves	41 – 60
8	Defoliation of almost all middle leaves, lesion severe on top leaves and some defoliation of top leaves evident	61 – 80
9	Defoliation of almost all leaves having bare stems, some leaflets may be present, but with severe leaf spot	81– 100

Results and Discussion

The analysis of variance for male parents revealed the presence of significant variation for all studied traits except days to 50% flowering and days to maturity traits. Further partitioning of variance indicated lack of variability among females for important characters *viz* disease incidence and disease severity. The crosses showed a significant difference among all investigated traits except plant height, days to 50% flowering and days to maturity traits. (Table 2).

The results of the general combining ability (GCA) are presented in Table 3. Negative GCA effect observed for days to maturity trait is required for the development of early maturing genotype as reported by Vishnuvardhan, *et al.* (2012). The negative and significant GCA effect exhibited by SAMNUT 25 indicated that it is a good general combiner for disease incidence. SAMNUT 26 is a good general combiner with a negative and significant GCA effect for disease severity. ICGV 12991, FDR-F7 67 and FDR-F7 61 are good general combiners with negative GCA effects on LLS resistance.

The progenies with negative SCA effects for disease incidence and disease severity SAMNUT 24 x FDR-F7 61 and SAMNUT 25 x FDR-F7 67 crosses were identified as the most promising genotypes in breeding program for LLS resistance traits. These progenies originated from parents with positive GCA values in negative direction. This suggest the difficulty in predicting the *P. personata* resistant level of the progenies based on GCA alone and should necessitate testing of specific male x female combinations (John *et al.*, 2012). Arunga *et al.* (2010) reported that the SCA effect alone has limited value for parental choice in breeding programs. They, therefore suggested that SCA effects should be used in combination with other parameters, such as hybrid means and the GCA of the respective parents such that hybrid combination with both high mean and favorable SCA estimates and involving at least one of the parents with high GCA, would tend to increase the concentration of favorable alleles; which is desired by any breeder (Cruz and Regazzi, 1994). Furthermore, it was observed that crosses involving one good combiner and one average or poor combiner showed negative SCA effects. For instance, SAMNUT 25 and FDR-F7 67 genotypes have a poor GCA values for disease incidence and severity resistance, while their cross shown a negative and desirable SCA effects. This manifestation of progenies having reactions not related to the parent's attributes introduced a different dimension in the inheritance of groundnuts resistance to LLS. John *et al.* (2012) and Ayo-Vaughan *et al.* (2013) observe similar phenomena in groundnuts and cowpeas, respectively and attributed it to genetic interaction between favorable alleles and between unfavorable alleles contributed by both parents. This suggests that inheritance of this trait is not simple and that inter-allelic interactions due to epistasis could be responsible. However, SCA effects are not very important for crops like groundnuts that are highly self-pollinated and difficult to produce commercial hybrids, a point advanced by Kimani and Derera (2009) while working on beans; self-pollinated counterpart of groundnut. (Table 4).

The relative importance of GCA to SCA variance was judged from the ratio of the GCA to SCA variance which helps to indicate the predominance of either additive or non-additive action (Ji *et al.*, 2006). The predominance of non-additive genetic variance over additive genetic variance indicated by the values with magnitude less than unity for all the traits measured, it may be due to differences in the genotypes used as parents as stated by Abul-Kalam, *et al.* (2014), (Table 5).

Conclusion

The study revealed ample genetic variability for the agronomic traits in the parents used for the study.

There was however, the preponderance of non-additive gene action to the inheritance of LLS as indicated by Baker‟s ratio which was less than unity.

Table 2: Mean Squares for some Agronomic Traits and Late Leaf Spot of Groundnut Genotypes Generated using North Carolina Design II Evaluated at Samaru in 2016.

Sources of variation	Df	PLHT(cm)	50% F	DM	MPPP	SPP	SWGT(g)	DI (%)	DS (%)
Rep	2	16.65	19.72	18.15	0.82	0.02	0.16	0.05	0.07
Male	4	59.85**	2.28	10.03	35.79**	0.20**	1.63**	0.02**	0.03**
Female	3	10.27	1.93	33.91**	28.06**	0.26**	65.38**	0.01	0.01
Female x Male	1	12.85	4.72	4.37	24.88*	0.12*	4.44**	0.01*	0.01**

	2				*	*		*	
Error	38	12.70	6.97	5.63	0.97	0.01	0.14	0.01	0.01

** = 0.01 probability levels respectively. PLHT (cm) = plant height, 50%F=days to 50% flowering, DM=days to maturity, MPPP= number of mature pod per plant, SPP= number of seed per pod, SWGT (g), = 100 seed weight, DS (%) =disease severity in percentage, DI (%) =disease incidence in percentage.

Table 3: Estimates of General Combining Ability effects of Groundnut Genotypes Evaluated for some Agronomic Traits and Late Leaf Spot at Samaru in 2016

GENOTYPE	PLHT(cm)	50%F	DM	MPPP	SPP	SWGT(g)	DI (%)	DS (%)
Males								
ICGV12991	-3.18**	0.37	-20.87**	-0.50	-0.13**	3.28**	-0.01	-12.00**
ICGV 7878	-0.93	-0.35	23.72**	-1.12**	0.10**	6.72**	0.01	2.08**
FDR-F7 82	0.07	0.45	27.05**	1.22**	0.02	-3.02**	-0.02	0.83**
FDR-F7 67	1.07	0.12	23.63**	-1.25**	-0.19**	-2.02**	0.04*	-0.68**
FDR-F7 61	-0.20	-0.22	26.80**	1.15**	0.08**	-1.68	-0.03	-2.23**
SE±	0.92	0.68	0.61	0.25	0.02	1.85	0.02	0.02
Females								
SAMNUT 23	2.40**	-0.63	-20.80**	0.33	0.13**	1.03	0.06**	11.93**
SAMNUT 24	-0.85	0.45	-20.07**	2.25**	0.13**	0.53	0.01	6.00**
SAMNUT 25	1.82*	-0.13	-20.40**	-1.75**	-0.02	-1.80	-0.05**	-0.02
SAMNUT 26	-0.18	-0.05	-19.07**	-0.33	-0.12*	-3.05	-0.01	-5.90**
SE±	1.03	0.76	0.69	0.28	0.03	2.07	0.02	0.02

* and ** = significant at 0.05 and 0.01 probability levels respectively. PLHT (cm)= plant height, 50%F=days to 50% flowering, DM=days to maturity, MPPP= number of mature pod per plant, SPP= number of seed per pod, SWGT(g),= 100 seed weight, DS (%)=disease severity in percentage, DI (%)=disease incidence in percentage.

Table 4: Estimates of Specific Combining Ability effects of Groundnut Genotypes Evaluated for some Agronomic Traits and Late Leaf Spot at Samaru in 2016.

CROSSES	PLHT(cm)	50% F	DM	MPPP	SPP	SWGT(g)	DI(%)	DS (%)
SAMNUT 23 x ICGV12991	-4.07	-1.23	-0.23	-3.80**	-0.25**	-11.30*	-0.04	-0.74**
SAMNUT 23 x ICGV7878	2.85	2.35	-0.48	0.95	-0.02	1.87	-0.05	0.22**
SAMNUT 23 x FDR F782	0.85	-0.40	0.27	1.28*	0.00	6.20	0.06	0.13**
SAMNUT 23 x FDR F767	-0.15	-0.82	-1.40	3.53**	0.16**	-0.88	0.00	0.19**
SAMNUT 23 x FDR F761	0.52	0.10	1.85	-1.97**	0.11*	4.12	0.04	0.20**
SAMNUT 24 x ICGV12991	0.93	-0.03	0.10	2.53**	0.02	-1.57	0.06	0.34**
SAMNUT 24 x ICGV7878	-0.15	-0.78	0.85	3.62**	0.05	6.27	0.04	-0.01
SAMNUT 24 x FDR F782	0.52	-0.20	-0.40	-0.72	-0.10*	-3.40	0.00	-0.12**
SAMNUT 24 x FDR F767	0.52	1.05	0.93	-4.47**	0.14*	6.52	0.00	-0.09*
SAMNUT 24 x FDRF761	-1.82	-0.03	-1.48	-0.97	-0.11*	-7.82	-0.10*	-0.11*
SAMNUT 25 x ICGV12991	1.60	0.63	1.50	1.33*	0.23**	11.77*	-0.03	0.22**
SAMNUT25 x ICGV7878	-2.15	-1.78	-0.42	-0.92	-0.10*	-1.40	0.06	-0.08*
SAMNUT 25 x FDR F782	0.52	1.47	-1.00	-0.25	0.28**	0.60	-0.04	-0.06
SAMNUT 25 x FDR	0.85	-0.95	-	-0.67	-	-2.15	-	-0.08*

F767			0.33		0.22**		0.08*	
SAMNUT 25 x FDR F761	-0.82	0.63	0.25	0.50	-0.20**	-8.82*	0.09*	-0.01
SAMNUT 26 x ICGV12991	1.53	0.63	-1.37	-0.07	0.00	1.10	0.01	0.18**
SAMNUT 26 x ICGV7878	-0.55	0.22	0.05	-3.65**	0.07	-6.73	-0.04	-0.13**
SAMNUT 26 x FDR F782	-1.88	-0.87	1.13	-0.32	-0.18**	-3.40	-0.01	0.05
SAMNUT 26 x FDR F767	-1.22	0.72	0.80	1.60*	-0.08	-3.48	0.08	-0.02
SAMNUT 26 x FDR F761	2.12	-0.70	-0.62	2.43**	0.20**	12.52**	-0.03	-0.08*
SE±	2.06	1.52	1.37	0.57	0.05	4.13	0.04	0.04

* and ** = significant at 0.05 and 0.01 probability levels respectively. PLHT (cm)= plant height, 50%F=days to 50% flowering, DM=days to maturity, MPPP= number of mature pod per plant, SPP= number of seed per pod, SWGT(g),= 100 seed weight, DS (%)=disease severity in percentage, DI (%)=disease incidence in percentage.

Table 5: Component GCA and SCA Variance of Groundnut Genotypes Evaluated for some Agronomic Traits and Late Leaf Spot at Samaru in 2016.

Estimates	PLHT(cm)	50%F	DM	MPPP	SPP	SWGT(g)	DI(%)	DS (%)
σ^2_{GCA}	8.57	3.15	2.91	16.59	0.08	2.96	0.01	0.01
σ^2_{SCA}	40.99	-9.59	30.09	63.46	0.44	63.38	0.02	0.03
$\frac{\sigma^2_{GCA}}{\sigma^2_{SCA}}$	0.21	-0.33	0.10	0.26	0.18	0.05	0.40	0.27

PLHT(cm)= plant height, 50%F=days to 50% flowering, DM=days to maturity, MPPP= number of mature pod per plant, SPP= number of seed per pod, SWGT(g)= 100 seed weight, DS (%)=disease severity in percentage, DI (%)=disease incidence in percentage.

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