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FIELD ASSESSMENT OF GROUNDNUT (*ARACHIS HYPOGEAE* L.) ADVANCED BREEDING LINES FOR RESISTANCE TO *FUSARIUM* WILT AND POD ROT DISEASES IN KANO STATE, NIGERIA

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ABSTRACT

Fusarium wilt and Pod rot are serious diseases of groundnut in Kano state. Thirty-two advanced breeding lines and four improved varieties of groundnut were evaluated against *fusarium* wilt and pod rot diseases in the field under natural inoculums in ICRISAT research station of Minjibir, Kano state, during the2020 rainy season. Among the tested breeding lines and checks, complete resistance to *fusarium* wilt and pod rot was present on 20 breeding lines such as ICGV's 00338, 02005, 06143, 06149, 06183, 07106, 07213, 07406 and 2 improved varieties (SAMNUT 22 and 24). Strong and negative effects of these diseases were observed on the yield and agronomic components viz., pod and fodder yield, hundred seed weight, chlorophyll content and normalised difference vegetation index. However, ICGV's 06183, 07390 and 00338 were both high yielding and highly resistant to *fusarium* wilt and pod rot diseases; hence they could be utilized in breeding program to develop resistant and high yielding varieties in Kano state, Nigeria.

Keywords: Groundnut; *Fusarium* wilt; Pod rot; Resistance; Yield.

INTRODUCTION

Groundnut (*Arachis hypogeae* L.) is native to South America and now cultivated in more than hundred (100) countries, covering an area of 26.4 million hectare with current annual production of about

47.6 million metric tonnes round the world [International Nut and Dried fruit (INC, 2020-2021)]. It is valuable and economically important oilseed and cash crop, grown extensively in the savannah region of Nigeria, and it is cultivated for direct consumption as food and for industrial use (Abalu, 1996). Nigeria is the largest producing country in West Africa, accounting for 51%, also contributes 8% of total global production and 39% that of Africa (FAO, 2004).

A variety of stresses affect groundnut production from sowing to storage. Among these, disease is the major stress. Different diseases hamper groundnut production (Ganesan and Sekar, 2004). These include fungal, viral, bacterial and nematode diseases (Smith, 1994). The majority of the diseases are caused by fungi and several of them cause reduction in yield at varying quantities in different regions and seasons (Mayee, 1995). Among these fungi, soil borne fungal pathogens that causes serious losses have prime importance (Mathur and Cunfer, 1993). *Aspergillus flavus*, *Aspergillus niger*, *Curvularia* spp., *Fusarium solani*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Mucor*, *Rhizoctonia solani*, *Rhizophus* spp., *Penicillium* spp., *Pythium* spp. and *Sclerotium rolfsii* (Sadashivaiah *et al*., 1986; Parvathi *et al*., 1985; Aliyu and Kutama, 2007) are serious pathogens of groundnut round the globe as well in Nigeria.

Generally, these pathogens infect underground parts of the plant and reduce yield (Wisniewska and Chelkowski, 1999). In groundnut growing areas of the world, pod rot and *fusarium* wilt are serious diseases with 95% incidence. Host resistance is the fundamental constituent for disease management in plants. Performance of resistant cultivars is better than cultivars with low disease resistance, particularly in favourable environmental conditions for disease development. Therefore, the present study is designed to investigate resistance in groundnut advanced breeding lines against pod rot and *fusarium* wilt.

MATERIAL AND METHODS

Experimental site and design

The experiment was conducted during the 2020 rainy season at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Research Farm at Minjibir, Kano (latitude 12º10¹42N, longitude 8º39¹33E). This location has a soil type of sandy loam and is characterized by two seasons: a wet season (May to September) and dry season (October to April), with a mean annual rainfall, temperature, relative humidity, wind speed and sunlight of about 800mm, 31ºC, 90.0 %, 1.8 m/s and 1054 W/m^2 respectively. The treatment comprised of 32 groundnuts advanced breeding lines and 4 improved varieties as checks. These breeding lines were developed by and sourced from ICRISAT, Kano while, the improved varieties were developed by ICRISAT/Institute for Agricultural Research (IAR) Samaru, Ahmadu Bello University, Zaria and sourced from ICRISAT as indicated in table 1 below. They were laid out in a Randomised Complete Block Design (RCBD) with 3 replications and 4 blocks per replicate. The experimental field was ploughed, harrowed and ridged to 75 cm (0.75 m) apart, then marked out into four (4) blocks per replicate, each block was divided into 9 plots of 6.0 m^2 (4x1.5 m) with 0.75 m and 1.0 m spacing left out as discard between blocks and replicate. Groundnut seeds were sown at 75 cm inter row and 10 cm intra row spacing with 1 seed per hole. Precaution was taken to ensure uniform and proper depth of planting (5 cm).

Table 1: Description of the Groundnut Varieties

Variety	Original name	Characteristics	Origin/ Source	Breeders	Max yield	Release	Registered
SAMNUT 22	ICIAR 19BT	-Extra early maturing -Rosette resistant -High oil cont	IAR, Samaru	Echeku C.A et al.	2t/ha	2011	2011
SAMNUT 23	ICCGV-1596894	-Extra early maturing -Rosette resistant	ICRISAT Kano	Olorunju P.E	t/h	2000	2001
SAMNUT 24	ICIAR 19BT	-Extra early maturing -Rosette resistant -High oil cont	IAR, Samaru	Echeku C.A et al.	2t/ha	2011	2011
SAMNUT 26	ICGX-SM-00018/P5/P15/P2	-Highrosette resistant -High yield -Early maturity	ICRISAT Kano	Echeku C.A et al.	3.8t/ha	2013	2013

Source: Nigerian Seed Portal Initiative, 2020

Data collection

Stand count

This was carried out by counting the number of seeds that germinated at 12 days after sowing (DAS).

Days to 50 per cent flower

This was made by counting the number of days from sowing to when 50 per cent of the stands in a plot flowered (Yoshitaka, 1979, Demelash and Yasin, 2020).

Chlorophyll content

Three plants per plot were selected randomly at 62 DAS (flowering), the fully opened leaf from the main axis was chosen and read for chlorophyll using chlorophyll meter [SPAD-502 Plus, Konica Minolta, INC, Japan (Samdur *et al.,* 2000)]. This device determines the relative amount of chlorophyll present by measuring the absorbance of the leaf in two wavelengths. It has good features like trend graph display, compact and lightweight, quick easy measurement, water resistant, low power consumption, small measuring area and high accuracy.

Normalized difference vegetation index (NDVI)

This is determined at ground level by the use of commercially available device called GreenSeeker. It emits electromagnetic radiation through two types of light emitting diodes, in the red (650nm) and near infrared (770nm) electromagnetic spectrum ranges toward the crops, in which the crops absorb and reflect part of this radiation. The reflection is captured through optical sensors which are then processed internally to calculate the NDVI (Cortinove *et al.,* 2012). Evaluation with this device was manually performed by passing it over the plant tops at 0.50 m height approximately. Data were collected when crops were fully developed (phase of pod maturation), approximately 100 DAS (Cristiano *et al*. 2016).

Disease incidence

Fusarium wilt on groundnut is determined by observing the symptoms as vein clearing, leaf epinasty, wilting, chlorosis, necrosis, and abscission. Severely infected plants wilt and die (Agrios, 1997) while, pod rot shows various degrees of discoloration, from superficial russet to complete blackening of the pod, plus various stages of pod and kernel decay (Melouk and Backman, 1995). The incidence of *Fusarium* wilt was assessed at 45 (DAS) and pod rot at harvest, by counting the number of plants infected as indicated above, and expressing it as a percentage of the total number of plants per plot as given as

$$\text{Disease incidence (\%)} = \frac{No.of diseased plants}{Total no.of plants examined} \times \frac{100}{1}$$

Disease Severity

Disease severity (*fusarium* wilt and pod rot) was assessed based on a modified rating scale of increasing severity of 1-5 (Aart and Macial, 1994; Lewis and Filonow 1990). Disease score 1 means 0% infection; 2 for 1–20%; 3 for 21–60%; 4 for 61–80%; 5 for 81–100%. Breeding lines with a disease score 4-5 were considered susceptible and highly susceptible

Yield/Yield Components

Dry Weight of Pods per Hectare

After hand picking the pods, they were then sun dried on the ground to less than 10% moisture content, the dried and cleaned (removal of pegs, leaf debris, sand, diseased and unfilled pods etc.) pods were weighed and extrapolated to kg per hectare.

Dry Weight of Fodder per Hectare

After hand picking the pods, the haulms were dried in the field for 4-5 days. The dried haulms were weighed per plot and expressed in kg per hectare.

100 Seed Weight

This was done by counting 100 seed per plot and weighed using electronic weighing balance.

Statistical Analysis

The data collected were summarised using Microsoft Excel software. Percentage data were transformed using arcsine transformation in Microsoft Excel prior to analysis of variance. GenStat Statistical Software (17.0 edition) was used for analysis of variance and to find correlations among means. Means were separated at 5% level of probability using Student Newman Keuls (SNK).

RESULTS AND DISCUSSION

Among the tested groundnut advanced breeding lines and the improved varieties, complete resistance to pod rot and *fusarium* wilt was present on 20 breeding lines and 2 checks (Table 2). The groundnut lines ICGVs 06138, 06151, 07405 were among the lines that exhibited high level of resistance to pod rot with minimum disease incidence (Figure 1).

Table 2: Disease Severity Rating and Reaction of 32 Advanced Breeding Lines and 4 Improved Varieties of Groundnut to *Fusarium* Wilt and Pod Rot Diseases

Advanced Breeding Lines	*Fusarium* wilt	Reaction	Pod rot	Reaction
ICGV 00338	3.0	Resistant	2.8	Highly resistant
ICGV 02005	3.3	Resistant	2.6	Highly resistant
ICGV 02038	4.0	Susceptible	4.4	Susceptible
ICGV 06138	4.3	Susceptible	3.2	Resistant
ICGV 06139	3.0	Resistant	4.2	Susceptible
ICGV 06142	4.1	Susceptible	3.5	Resistant
ICGV 06143	1.4	Immune	3.7	Resistant
ICGV 06144	3.3	Resistant	3.4	Resistant
ICGV 06145	1.3	Immune	3.1	Resistant
ICGV 06149	2.1	Highly resistant	2.2	Highly resistant
ICGV 06150	4.5	Susceptible	3.5	Resistant
ICGV 06151	3.2	Resistant	2.8	Highly resistant
ICGV 06176	4.6	Susceptible	3.1	Resistant
ICGV 06183	3.0	Resistant	2.8	Highly resistant
ICGV 06237	3.8	Resistant	3.0	Resistant
ICGV 07106	1.0	Immune	2.9	Highly resistant
ICGV 07210	3.4	Resistant	3.4	Resistant
ICGV 07211	3.7	Resistant	3.0	Resistant
ICGV 07213	3.1	Resistant	3.2	Resistant
ICGV 07214	4.2	Susceptible	3.3	Resistant
ICGV 07235	4.4	Susceptible	3.9	Resistant
ICGV 07270	4.0	Susceptible	4.3	Susceptible
ICGV 07273	4.2	Susceptible	3.6	Resistant
ICGV 07286	3.2	Resistant	3.8	Resistant
ICGV 07390	3.2	Resistant	2.4	Highly resistant
ICGV 07392	4.7	Susceptible	2.9	Highly resistant
ICGV 07395	3.5	Resistant	2.2	Highly resistant
ICGV 07396	3.8	Resistant	2.5	Highly resistant
ICGV 07403	4.0	Susceptible	1.9	Immune
ICGV 07404	3.0	Resistant	2.9	Highly resistant
ICGV 07405	1.4	Immune	2.3	Highly resistant
ICGV 07406	3.2	Resistant	2.8	Highly resistant
SAMNUT 22	3.0	Resistant	2.8	Highly resistant
SAMNUT 23	1.0	Immune	4.2	Susceptible
SAMNUT 24	3.9	Resistant	3.4	Resistant
SAMNUT 26	4.2	Susceptible	2.9	Highly resistant
Means	3.306		3.136	
CV%	6.1		27.2	
SED	0.166		0.696	

Breeding lines are categorised based on mean disease severity rating of resistance/susceptible reaction to fusarium wilt and pod rot disease on a 1-5 rating scale where 1=immune, 2=highly resistant, 3=resistant,4=susceptible, 5=highly susceptible. CV%= Coefficient of variability, SED= Standard error difference

This might be as a result of thick outer layer of their pods. Sherwood and Berg (2006) stated that, the cell walls in the epicarp and sclerenchymatous mesocarp in resistant genotype were thicker and more lignified than in the susceptible ones. Also, Brenneman *et al*. 1990 stated that, resistance in groundnut to pod rot may be attributed to phonological, metabolical or structural factors. In contrast, ICGVs 02038, 06139, 07270 and SAMNUT 23 were found to be susceptible and at the same time produces low pod yield. The possible reason for this could be, the epicarp and mesocarp of their pod was thin and less lignified.

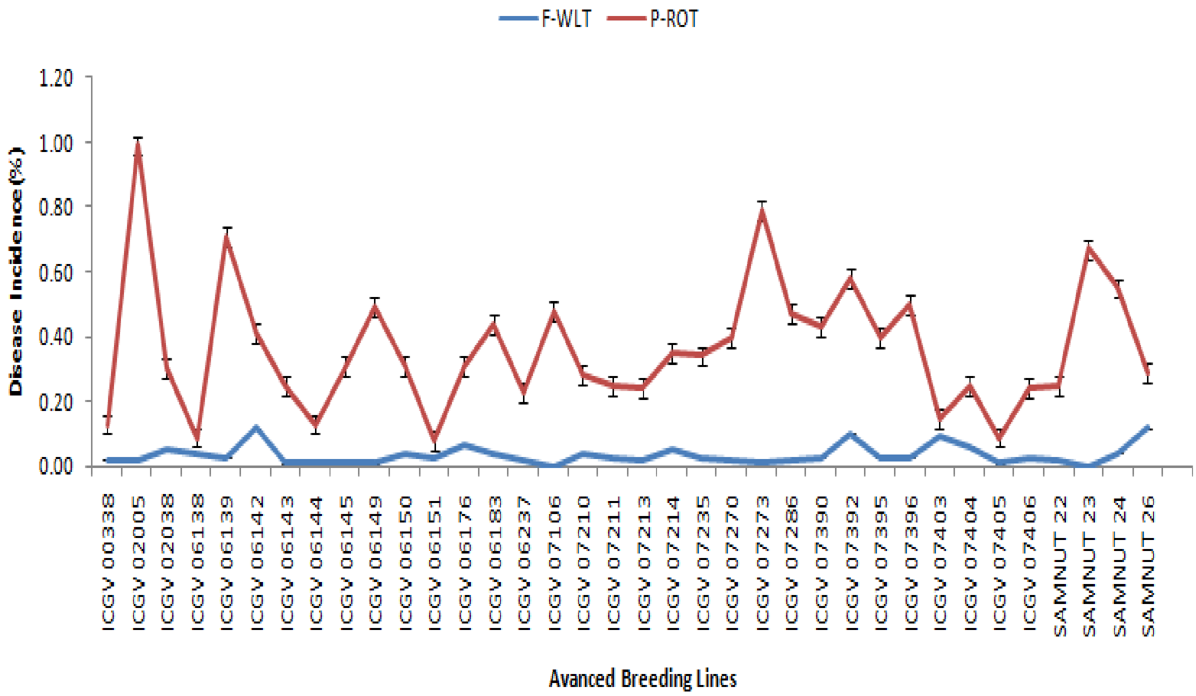

Figure 1: *Fusarium* Wilt and Pod Rot Incidence on Groundnut Advanced Breeding Lines and improved varieties (checks)

However, ICGVs 00338, 06143, 06144, 06145, 07273 and Samnut 23 were found to be immune and highly resistant, and at the same time showed low level of incidence to *fusarium* wilt. Among these lines, ICGV 00338 was found to be one of the best yielding lines (Figure 2). The resistant lines might produce chemical or activate mechanical barriers that may prevent the wilt pathogens from entering the roots of resistant lines, which might cause blockage of water vessels that result to wilt in susceptible lines. Chand *et al*. 2016 reported that host plants resist infection by wilt *Fusarium* species in a variety of ways, elicitors from pathogen and host, synergistically act as signalling molecules for the activation of defence mechanisms. Also, Aguilar's study (as cited in Amin *et al*., 2015) discovered that there is an increase in and higher levels of phenylalanine ammonia lyase and peroxidase activity in resistant than susceptible groundnut.

Significant difference was observed on pod, fodder yield and hundred seed weight. In terms of pod yield ICGVs 07211, 07213 and 07214 had the highest, followed by 00338, 07273 and 07395 (figure 2), and the first two lines were resistant to both diseases. However, heaviest hundred seed weight was found among these lines.

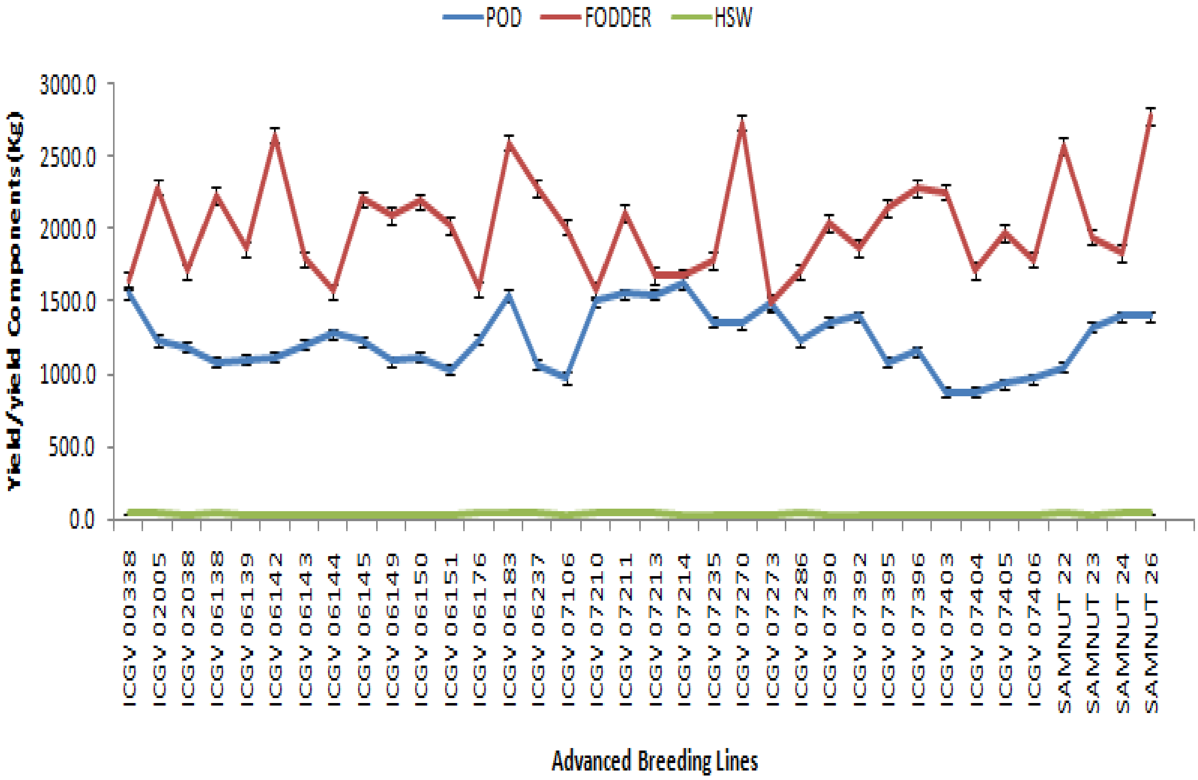

Figure 2: Yield/Yield Components of Advanced Breeding Lines and Improved Varieties of Groundnut

Fodder yield was found to be higher on ICGVs 06142, 06237, 07270 and SAMNUT 26 with 06237 being resistant *fusarium* wilt. This indicates that resistant lines have genetic ability to resist disease stress and produce high yield. This is in line with the finding of Wambi *et al*. 2014, which states the presence of high genetic variability in the resistant genotypes to produce high yield

Significant differences were observed in germination count, flower Initiation, chlorophyll content and normalised difference vegetation index (Table 3). ICGVs 02038and 02005 which were resistant to both diseases had the highest germination followed by ICGVs 06151 and 06237. SAMNUT 24 (check) and ICGV 07210 first flowers appear earlier than that 07286 and 07390. However, high chlorophyll content was observed on ICGVs 07213, 07214, while check (SAMNUT 26) and 06145 recorded the highest NDVI readings and high yield.

Table 3: Germination Count, Days to 50% Flowering, Chlorophyll Content and Normalised Difference Vegetation Index of Groundnut Advanced Breeding Lines

Advanced Breeding Lines	Germination count	Days to 50% flowering	Chlorophyll content	Normalised diff. veg. Index
ICGV 00338	53.00ab	28.33a-e	36.07abc	0.64ab
ICGV 02005	70.00a	28.67a-f	29.37c	0.66ab
ICGV 02038	71.67a	28.67a-f	37.60abc	0.59ab
ICGV 06138	61.67ab	31.33e-h	37.00abc	0.62ab
ICGV 06139	67.67a	31.33e-h	36.70abc	0.58ab
ICGV 06142	57.67ab	31.00b-h	36.20abc	0.65ab
ICGV 06143	64.00ab	30.33b-h	32.63bc	0.62ab
ICGV 06144	60.67ab	30.00a-h	29.87c	0.56ab
ICGV 06145	66.00ab	31.67fgh	36.83abc	0.45b
ICGV 06149	64.67ab	30.67b-h	35.17abc	0.50ab
ICGV 06150	62.33ab	32.33gh	32.53bc	0.63ab
ICGV 06151	69.33a	30.67b-h	36.07abc	0.56ab
ICGV 06176	66.00ab	31.67fgh	37.57abc	0.62ab
ICGV 06183	67.00ab	31.67fgh	41.27abc	0.61ab
ICGV 06237	68.33a	28.67a-f	33.70abc	0.65ab
ICGV 07106	68.00a	31.67fgh	34.10abc	0.59ab
ICGV 07210	70.00a	28.00ab	33.50abc	0.56ab
ICGV 07211	60.00ab	28.00abc	31.57bc	0.62ab
ICGV 07213	62.67ab	30.00a-h	46.67a	0.61ab
ICGV 07214	62.00ab	30.67b-h	46.80a	0.58ab
ICGV 07235	69.00a	33.00h	37.60abc	0.60ab
ICGV 07270	68.00a	31.00b-h	41.97abc	0.58ab
ICGV 07273	60.67ab	32.00gh	39.00abc	0.57ab
ICGV 07286	58.33ab	32.67h	44.80ab	0.57ab
ICGV 07390	68.00a	32.67h	35.00abc	0.50ab
ICGV 07392	66.67ab	31.00b-h	33.50abc	0.60ab
ICGV 07395	57.33ab	31.67fgh	39.93abc	0.60ab
ICGV 07396	63.00ab	31.33e-h	33.83abc	0.61ab
ICGV 07403	65.33ab	31.67fgh	37.73abc	0.62ab
ICGV 07404	62.67ab	31.67fgh	41.67abc	0.56ab
ICGV 07405	46.33ab	31.67fgh	44.60ab	0.63ab
ICGV 07406	58.00ab	32.00gh	35.87abc	0.60ab
SAMNUT 22	49.67ab	29.33a-g	36.17abc	0.63ab
SAMNUT 23	43.00b	30.00a-h	45.20ab	0.66ab
SAMNUT 24	64.00ab	27.33a	39.20abc	0.69ab
SAMNUT 26	61.67ab	28.00a-d	39.50abc	0.74a
Means	62.62	30.62	37.41	0.60
CV%	12.5	3.4	11.5	14.1
SED	6.368	0.848	3.502	0.069

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Student-Newman Keuls Test (SNK).CV%= Coefficient of variability, SED= Standard error difference

It has been suggested that genotypes with good germination, high chlorophyll content and normalised difference vegetation index are likely to produce high yield. This confirm the finding of Cristiano *et al*. (2016) which affirm that it is possible to establish a relationship between chlorophyll, NDVI and other agronomics characteristics that have similar behaviour to high yield in groundnut.

The agronomic and yield parameters of the groundnut advanced breeding lines and checks *viz.* days to 50% flowering, normalised difference vegetation index, pod yield (Kg/ha), fodder yield (Kg/ha) and 100 seed weight (g) were positively associated to each other except chlorophyll content (SPAD), but negatively associated with *fusarium* wilt and pod rot disease severities (Table 4).

Table 4: Matrix of Simple Correlation between Soil Borne Disease Severities and Yield/Yield Components of Advanced Breeding Lines and Improved Varieties of Groundnut (checks)

	POD	FODDER	HSW	SPAD	NDVI	F-WLT	P-ROT
POD	1.000						
FODDER	0.228**	1.000					
HSW	0.093	0.157	1.000				
SPAD	0.161	-0.096	-0.095	1.000			
NDVI	0.041	0.260*	0.279**	0.091	1.000		
F-WLT	-0.177*	0.033	0.094	-0.070	0.089	1.000	
P-ROT	-0.161	-0.179*	-0.075	0.052	-0.258**	0.081	1.000

*, **Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, POD=pod yield, FODDER= fodder yield, HSW=hundred seed weight, SPAD=chlorophyll content, NDVI=normalised difference vegetation index, F-WLT=fusarium wilt severity, P-ROT=pod rot severity.

This indicates that severity of these diseases causes significant yield losses of susceptible lines. Khalid *et al*. (2018) Reported highly significant negative correlation between soil borne diseases with dry pod yield and 100 seed weight, in which the activities of disease causal organisms interfere with the productivities of groundnut.

CONCLUSION

Introduction of resistant cultivars still remains the most feasible approach to the management of *fusarium* wilt and pod rot in groundnut. To evaluate resistance in groundnut against soil borne pathogens, field screening is the effective method (Shokes *et al*., 1992). In this study, thirty two (32) groundnuts advanced breeding lines and four (4) improved varieties were screened against *fusarium* wilt and pod rot. High level of resistance was exhibited by twenty (20) groundnut advanced breeding lines (ICGV’s 00338, 02005, 06143, 06149, 06183, 07106, 07406, 06144, 06145, 06151, 06237, 07210, 07211, 07213, 07286, 07390, 07395, 07396, 07404, 07405) and two (2) improved varieties (SAMNUT 22 and 24) under field conditions. ICGV’s 06183, 07390 and 00338 were both high yielding and highly resistant to *fusarium* wilt and pod rot, hence these lines could be utilized in breeding program to develop resistant and high yielding varieties against these diseases for rain fed areas of savannah and other groundnut growing areas of Nigeria.

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ABBREVIATIONS

INC	International Nut and Dried fruit
FAO	Food Agricultural Organisation
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
RCBD	Randomised Complete Block Design
DAS	Days After Sowing
SPAD	Chlorophyll Content
NDVI	Normalized Difference Vegetation Index
SNK	Student Newman Keuls
SAMNUT	Samaru Nut,
CV	Coefficient of Variability
SED	Standard Error Difference
HSW	Hundred Seed Weight
F-WLT	Fusarium Wilt
P-ROT	Pod Rot

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