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Major Diseases of Groundnut (*Arachis hypogaea* L.) in Benue State of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author BIR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MUU and TA managed the analyses of the study. Author TA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Groundnut (*Arachis hypogaea* L.) farming is an important source of income, food and employment to the teaming population of Benue state indigenes. The disease is one of the major biotic factors undermining groundnut production in the area particularly when the crop is grown in rotation after cultivation.
Methods: Field survey of 2011 and 2012 was conducted to assess the incidence and severity of major diseases of groundnut in Obi, Gboko, Guma and Makurdi Local Government Areas of Benue State. Three villages (groundnut fields) were investigated from each location. Quadrat measuring 1 x 0.5 m was thrown at random in different parts of the farm for the disease assessment.
Results and Conclusion: In 2011 and 2012 surveys, symptoms of *Cercospora* leaf spot, rust (Fungal infection) and rosette (Viral infection) were observed with variation in their percent incidences and severities in the three villages investigated from the four agro-ecological locations. Results showed that there were significant differences ($P<0.05$) in the leaf spot incidence in 2011

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rosette incidence in 2012 among the agro-ecological locations. The highest leaf spot incidence of 43.34% was recorded at Obi agro-ecological location in 2011 and while Gboko agro-ecological location recorded higher disease incidence of 45.36% followed by Guma location in 2012. Makurdi Agro-ecological location recorded the lowest leaf spot incidence in both 2011 and 2012. The highest rosette incidence of 28.07% was recorded at Makurdi location compared to other agro-ecological locations in 2012. The severity of leaf spot disease in both 2011 and 2012, and rust in 2011 were not significantly different ($P>0.05$) among the four locations. The severity of rust and the severity of rosette in both 2011 and 2012 were significantly ($P<0.05$) different among the locations. In 2011, higher rosette severity of 40.07% was recorded at Makurdi location compared to Obi, Guma and Gboko agro-ecological locations. In 2012, Obi location recorded significantly the highest rosette severity of 53.2% followed by Guma and Makurdi agro-ecological locations and while Gboko location recorded 35.1% as the lowest rosette disease severity. Similarly, in 2012 the result showed that Guma and Gboko locations recorded higher rust disease severity of 70.1% and 62.3%, respectively compared to Makurdi and Obi agro-ecological locations. Results of the interaction with the famers through participatory rural appraisal (PRA) using Pair Wise Ranking method revealed seven major production constraints that undermined groundnut cultivation in the areas of which lack of finance ranked the most important production constraint (43.0) while weed (37.75), disease/insects problems (35.25) and inaccessible to chemicals were highly important problems resulting to unattainable yield in groundnut production in this agro-ecology. The result of this study will serve as a first-hand information to the farmers in order to adopt effective disease management strategic option to curtail menace of the diseases and also help the government in formulating favorable agricultural policy that will enhance production in the State.

Keywords: Agro-ecological locations; disease; groundnut (Arachis hypogaea L.); incidence; leaf spot; rosette; rust; severity.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a very important seed and staple food crop grown in Nigeria and more than 100 countries in the world [1]. Worldwide, nearly 23.95 million hectares have been devoted for groundnut cultivation with the total production of 36.45 million tones and with an average yields of 1520 kg/ha [2]. [3] observed that yields could range from 400 – 1650 kg/ha and also that yield of more than 2200 kg/ha could be possible. The Nigeria's annual production of groundnut yield (in-shells) in 1990, 1995 and 1998 were 0.992, 1.6 and 2.6 million tones while the areas under cultivation were 0.7, 1.8 and 2.3 million hectares respectively [4]. Yields in developing countries including Nigeria are very low ranging from 0.3 to 0.9 tons per hectare compared to very high yields of 2.8 tons per hectare in the United States of America [1].

Benue State is rated among the major groundnut producers in Nigeria [5]. The crop is grown sole or intercropped with other crops and therefore serves as one of the prime source of big income for the resource-poor subsistence farmers. Nutritionally, groundnut is valued for its high quality edible oil, easily digestible protein (Upadyaya et al. [6]). and as a good source of vitamin E, K and B and considerable amount of some important mineral elements such as phosphorus, potassium and calcium ([7], Asibuo et al. [8]). The farmers grow groundnut as sole crop in one or two years' rotation with millet, maize, sorghum or mixed. It is employed in mixed-cropping because of its ability to fix atmospheric nitrogen into the soil and also in rotation and fallowing for improvement of the nutrient status of the soil. [9] estimated that 95% of the groundnuts in Nigeria and 56% in Uganda are grown as mixed with other crops. [10] also reported that in Northern Guinea Savanna Zone of Nigeria only about 16% of the total area underground cultivation was in sole cropping while about 70% was in 2 to 4 mixtures.

The down trend in groundnut yields has made Nigeria one of the major importers of groundnut and groundnut-by products ([11,3,12]). Several production constraints such as diseases, insect-pests, weeds, negligence and poor crop management to name but few contributes to low yield production. Among the groundnut diseases, fungal early leaf spot (*Cercospora arachidicola* Hori), late leaf spot (*Phaeoisariopisis personata* (*Berk & curt*) and rust (*Puccinia arachidis* Speg) are destructive fungal diseases which can infect the leaf, stems, petioles, pegs causing significant premature leaf defoliation deterioration and yield reduction. Rosette disease, a viral infection

transmitted by *Aphis craccivora* can cause stunted growth, lost of vigor, curling of the leaves, slow growth rate, yellowing, browning, wilting, bunchy top head, defoliation of the leaves, poor yield return and plant death [13]. Many disease control management strategies have been adopted to reduce crop disease menace to economic minimum level in the developing countries (Richard et al. [14].). But in Makurdi and other parts of Nigeria, farmers are still at high risk of yield losses to disease probably due to lack of effective disease control approaches, lack of awareness of the disease and high exorbitant cost of chemical pesticides. Therefore, the field survey was carried to assess the incidence and severity of major diseases of groundnut and also to identify some of the basic problems undermining groundnut production and its sustainability in Benue State.

2. MATERIALS AND METHODS

The survey was carried out on the 24 – 26th of May, 6 – 8th of June, 18 – 21 of June and 26 – 29th of June at Obi, Gboko, Makurdi and Guma respectively in 2011. The field survey was repeated on the 4 – 6th of June, 10 – 12th of June, 28 – 30th of June and 3rd – 6th of July at Obi, Gboko, Makurdi and Guma respectively in 2012. In Gboko Agro-ecological location, the groundnut farms investigated were at Abayion, Piya and Nyande villages. In Guma Agro-ecological location, Tyohembe, Inunde and Tse-yol villages grown groundnut crop were assessed. In Makurdi location the groundnut field visited was at Ibua, Zongu and Anter villages, and in Obi Agro-ecological location Ijanke, Adum East and Adiko villages cultivated groundnut crops were surveyed. Only one groundnut field was investigated at each village. The four agro-ecological locations visited formed the treatments and while each of the 3 farms surveyed formed the replications arranged in Randomized Complete Block Design RCBD. Quadrate measuring 1 x 0.5 m was used as a survey tool.

2.1 Disease Assessment

2.1.1 Disease incidence (%)

At each farm and location, the disease incidence was assessed by throwing the quadrat 50 times from different standing points. The number of plant stands infected were counted and divided by the total number of plant stands inside the circumference of the quadrate and then multiply by 100 using the disease incidence formula according to [15].

$$Z = \frac{K}{Y} \times 100$$

Where:

Z = Disease incidence, K = Number of infected plant stands in the quadrat and Y = total number of plant stands (infected and uninfected) in the quadrat.

The percentage disease incidences on each farm were obtained by the summation of all the disease incidence values recorded from the times the quadrat was thrown and divided by 50.

2.1.2 Disease severity (%)

Similarly, at each farm and location the severity of leaf spots and rust disease were assessed by throwing the quadrat 10 times from different stand standard points. At each point thrown, 10 plant stands within the circumference of the quadrat were randomly selected, tagged and scored for disease severity, using the disease severity scale according to [16].

Where:

0 = No disease
2 = 1 – 14% of leaves with few small spots.
4 = 15 – 28% of leaves with many spot.
6 = 29 – 42% of leaves with few large spots.
8 = 43 – 56% of leaves with few large and small spots.
10 = 57 – 70% of leaves with many large spots.
12 = 70% of leaves with many and small spots.

The percentage of disease severity on each farm was obtained by summation of all the disease severity values recorded from the time the quadrat was thrown and divided by 10. The computation was done using the formula:

$$\text{Disease severity: } = \frac{\sum n \times 100}{N \times 12}$$

Where:

∑n = summation of individual assessments
N = Total no. of plant assessed
12 = Highest score of the severity scale

2.1.3 Severity of groundnut rosette (%)

The rosette severity was scored using a 1 – 5 disease rating scale according to Pande et al. [17], and Olorunju et al. [13]. As follows:

0 = No visible symptoms on leaves (Highly Resistant)
1 = Rosette symptoms on 1 -20% leaves, but no obvious stunting (Resistant)
2 = Rosette symptoms on 21 – 50% leaves with stunting (moderately resistant)
3 = Severe symptoms on 51 – 70% leaves with stunting (Susceptible), and
4 = Severe symptoms on 71 to 100% leaves with stunting (Highly susceptible).

The severity of rosette viral disease was computed using the formula:

$$\text{Disease Severity (\%)} = \frac{\sum n \times 100}{N \times 5}$$

Where:

∑n = summation of all individual assessments (ratings)
N = total number of plant stands assessed
5 = Highest number in the disease severity scale.

2.1.4 Farmer's participation and perception

Participatory Rural Appraisal (PRA) was conducted through interaction with the farmers to assess the farmer's constraints, preference and acceptance (Odendo et al. [18]). The resource source problems were scored in order of importance as it influenced the groundnut production of the farmers in the areas using the scale:

1 = 1 - 10 non-important
2 = 11- 20 Fairly important
3 = 21 - 30 important
4 = 31 - 40 very important
5 = 41 - 50 Most important

A pair wise ranking method was used in assessing the percentages and means of production constraints of greater priority in these areas. Fifty (50) farmers in each area were given two choices to decide and agree on problems of greater priority through mutual understanding by marking "X" indicating YES and "Y" indicating NO. The means of X and Y were each obtained by summation of the total scores of individual problem assessed and divide by the total number of agro-ecological zones assessed using the formula:

$$M = \frac{\sum n}{N}$$

Where: M = mean
∑n = Summation of the scores of each individual problem assessment
N = total number of agro-ecological zones assessed.

The mean scores were compared using the problems priority scale.

2.2 Data Analysis

Data generated were subjected to statistical analysis using SAS, 2009 version. While the mean separation was done using Duncan's New Multiple Range Test (DNMRT) at 5% level of probability. Microsoft Excel 2007 and Graphpad Prism 6 were used to plot the bar charts.

3. RESULTS

Results on the disease incidence in surveyed village farms at Gboko, Guma, Makurdi and Obi agro-ecological locations of Benue State in 2011 and 2012 cropping seasons are presented in Table 1.

The incidence of *Cercospora* leaf spot, rust and rosette viral disease were apparent in all the village farms grown with groundnut crop in the four agro-ecological locations surveyed in 2011 and 2012. In 2011, leaf spot incidence was higher at Mbayion (35.78%) and Yandev (32.23%) compared to Ipyiav village (27.95%) in Gboko agro-ecological location. In Guma agro-ecological location, Tse-Yol village (34.36%) recorded the highest disease incidence compared to Tyohembe village (28.50%) and Inundu village (27.93%). Disease incidence at Ibua, Zongu and Anter villages in Makurdi agro-ecological location was lower and ranged from 26 to 27.64%. Among the village farms investigated in the four locations, the highest disease incidence was recorded among Ijanke (43.94%), Adum East (44.77%) and Adiko (43.33%) villages in Obi agro-ecological location.

In 2012, Yandev village (46.73%) recorded the highest disease incidence followed by Mbayion village (45.64%) and Ipyiav village (43.72%) in Gboko agro-ecological location. Disease incidence among Tyohembe, Inundu and Tse-Yol villages in Guma agro-ecological location ranged from 39 to 41.84%. In Makurdi location, disease incidence among Ibua, Zongu and Anter villages ranged from 32 - 38.82%. In Obi agro-ecological location, Adiko (41.07%) and Adum East (40.50%) villages recorded higher disease incidence compared to Ijanke village (32.79%).

Incidence of *Cercospora* leaf spot was higher at all the villages in the four agro-ecological locations in 2012 than 2011.

In 2011, incidence of rust was higher at Yandev (43.78%) and Mbayion (41.43%) villages compared to Ipyiav village (34.43%) in Gboko agro-ecological location. In Guma location, Inundu village (51.72%) recorded higher rust incidences compared to Tyohembe (41.19%) and Tse-Yol (44.77%) villages. In Makurdi agro-ecological location, Anter village (57.11%) had the highest disease incidence followed by Zongu village (49.05%) while Ibua village (44.33%) recorded the lowest. Similarly, in Obi agro-ecological location, higher disease incidences were recorded at Adiko (47.48%) and Adum East (43.52%) villages, while Ijanke village (34.36%) had the lowest. Anter village had the highest rust incidence than all villages grown to groundnut crops in the four different agro-ecological locations in 2011.

In 2012, rust incidence was higher at Yandev village (53.23%) followed by Ipyiav village (49.54%) and Mbayion village (47.36%) in Gboko agro-ecological location. In Guma agro-ecological location, higher disease incidence was observed among Tse-Yol (61.12%) and Inundu (57.39%) villages compared to Tyohembe village (48.72%). In Makurdi location, rust incidence was higher at Anter (56.70%) and Zongu (54.21%) villages, while Ibua village (50.83%) recorded the lowest disease. Rust incidence among Ijanke, Adum West and Adiko villages in Obi agro-ecological locations ranged from 53 - 55.44%. The incidence of rust was higher in 2012 than 2011. Similarly in 2012, it was noticed that rust incidence was higher at Tse-Yol village than all the villages grown to groundnut crop in the four agro-ecological locations.

In 2011, incidence of rosette was higher among Mbayion (22.65%) and Ipyiav (24.99%) villages compared to Yandev village (17.14%) in Gboko agro-ecological location. In Guma location, disease incidence was higher at Tyohembe village (25.10%) compared to Inundu (11.79%) and Tse-Yol village (16.38%) villages. Rosette incidence among Ibua, Zongu and Anter villages in Makurdi agro-ecological location ranged from 18 – 22.68%. Similarly, in Obi location, disease incidence at Ijanke, Adum East and Adiko villages ranged from 18 - 20.79%.

In 2012, disease incidence at Mbayion, Ipyiav and Yandev villages in Gboko agro-ecological location ranged from 16 - 19.46%. Similarly, disease incidence at Tyohembe, Inundu and Tse-Yol villages in Guma location ranged from 18 – 22.98%. In Makurdi agro-ecological location, higher rosette incidence was observed at Ibua village (31.03%) compared to Zongu (27.48%) and Anter (25.70%) villages. Groundnut rosette incidence was higher at Ijanke (23.90%) and Adum East (21.89%) villages compared to Adiko village (17.55%) in Obi agro-ecological location in 2012. In the two cropping seasons, incidence of rosette was lower than the incidence of *Cercospora* leaf spot and rust in all the villages surveyed in the four agro-ecological locations in both 2011 and 2012.

Result on disease severity in the surveyed villages at Gboko, Guma, Makurdi and Obi agro-ecological locations of Benue State in 2011 and 2012 cropping seasons are presented in Table 2.

Table 1. Mean incidence (%) of leaf spot, rust and rosette in each of the three respective villages of the four agro-ecological locations of Benue State in 2011 and 2012 cropping seasons

Agro-ecological locations	Village	Leaf spot		Rust		Rosette	
		2011	2012	2011	2012	2011	2012
Gboko	Mbayion	35.78	45.64	41.43	47.36	22.65	16.38
	Ipyiav	27.95	43.72	34.43	49.54	24.99	19.46
	Yandev	32.23	46.73	43.78	53.23	17.14	17.87
Guma	Tyohembe	28.50	39.45	41.19	48.72	25.10	22.98
	Inundu	27.93	39.48	51.72	57.39	11.79	20.74
	Tse-yol	34.36	41.84	44.77	61.12	16.38	18.57
Makurdi	Ibua	26.74	38.82	44.33	50.83	22.68	31.03
	Zongu	27.34	35.60	49.05	54.21	20.64	27.48
	Anter	27.64	32.53	57.11	56.70	18.34	25.70
Obi	Ijanke	41.94	32.79	34.36	53.32	18.32	23.90
	Adum East	44.77	40.50	43.52	54.67	20.79	21.89
	Adiko	43.33	41.07	47.48	55.44	20.07	17.55

The results revealed that there were variations in disease severity in all the villages grown with groundnut crops in the four agro-ecological locations in 2011 and 2012.

In 2011, severity of leaf spot was higher at Ipyiav village (41.83%) compared to Yandev (37.83%) and Mbayion (33.17%) villages in Gboko agro-ecological location. In Guma location, Inundu (36.50%) and Tse-Yol (38.50%) villages recorded higher disease severity while Tyohembe village (31.83%) had the lowest. Higher disease severity was observed at Anter village (35.61%) compared to Zongu e (31.81%) and Ibua (29.0%) villages in Makurdi agro-ecological location. In Obi location, disease severity at Ijanke, Adum East and Adiko villages ranged from 36.18 to 37.33%.

In 2012, severity of leaf spot among Mbayion, Ipyiav and Yandev villages in Gboko location ranged from 40.0 - 45.36%. In Guma location, the highest disease severity was recorded at Tyohembe village (48.17%) compared to Inundu (44.78%) and Tse-Yol (42.83%) villages. In Makurdi agro-ecological location, higher disease severity was observed at Zongu (45.34%) and Anter (41.67%) villages, while Ibua village (36.83%) had the lowest. Results revealed that in Obi location, disease severity was higher at Adiko village (45.5%) followed by Adum East (41.17%) and Ijanke (37.33%) village. Higher leaf spot was observed at all the village farms surveyed in the four agro-ecological locations in 2012 than 2011.

In 2011, severity of rust disease was higher at Yandev (60.17%) and Ipyiav (57.67%) villages than Mbayion village (50.17%) in Gboko agro-ecological location. In Guma location, Tyohembe (61.67%) and Inundu (60.67%) villages recorded higher disease severity than Tse-Yol village (50.3%). The rust severity at Zongu, Ibua and Anter villages in Makurdi location ranged from 59 - 62.67%. In Obi agro-ecological location, Adiko village (63.17%) had the highest disease severity compared to Ijanke (59.5%) and Adum West (58.33%) villages. In 2012, disease severity among Mbayion, Ipyiav and Yandev villages in Gboko location ranged from 60 - 64.36%. Inundu (72.17%) and Tse-Yol (70.33%) villages recorded higher disease severity compared to Tyohembe village (67.83%) in Guma location. In Makurdi location, disease severity among Zongu, Anter and Ibua villages ranged from 48 - 52.0%. In Obi agro-ecological location, Adiko village (70.33%) scored the highest disease severity followed by Adum East village (53.67%) and Ijanke village (49.67%). In 2012, severity of rust disease was higher at all the villages investigated in the four locations than in 2011. On the same trend, Inundu village in Guma agro-ecological location recorded the highest rust severity than other village farms grown to groundnut crop in the four agro-ecological locations.

In 2011, rosette severity at Mbayion, Ipyiav and Yandev villages in Gboko; Tyohembe, Inundu and Tse-Yol villages in Guma; and Ibua, Zongu and Anter villages in Makurdi location(s) ranged from 29 - 38.17%, 29 - 37.83% and 37 - 42.83%,

Table 2. Severity (%) of leaf spot, rust and rosette in each of the three respective villages of the four agro-ecological locations of Benue State in 2011 and 2012 cropping seasons

Agro-ecological locations	Village	Leaf spot		Rust		Rosette	
		2011	2012	2011	2012	2011	2012
Gboko	Mbayion	33.17 (6)	40.17 (6)	50.17 (8)	60.5 (10)	32.17 (3)	34.10 (3)
	Ipyiav	41.83 (6)	40.17 (6)	57.67 (10)	64.36 (10)	38.17 (3)	33.10 (3)
	Yandev	37.83 (6)	45.36 (8)	60.17 (10)	61.97 (10)	29.67 (3)	38.17 (3)
Guma	Tyohembe	31.83 (6)	48.17 (8)	61.67 (10)	67.83 (10)	37.83 (3)	44.10 (3)
	Inundu	36.50 (6)	44.78 (8)	60.67 (10)	72.17 (12)	29.5 (3)	47.0 (3)
	Tse-yol	38.50 (6)	42.83 (8)	50.3 (8)	70.33 (12)	33.10 (3)	47.67 (3)
Makurdi	Ibua	29.0 (6)	36.83 (6)	60.5 (10)	52.0 (8)	42.83 (3)	41.17 (3)
	Zongu	31.81 (6)	45.34 (8)	59.0 (10)	48.83 (8)	39.88 (3)	39.97 (3)
	Anter	35.61 (6)	41.67 (6)	62.67 (10)	51.0 (8)	37.50 (3)	47.17 (3)
Obi	Ijanke	37.33 (6)	38.0 (6)	59.5 (10)	49.67 (8)	40.10 (3)	54.67 (4)
	Adum West	36.34 (6)	41.17 (6)	58.33 (10)	53.67 (8)	35.83 (3)	55.17 (4)
	Adiko	36.18 (6)	45.5 (8)	63.17 (10)	70.33 (12)	35.85 (6)	49.67 (3)

respectively. Higher severity of rosette was observed at Ijanke village (40.10%) compared to Adun East (35.83) and Adiko (35.85%) villages in Obi location. In 2012, higher severity of rosette was observed at Yandev village (38.17%) compared to Mbayion (34.10%) and Ipyiav (33.10%) villages. The severity of rosette at Tyohembe, Inundu and Tse-Yol villages in Guma; and Ijanke, Adum East and Adiko villages in Obi agro-ecological locations ranged from 44 - 47.67% and 49 - 55.17% respectively. In Makurdi location, higher disease severity was recorded at Anter village (47.17%), compared to Ibua (41.17%) and Zongu (39.97%) villages. In 2012, higher disease severity was in all the fields than in 2011. Similarly, Ijanke, Adum East and Adiko villages in Obi location recorded higher severity of rosette compared to all the villages in other three agro-ecological locations.

The results in Figs. 1 and 2 show the percentage incidence of *Cercospora* leaf spot, rust and rosette diseases of groundnut at Gboko, Guma, Makurdi and Obi agro-ecological locations of Benue State in 2011 and 2012 cropping seasons. In 2011, results show that Obi agro-ecology recorded the highest *Cercospora* leaf spot incidence of (43.34%). The results indicate that Gboko (31.98), Guma (30.26%) and Makurdi (27.24%) recorded lower leaf spot incidence. In 2012, Gboko (45.36%) and Guma (40.25%) agro-ecological zones recorded higher leaf spots incidence. The results revealed that Makurdi (28.07%) location had the highest groundnut rosette incidence while Gboko (17.90%), Guma (20.76%) and Obi (21.11%) recorded lower groundnut rosette incidence in 2012.

Results in Table 3 present the severity of *Cercospora* leaf spot, rust and rosette of groundnut at Gboko, Guma, Makurdi and Obi agro-ecological locations of Benue State in 2011 and 2012 cropping seasons.

Severity of *Cercospora* leaf spot (Plate 1) and rust (Plate 2) disease in the four agro-ecological locations were not significantly different ($P>0.05$) in 2011 but the severity of rosette infection (Plate 3) was significantly different over locations. In 2012, severity of rust and rosette were significantly different ($p<0.05$) among the four agro-ecological locations but the severity of *Cercospora* leaf spot was not significantly different ($P>0.05$) among the locations. In 2011, higher groundnut rosette severity of 40.07, 33.48 and 37.26% were recorded from Makurdi, Guma and Obi respectively, but which did not significantly vary from each other. The lowest rosette severity of 33.34% was recorded from Gboko in 2011. In 2012, Gboko and Guma agro-ecological zones which recorded higher rust severity of 62.28 and 70.11% respectively were statistically indifferent ($p>0.05$) from each other. Makurdi and Obi locations which had lower rust severity of 50.61 and 57.89% respectively were not significantly different from each other. In 2012 Obi agro-ecology recorded significantly higher ($P<0.03$) rosette severity of 53.17%. This was followed by Makurdi and Guma agro-ecological locations which recorded statistically similar rosette severity of 42.77 and 46.26%, respectively. The lowest groundnut rosette severity of 35.12% was obtained from Gboko agro-ecological location. In 2012 there was an increase in severity of groundnut rosette in all the four agro-ecological locations compared to 2011 while rust infection was generally high in all the locations in 2012.

Table 4 revealed the result of seven major production constraints peculiar among the farmers, but with varied degrees of priority. Results obtained from interaction with the farmers indicated that inaccessibility to finance to fund their groundnut production activities ranked the most important production constraint (43.0). Weed problem (37.75), lack/exorbitant cost of chemicals (36.75) and diseases/insect pests (35.25) were very important constraints; lack of improved seeds (29.75) and transportation (27.75) ranked important, while lack of storage facilities (19.5) ranked fairly important. None of these factors were ranked as not important. This indicates that when combination of these factors are made available it will go a long way to boost groundnut production and also other economic crops in these various agro-ecologies of Benue State.

4. DISCUSSION

The survey results have shown that Leaf spots caused by *Cercospora arachidicola* Hori (Early leaf spot), *Phaeiosariopsis personanta* (Late leaf spot), Rust (*Puccinia arachidis*) and rosette were the major destructive diseases that pose a big threat in groundnut production in Agro-ecology of Benue State. The leaf spots and rust are fungal infection while the rosette is a viral infection usually transmitted by an insect-vector called "*Aphis craccivora*". Results of 2011 and 2012 surveys revealed that there were variation among the village farms assessed for disease

incidence and severity. The mean incidence of *Cercospora* leaf spot and rust diseases were higher in all the groundnut crop farms investigated in all the villages in 2012 than in 2011. Similarly, the mean severity of *Cercospora* leaf spot, rust and rosette were higher in all the groundnut crop fields surveyed in the villages in 2012 than in 2011. Among the village groundnut fields investigated, the highest mean severity of rust was observed at Inundu village farms (72.17%). The growth stage of the crops, cultural practices and seasonal environmental conditions could have led to the disease variation. Generally, the four agro-ecological zones surveyed exhibited variation in leaf spots in 2011 and 2012, and rosette incidence only in 2012. Obi had the highest leaf spots incidence in 2011, Gboko and Guma had the highest leaf spot disease incidence in 2012. Rosette incidence was higher in Makurdi compared to other zones in 2012. The percentage of rust incidence was higher than the incidence of both leaf spots and rosette but did not vary significantly over the four locations. The results also revealed significant variation among the locations in the severity of rosette in 2011 and 2012, and severity of rust in 2012. The percentage of leaf spots severity did not vary in the four locations but the percentage of rust severity in those four agro-ecological zones was higher compared to severity of leaf spots and rosette diseases in the two years.

The variation of disease incidence and severity percentage in the survey zones could have been attributed to difference in varieties and different environmental conditions. McDonald et al. [19] conducted a survey on the prevalence of fungal diseases of groundnut in Nigeria reported that the early and late leaf spots of groundnut were the most important in more than 89% of the surveyed field. Alabi et al. [20] also reported that leaf spot, rosette and virus are the most serious damaging disease of groundnut in Nigeria. The presence of these disease forms a complex-disease infection injurious to the well being of the crop resulting in gross yield reduction. This result agrees with ICRISAT [1] which reported that rust and leaf spots were destructive fungal diseases which can cause more than 50% yield loss in groundnut in many countries. The disease epiphytotic level in those agro -ecological areas could possibly be due to cultural practices, varietal response and time of sowing which may differ from one location to another location. According to Nigam et al. [21], rosette disease contributes to an annual loss of US 156 million across Africa. It is also the most damaging disease of groundnut in Sub-Saharan Africa causing yield losses approaching 100% whenever the epidemic occur (Ntarc et al. [22]). Pande et al. [17] in their survey reported that diseases incidence and severity of disease may vary depending on date of sowing and prevailing environmental conditions.

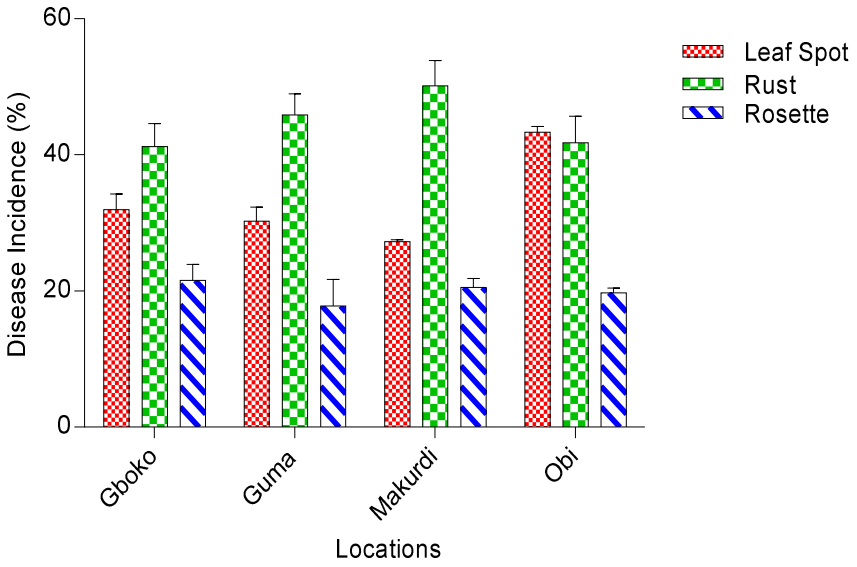

Fig. 1. Disease incidence (%) in 2011 at the four agro-ecological locations in Benue State

Table 3. Severity of groundnut cercospora leaf spot, rust and rosette in Gboko, Guma, Makurdi and obi agro-ecological locations of Benue State in 2011 and 2012 cropping seasons

Locations	Gboko		Guma		Makurdi		Obi		CV	P-value
	% Severity	Scale	% Severity	Scale	% Severity	Scale	% Severity	Scale		
2011										
Leaf Spot	37.61±2.50	(6)	35.94±2.23	(6)	32.14±1.92	(6)	36.58±0.37	(6)	9.80	0.28^{ns}
Rust	56.00±3.00	(8)	57.55±3.63	(10)	60.72±1.07	(10)	60.33±1.46	(10)	7.50	0.52^{ns}
Rosette	$33.34±2.52^{b}$	(3)	$33.48±2.41^{ab}$	(3)	$40.07±1.54^{a}$	(3)	$37.26±1.42^{ab}$	(3)	7.20	0.04
2012										
Leaf Spot	41.90±1.75	(6)	45.26±1.56	(8)	41.28±2.46	(6)	41.56±2.17	(6)	8.20	0.58^{ns}
Rust	$62.28±1.12^{ab}$	(10)	$70.11±1.26^{a}$	(10)	$50.61±0.53^{c}$	(8)	$57.89±6.33^{bc}$	(8)	9.50	0.01
Rosette	$35.12±1.55^{c}$	(3)	$46.26±1.10^{b}$	(3)	$42.77±2.23^{b}$	(3)	$53.17±1.76^{a}$	(4)	6.70	<0.01

Means values with the same alphabet along the same row are not significantly different from each other according to Duncan's New Multiple Range Test (DNMRT) at 5% level of probability

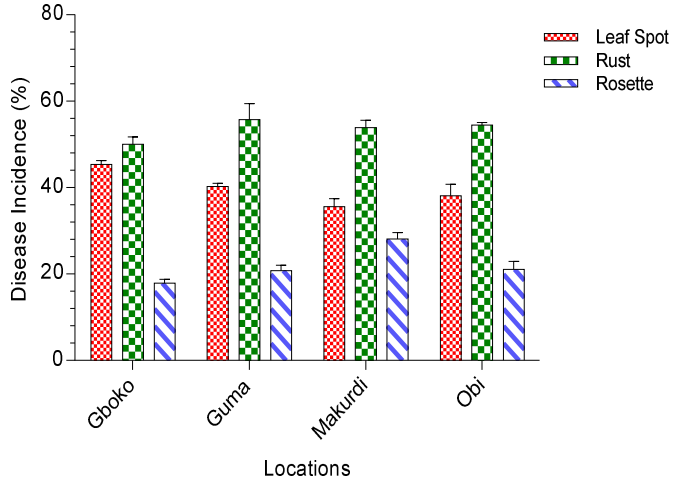

Fig. 2. Disease incidence (%) in 2012 at the four agro-ecological locations of Benue State

Plate 1. Cercospora leaf spots symptoms

Plate 2. Rust (*Puccinia arachidis)* rust disease symptoms

Plate 3. Stunted/Chlorotic leaf symptom of rosette

Table 4. Problems priority pair wise ranking base on farmer's perception

Production constraints	Gboko		Makurdi		Guma		Obi		Total	Score/ means
	X	Y	X	Y	X	Y	X	Y	X	Y
Improved seeds	33	17	28	22	28	22	30	20	29.75	20.25
Weeds	40	10	32	18	43	17	36	14	37.75	14.75
Finance	45	5	40	10	47	3	40	10	43.0	7
Chemicals	36	14	41	9	34	16	36	14	36.75	13.25
Transportation	31	19	23	27	29	21	28	22	27.75	22.25
Diseases/inset-pest	36	14	32	18	38	12	35	15	35.25	14.75
Storage facilities	15	35	22	28	19	31	22	28	19.5	30.5

Among several economic problems serving as bottle neck against crop production, lack of finance ranked the most important production constraint, while weed problem, inaccessibility to chemical pesticides and disease/insect pest were ranked as very important problems negatively affecting groundnut production in this agro-ecology.

5. CONCLUSION

The identification of these major diseases of economic importance in these agro-ecologies as it results in yield reduction, thus provides a window of opportunity and vital information for disease diagnosis, measurement, disease prediction, forecasting, crop yield loss assessment and management for retrospective and prospective aspects. Groundnut production and sustainability has to be backed up with sufficient finance and provision of other agricultural essential incentives. Lastly, effort should be directed towards educating and high lighten the farmers regarding the devastating effect of these diseases so that they can adopt other possibly available disease management strategies since chemical control alone might not be economically feasible on part of the resource-

poor farmers, while disease surveillance should be carried out routinely before it reaches destructive epidemic level.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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