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Effects of variety, fungicidal rate and intra - row spacing on Cercospora leaf spot disease of groundnut (Arachis hypogaea L.) in the Sudan savanna, north-eastern Nigeria

[1]A. S. Muhammad* and [2]B. S. Bdliya
[1]*Department of Crop Science, Usmanu Danfodiyo University, Sokoto*
[2]*Department of Crop Protection, University of Maiduguri*

Abstract: *A field trial was conducted during 2006, 2007 and 2008 cropping seasons to evaluate the effects of three groundnut varieties, four application rates of mancozeb and three intra-row spacing on cercospora leaf spot of groundnut in the Sudan Savannah zone of Nigeria. The experiment was conducted on the University Teaching and Research Farm, Faculty of Agriculture, University of Maiduguri. The varieties of groundnut used were Ex-Dakar, Sammnut 18 (RRB) and ICGV 86024.The spacing comprised 20cm (S_1,) 25cm (S_2) and 30cm (S_3) for intra-raw spacing and a maintained 50cm of inter-row spacing whereas the fungicidal rates were 0.8 kg a.i./ha, 1.6 kg a.i./ha, 3.2 kg a.i./ha and 0 kg a.i./ha (unsprayed). Spraying was done fortnightly. The treatments were factorially combined and laid out in a strip-split plot design, replicated three times. The variety was assigned to main plots while the fungicidal rate, to the sub-plots and spacing, to the sub-sub plots. Results of the work revealed that, Cercospora leaf spots of groundnut infected all the three groundnut cultivars with no single stand escaping infection in all the three years of the study. The incidence and severity of the disease were significantly (P>0.05) higher in variety Ex-Dakar than the other varieties. 3.2 kg a.i./ha and 1.6 kg a.i./ha recorded the lowest diseases parameters, followed by 0.8 kg a.i./ha, while the highest was recorded on the untreated plots.. The closer spacing of 20cm recorded the highest disease values, followed by 25cm while the widest spacing of 30cm had the lowest disease values. All the varieties had similar yield. The results revealed that, 0 kg a.i./ha significantly had the lowest yield then 0.8 kg a.i./ha and 1.6 kg a.i./ha, and 3.2 kg a.i./ha, recorded the highest yield in all the years and combined analysis. Therefore, it is hereby recommended that all the three varieties could be used by farmers in the study area and Mancozeb should be applied at the rate of 1.6 kg a.i./ha and 0.8kg a.i./ha for management of cercospora leaf spot of groundnut, while the spacing of 20cm, despite higher disease values, excelled in terms of yield due to higher plant population and should be adopted for the three varieties used in the study.*

Key Words: *Groundnut; Cercospora leaf spots; Variety; Fungicidal rate; Intra-Row Spacing; Yield*

I. Introduction

Early leaf spot (Cercospora arachidicola Hori.), late leaf spot (Phaeoisariopsis personata (Berk and curt.) v. Arx), and rust (Puccinia arachidis speg.) are the most serious diseases after the rosette virus (Alabi et al., 1993). It accounts for about 5 – 65 % pod yield loss and reduces the nutritive value of the hay and makes it unfit for feeding livestock (Muhammed, 2004). Soil and foliar borne diseases in peanut can reduce yield and quality. Environmental factors such as high humidity and rainfall coupled with warm temperatures provide conditions conducive to disease development. Jacobi and Backman (1991) reported that under severe leaf spot conditions, yield losses in Georgia and Florida exceeded 1100 kg/ha. Yield losses can exceed 70 % when no preventative fungicides are applied and a susceptible cultivar is sown (Nutter and Shokes, 1995). Studies on the effects of intercropping pattern (Bdliya and Muhammad, 2006), varietal resistance (Muhammed, 2004), plant extracts (Alkali, 2005) and efficacy of some fungicides (Gwio-Kura, 2006) on Cercospora leaf spots have been conducted in the study area with varying results. Therefore, evaluation of the effects of these factors on Cercospora leaf spots of groundnut would discover knowledge that can further benefit individual farmers by reducing their annual yield losses.

This paper reports the results of an experiment to identify the ideal variety, fungicidal rate and intra row spacing that recorded the lowest incidence and severity of cercospora leaf spot of groundnut with corresponding increased yield in the Sudan savanna in north-eastern Nigeria.

II. Materials And Methods

The study was conducted at, Teaching and Research Farm of the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, Nigeria (Latitude 11º51'N; 13º15'E) during 2006, 2007 and 2008 cropping seasons. The area has been cropped with groundnut for several years ensuring build up of disease inocula. Natural epiphytotics in field were therefore relied upon as the source of inocula in all the seasons.

The treatments consisted of factorial combination of three groundnut cultivars, four fungicidal rates and three spacing. The varieties of groundnut include Ex-Dakar, Sammnut 18 (RRB) and ICGV 86024. The fungicidal rates comprised 0, 1, 2 and 4 $kgha^{-1}$ of mancozeb which is a wettable powder (WP) whereas the spacing comprises 20cm (S_1,) 30cm (S_2) and 40cm (S_3) for intra-raw spacing and a maintained 50cm of inter-row spacing. The treatments were factorially combined and laid out in a strip-split plot design, replicated three times. The variety was assigned to the main plots while the fungicidal rate to the sub-plots and spacing to the sub-sub plots.

The layout consisted of three blocks each comprising 36 sub-plots measuring 3m x 5m (i.e., $15m^2$) replicated three times giving a total of 108 sub-plots. A space of 3 m was left between the blocks and 1m was left between the sub-plots. The total experimental area was 42m x 54m ($2268m^2$).

The land was ploughed mechanically by tractor followed by leveling with hoe before laying out of plots. The seeds were dressed with seed dressing chemical, Aldrex - T before sowing. Sowing was done manually by hoe using dibbling method. Two seeds per hole were sown. The fertilizer applied was NPK (15:15:15) at the rate of 432g/plot at sowing. Weeding was done manually and hand pulling at three weeks and six weeks after sowing. Twenty plants were selected randomly in each sub-plot for data collection on parameters such as, disease incidence, severity, number of pods per stand, kernel and yield haulm.

Data on disease incidence was taken at 65 days after sowing and at harvest. The number of stands showing symptoms of the diseases in each sub-plot was counted and the percentage of disease incidence was computed.

Disease severity assessment was carried out using a scale of 1 to 9 (Subrahmanyam et al., 1995). Twenty plants were selected at random which were observed and scored. Based on the extent of disease on each, a scale number was assigned.

The data collected were subjected to statistical analysis of variance (ANOVA) based on randomized complete block design and the difference between treatment means was determined using least significant difference (L.S.D) as described by Gomez and Gomez (1984).

III. Results And Discussion

Disease Incidence

The incidence of the disease was significantly ($P \leq 0.05$) higher in variety Ex-Dakar than in the other varieties. This could probably be attributed to the difference in the inherent resistance of the varieties to attack by the pathogen. The variety ICGV-86024 and RRB may be more tolerant to attack by the pathogen than Ex-Dakar. Variation in resistance to Cercospora leaf spots by different varieties has also been reported by other authors (Bdliya and Muhammad, 2006; Izge et al., 2007).

The incidence of the diseases was found to be higher in the control than in the treated crops. At 65 days after sowing, groundnuts sprayed with fungicide at the rate of 3.2 kg a.i. /ha and 1.6 kg a.i. /ha recorded the lowest diseases incidence, followed by those sprayed at the rate of 0.8 kg a.i. /ha, while the highest was recorded in the untreated plots. This difference could be due to difference in intrinsic toxicity which is clearly reflected in the higher application rates. Earlier reports on efficiency of mancozeb on plant diseases corroborate the results of this work. On cucurbit crops, Patel and Patel (1980) found that chlorothalonil and mancozeb provided satisfactory control of downy mildew on muskmelon. Khalil et al. (1992) reported that copper oxychloride and mancozeb were effective for the control of the fungal diseases on muskmelon. From the results of the three years study incidence of Cercospora leaf spot of groundnut at 65 days after sowing was reduced by 42.25%, 32.58% and 17.84% as the result of spraying mancozeb at the rate of 3.2 kg a.i. /ha, 1.6 kg a.i. /ha and 0.8 kg a.i. /ha, respectively.

Spacing significantly affected incidence of Cercospora leaf spots of groundnut. The closer spacing of 20 cm, which is equivalent to 100,000 stands per hectare of groundnut recorded the highest disease incidence, followed by 25 cm (80,000 stands/ha) while the widest spacing of 30 cm (66,666 stands/ha) had the lowest disease incidence at 65 days after sowing. This difference could be attributed to difference in plant population. The more densely populated groundnut canopy favours rapid spread of leaf spots because secondary infection tends to be higher due to modification of the microclimate making it more humid which favours rapid sporulation and thus faster infection of healthy stands closer to the primary infected stands. This result is in conformity with report by Pande (1995) that wider and moderate spacing ensure reduced incidence and severity of Cercospora leaf spot whereas closer spacing causes the build-up of relatively high humidity; a favourable condition for disease proliferation in the tropics.

Table1: Effects of variety, fungicidal rate and spacing on incidence (%) of Cercospora leaf spots at 65 Days after sowing

	Incidence of Cercospora leaf spots at 65 DAS (%)			
Treatment	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	45.70	57.80[a]	50.71	49.43
RRB	41.92	52.40[b]	48.67	48.92
ICGV-86024	39.78	52.51[b]	46.21	46.88
SE (±)	3.184	0.719	2.205	0.478
Fungicidal rate (F)				
3.2 kg a.i. /ha	33.80[c]	36.68[d]	38.70[c]	36.39[d]
1.6 kg a.i. /ha	41.58[bc]	44.62[c]	41.24[c]	42.48[c]
0.8 kg a.i. /ha	44.24[ab]	60.35[b]	50.71[b]	51.77[b]
0 kg a.i. /ha	50.25[a]	75.29[a]	63.47[a]	63.01[a]
SE (±)	2.623	1.109	1.866	0.816
Spacing (S)				
20 cm	46.47[a]	58.92[a]	54.30[a]	53.23[a]
25 cm	41.11[b]	53.64[b]	47.75[b]	47.50[b]
30 cm	39.83[b]	50.14[c]	43.55[c]	44.51[c]
SE (±)	1.464	0.981	0.576	0.614
Interactions				
V x F	NS	NS	NS	NS
V x S	NS	NS	NS	NS
F x S	NS	NS	NS	NS
V x F x S	NS	NS	*	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability (DMRT) NS = Not significant; DAS = Days after sowing, * = Significant at 5% level of probability

Disease Severity

Disease severity was significantly higher in variety Ex-Dakar than the other varieties, probably due to its inherent susceptibility to attack by the pathogens than the other varieties. In a study to determine the level of variability of groundnut to Cercospora leaf spot, Izge et al. (2007), concluded that, a lot of variability existed among the groundnut varieties evaluated in all characters, and that the varieties ICGV-SM-9353i, ICGV-IS-96802, ICGV-IS-96827 and ICGV-IS-96808 were found to be tolerant to Cercospora leaf spot disease based on their level of incidence and their respective kernel yield. Bdliya and Muhammad (2006) also reported that severity of Cercospora leaf spot varied among the three groundnut varieties studied and the disease severity was significantly higher in Ex-Dakar compared with RMP 12 and Damboa local. Other authors have also reported variation in severity of Cercospora leaf spots on different groundnut varieties (Subrahmanyam et al., 1983).

The severity of Cercospora leaf spots varied among the fungicidal rates. This could be attributed to the difference in the toxicity level of the rates. At 65 days after sowing, 1.6 and 3.2 kg a.i. /ha rates had similar disease severity, while control recorded the highest disease severity, in all the years and in combined analysis. This difference in disease severity among the rates of mancozeb application might be attributed to the difference in toxicity levels of the three rates which is determined by the amount of active ingredient of the fungicide applied per unit area. Patel and Patel (1980) found that chlorothalonil and mancozeb provided satisfactory control of downy mildew on muskmelon. Fungicidal rates of 0.8 kg a.i. /ha, 1.6 kg a.i. /ha and 3.2 kg a.i. /ha reduced the severity of Cercospora leaf spots by 16.84%, 31.02%, 32.83% at 65 days after sowing. The use of mancozeb (Dithane M-45) for the control of Cercospora leaf spot in Nigeria has been documented (RMRDC, 2004; Fowler and MacDonald, 1981).

The severity of Cercospora leaf spots also varied among the three spacing, with 20 cm recording the highest and 30 cm recording the lowest at 65 days after sowing in all the years and their combined analysis. This variation could be attributed to difference in plant population of the three spacing. Higher plant population is known to alter the microclimate, making it favourable to fungal disease outbreak and rapid spread leading to epidemic. These results are in line with the report of Pande and Narayana Rao (2002). According to them, the severities of leaf spots and rust diseases were significantly higher at higher plant densities than at lower plant densities in all the cultivars tested. However, contrary to these results, Yayock (1981) reported that the early maturing cultivar "Spanish 205" showed less late leaf spots severity in higher plant densities than in lower densities. But more recently, Ihejirika et al. (2006) attributed the higher disease severities of the higher population densities of groundnut to the high competition for soil nutrient leading to nutrient deficiency situation, resulting in quick reaction to disease infection and symptom manifestation.

Table 2: Effect of variety, fungicidal rate and spacing on severity (%) of Cercospora leaf spots of groundnut at 65 DAS during the 2006, 2007, 2008 rainy seasons and the combined analysis

	Severity of Cercospora leaf spots at 65 DAS (%)			
Treatment	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	43.13[a]	39.89	41.66[a]	41.57[a]
RRB	26.35[b]	37.36	38.08[ab]	34.03[b]
ICGV-86024	28.70[b]	34.54	35.45[b]	32.90[b]
SE (±)	1.308	1.290	1.6313	1.4100
Fungicidal rate (F)				
3.2 kg a.i. /ha	27.03[c]	32.20[c]	31.95[c]	30.40[c]
1.6 kg a.i. /ha	28.93[c]	31.15[c]	33.58[c]	31.22[c]
0.8 kg a.i. /ha	34.87[b]	38.55[b]	39.53[b]	37.64[b]
0 kg a.i. /ha	40.09[a]	47.15[a]	48.52[a]	45.26[a]
SE (±)	1.206	1.105	1.4343	1.2480
Spacing (S)				
20 cm	35.53[a]	39.80[a]	41.02[a]	38.78[a]
25 cm	32.69[b]	37.51[b]	38.64[b]	36.28[b]
30 cm	29.97[c]	34.49[c]	35.53[c]	33.33[c]
SE (±)	0.497	0.328	0.5993	0.4750
Interactions				
V x F	NS	NS	NS	NS
V x S	NS	NS	NS	NS
F x S	NS	NS	NS	NS
V x F x S	NS	*	*	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing, * = Significant at 5% level of probability

IV. Number of Pods per Stand

The mean number of pods per stand was significant only in 2006 among the varieties and was significantly higher in RRB and ICGV-86024 than in Ex-Dakar, but in 2007, 2008 and in combined analysis, all the varieties had similar pod yield. This could be attributed to the disease tolerance of the variety Ex-Dakar, since the disease severity was more on the variety. This result confirmed the earlier report by Bdliya and Muhammad (2006), that Ex-Dakar is a high-yielding cultivar which requires less rainfall and is more tolerant to the Cercospora leaf spot than RMP 12 and Kano 38. The reason for the three varieties having similar pod yield could be due to the facts that all of them are improved varieties developed to suit the agro-ecological zone where the study was conducted.

Number of pods per stand was significantly affected by fungicidal rate in all the years and in combined analysis. The results revealed that, the control significantly had the lowest number of pods per stand. Spraying Mancozeb at the rate of 0.8 kg a.i. /ha resulted in a significant increase in the number of pods in 2006, 2007 and in combined analysis, with the exception of 2008. When the rate was doubled to 1.6 kg a.i. /ha, the number of pods significantly increased in all the years and in combined analysis. But when the rate was increased to 3.2 kg a.i. /ha, no further significant increase in the number of pods per stand was recorded in all the years and in combined analysis. This could be due the lower disease incidence and severity recorded as a result of application of mancozeb compared to the untreated crops. The application of mancozeb resulted in pod yield increase from 10.12% to 29.07%, 22.22% to 63.51% and 5.33% to 34.02% in 2006, 2007 and 2008 rainy seasons respectively. These results agree with the findings of Naab et al. (2005) who reported that application of foliar sprays of fungicide in Ghana was effective in controlling Cercospora leaf spot and improved groundnut biomass and pod yield by 39% and 75% respectively when averaged across cultivars and years. In Nigeria, Salako (1985) investigated the application of a range of fungicides for disease control in groundnut and reported a yield increase of 132 – 286% over unsprayed plots depending on the fungicide used.

The mean number of pods per stand was significantly higher in intra-row spacing of 30 cm than in 25 cm and 20 cm. It was also higher in 25 cm spacing than in 20 cm. This difference in number of pods per stand among the spacing could be attributed to difference in disease incidence and severity recorded by the individual spacing. Closer spacing had higher plant population per unit area (density) which resulted in severely infected plants that yielded lower number of pods per stand than the less severely infected plants of the wider spacing.

These findings are in line with the findings of Ihejirika et al. (2006) who reported that 20x20 cm spacing had higher number of pods per stand than 10x10cm spacing. The report by Elad et al. (1982) that, pod and total weight per plant were larger with wider in-row and between-row spacing; however, pod yield and plant weight per hectare were greater with close in-row and between-row spacing further corroborates the findings of this study.

Table 3: Effects of variety, fungicidal rate and spacing on number of pods per stand

Treatment	Number of pods per stand			
	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	28.41[b]	25.83	30.91	28.39
RRB	34.83[a]	25.26	32.35	30.82
ICGV-86024	35.35[a]	24.81	31.72	30.71
SE (±)	0.5061	1.173	1.728	34.26[a]
Fungicidal rate (F)				
3.2 kg a.i. /ha	36.85[a]	30.02[a]	35.93[a]	34.26[a]
1.6 kg a.i. /ha	34.92[a]	30.41[a]	35.68[a]	33.67[a]
0.8 kg a.i. /ha	31.44[b]	22.44[b]	28.24[b]	27.37[b]
0 kg a.i. /ha	28.55[c]	18.36[c]	36.81[c]	24.57[c]
SE (±)	1.005	1.205	1.587	8.248
Spacing (S)				
20 cm	33.83	23.55[b]	29.40[c]	28.38[c]
25 cm	32.80	24.52[b]	31.56[b]	29.63[b]
30 cm	32.19	27.84[a]	34.03[a]	31.90[a]
SE (±)	0.562	0.603	0.563	0.371
Interactions				
V x F	NS	NS	NS	NS
V x S	NS	NS	NS	**
F x S	NS	NS	NS	*
V x F x S	NS	NS	NS	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing, ** and * = Highly Significant at 1% and Significant at 5% levels of probability

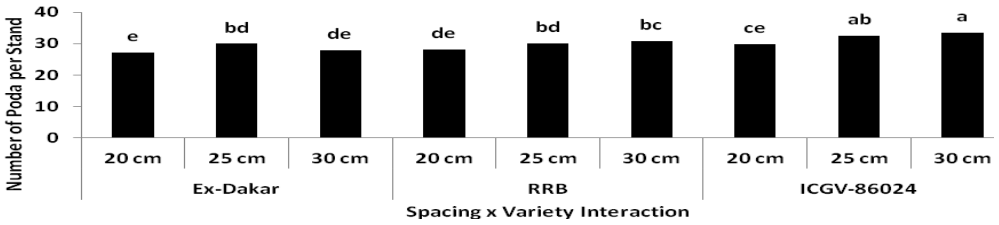

Figure 1: Interaction between variety and spacing on number of pods per stand of groundnut in the combined analysis

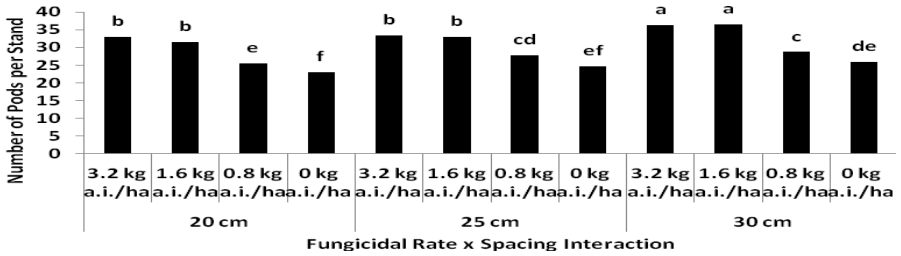

Figure 2: Interaction between fungicidal rate and spacing on number of pods per stand of groundnut in the combined analysis

Pods Yield

Pod yield was statistically similar among the three varieties in all the years and combined analysis. This was so despite the fact that, disease incidence and severity were significantly higher in variety Ex-Dakar than the remaining varieties. This might be attributed to the higher disease tolerance of Ex-Dakar. Bdliya and Muhammad (2006) also observed that, Ex-Dakar is a high-yielding variety, which requires less rainfall and is more tolerant to Cercospora leaf spot than the other varieties.

Pod yield varied among the fungicidal rates in all the years and in combined analysis. The highest pod yield was recorded by application of 1.6 and 3.2 kg a.i. /ha rates in the 2006, 2007 and 2008 rainy seasons, but in the combined analysis, 3.2 kg a.i. /ha rate significantly had the highest pod yield. The pod yield decreased with decrease in application rate of the fungicide mancozeb. The lowest pod yield thus was consistently recorded by the untreated control. Pod yield increased by 8.4 to 63.7%, 18.5 to 61% and 24.5 to 52.8% in the 2006, 2007 and 2008 rainy seasons respectively as a result of Mancozeb application at the rate of 0.8 – 3.2 kg

a.i. /ha. This could be attributed to the efficacy of mancozeb in reducing the incidence and severity of Cercospora leaf spot disease of groundnut. Efficacy of fungicides in controlling Cercospora leaf spot of groundnut has been reported (Naab et al., 2005).

Pod yield was significantly higher in 20 cm intra-row spacing than the remaining spacing. On the other hand, 25 cm recorded pod yield significantly higher than the 30 cm spacing. This might be due to the difference in plant population at the spacing. Spacing 20x50cm gives a population of 100,000 plants per hectare, 25x50 gives 80,000 plants per hectare while 30x50cm gives a population density of 66,666 plants per hectare. This result strongly confirmed the findings of Elad et al. (1982) that pod and total weight per plant were higher with wider intra and inter-row spacing; however, pod yield and plant weight per hectare were greater with close intra and inter-row spacing. These results confirmed that optimum population per unit area is required to harvest the maximum pod yield and the same result is obtained in the present investigation also. The reduction in pod yield in wide row spacing might be due to the lower plant population per unit area (Kalra et al., 1984).

Table 4: Effects of variety, fungicidal rate and spacing on pods weight (kg/ha) of groundnut

	Pod Weight (kg/ha)			
Treatment	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	2042.1	1639.3	2163.7	1948.4
RRB	2321.3	1696.7	2373.9	2130.6
ICGV-86024	2392.3	1605.4	2284.9	2103.5
SE (±)	78.98	76.99	139.10	73.82
Fungicidal rate (F)				
3.2 kg a.i. /ha	2864.8[a]	2014.6[a]	2634.9[a]	2504.8[a]
1.6 kg a.i. /ha	2536.4[a]	1844.8[a]	2589.2[a]	2323.5[b]
0.8 kg a.i. /ha	1893.7[b]	1479.8[b]	2147.6[b]	1840.4[c]
0 kg a.i. /ha	1749.7[b]	1249.3[b]	1724.6[c]	1574.5[d]
SE (±)	164.10	112.65	109.32	65.78
Spacing (S)				
20 cm	2638.9[a]	1959.6[a]	2716.5[a]	2438.3[a]
25 cm	2205.6[b]	1626.0[b]	2258.5[b]	2030.0[b]
30 cm	1939.0[c]	1355.7[c]	1847.4[c]	1740.0[c]
SE (±)	117.97	64.85	71.65	48.21
Interactions				
V x F	NS	NS	NS	*
V x S	NS	NS	NS	NS
F x S	NS	NS	NS	*
V x F x S	NS	NS	NS	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing, * = Significant at 5% level of probability

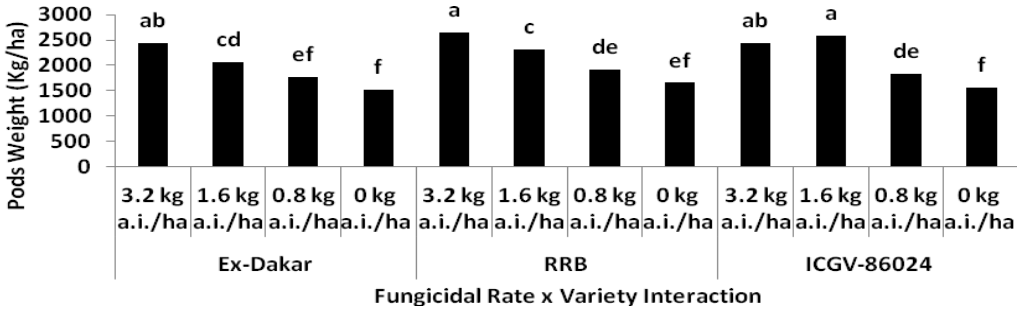

Figure 3: Interaction between variety and fungicidal rate on pods weight (Kg/ha) of groundnut in the combined analysis

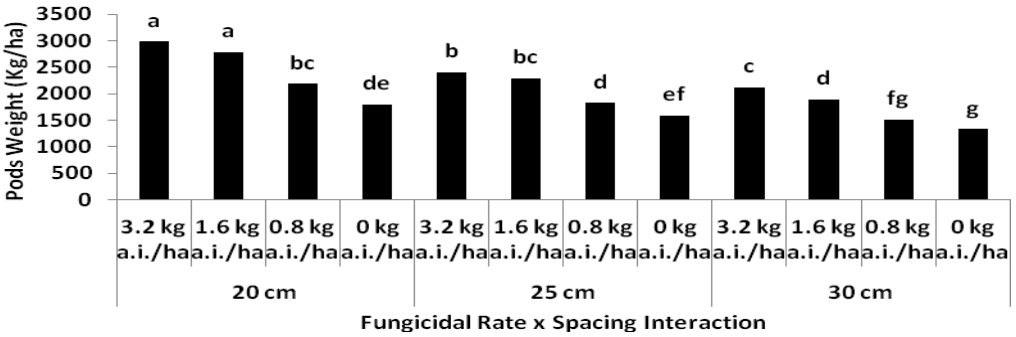

Figure 4: Interaction between fungicidal rate and spacing on pod weight (Kg/ha) in the combined analysis

V. 100-Seed Weight

Significant 100-seed weight difference was recorded in 2007, 2008 and their combined analysis among the groundnut varieties. The variety ICGV-86024 had higher seed weight than both Ex-Dakar and RRB, which had similar seed weight. This is probably due to difference in seed size, which varies with cultivars. Bdliya and Muhammad (2003) obtained significantly higher seed weight in variety RMP 12 than the other varieties. He observed that RMP 12 had bigger seeds than the other varieties. Variation in seed weight among groundnut varieties have been reported by other authors (Ahmad et al., 2007; Chandrasekaran et al., 2007).

Fungicidal rate also significantly ($P \leq 0.05$) affected hundred seed weight in all the years and combined analysis. In all the years and in combined analysis, 0 kg a.i. /ha significantly had the lowest seed weight. Application of Mancozeb at the rate of 0.8 kg a.i. /ha did not cause significant increase in the seed weight except in the combined analysis. On the other hand, increase in the application rate of Mancozeb to 1.6 kg a.i. /ha caused significant increase in the seed weight in all the years and in combined analysis. The seed weight did not change significantly as a result of doubling the rate to 3.2 kg a.i. /ha in all the years and in combined analysis. Similarly, Bdliya and Alkali (2008) reported that, three sprays of neem seed and garlic clove extracts gave the highest 100 seed weight while the lowest seed weight was recorded in the control. They attributed this to the reduced disease incidence and severity. Severe leaf spots might interfere with the photosynthetic processes reducing the amount of assimilate and hence the reduced seed weight. Thomas et al. (1996) also reported that severe foliar infection during grain filling reduces grain weight. Generally, Mancozeb application caused production of heavier seeds in 2006, followed by 2008 while the seeds were less heavy in 2007.

Spacing also had significant effect on hundred seed weight in all the years and in combined analysis. In 2006 and 2007, 30 cm produced the heaviest seeds, though similar to those obtained at 25 cm. The less heavy seeds were obtained at 20 cm, though similar to those produced at 25 cm. In 2008 and in combined analysis, 30 cm had seeds heavier than those at 25 cm and 20 cm whose seeds weight were similar. This could be attributed to the higher disease incidence and severity as well as higher plant competition for nutrients, space and moisture recorded by 20 cm spacing than the other spacings. These results agree with those of Zarafi and Emechebe (2006) where one thousand grain-weight increased with increase in intra-row spacing. On the contrary, Chandrasekaran et al. (2007) reported that, influence of spacing on 100-kernel weight was not significant.

Table 6: Effects of variety, fungicidal rate and spacing on 100 seed weight (g) of groundnut

	100 Seed Weight (g)			
Treatment	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	36.61	30.95^{b}	31.24^{b}	32.94^{b}
RRB	37.01	31.59^{b}	32.28^{b}	33.63^{b}
ICGV-86024	37.23	34.13^{a}	35.81^{a}	35.72^{a}
SE (±)	0.284	0.621	1.300	0.494
Fungicidal rate (F)				
3.2 kg a.i. /ha	38.51^{a}	34.67^{a}	35.92^{a}	36.34^{a}
1.6 kg a.i. /ha	38.31^{a}	34.55^{a}	35.86^{a}	36.26^{a}
0.8 kg a.i. /ha	37.15^{b}	30.69^{b}	31.65^{b}	33.17^{b}
0 kg a.i. /ha	33.81^{b}	28.98^{b}	29.02^{b}	30.61^{c}
SE (±)	0.632	1.036	0.860	0.724
Spacing (S)				
20 cm	36.23^{b}	31.59^{b}	32.82^{b}	33.55^{b}
25 cm	36.78^{ab}	32.16^{ab}	32.68^{b}	33.87^{b}
30 cm	37.82^{a}	32.93^{a}	33.84^{a}	34.86^{a}
SE (±)	0.610	0.492	0.505	0.377

Interactions				
V x F	NS	NS	NS	NS
V x S	NS	NS	NS	NS
F x S	NS	NS	NS	NS
V x F x S	NS	NS	NS	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing

Seed Yield

Significant seed yield difference was recorded only in 2006 among the groundnut varieties and it was highest inICGV-86024 followed by RRB and lowest in Ex-Dakar, while in 2007, 2008 and in combined analysis, the difference was not significant. This might be as a result of difference in inherent yield potential of the varieties, their disease tolerance as well as difference in weather components that affected disease development during the three seasons of the study. Disease tolerance of Ex-Dakar has been reported by Bdliya and Muhammad (2006).

Seed yield varied among the fungicidal rates in all the years and combined analysis. The highest seed yield was recorded at 1.6 and 3.2 kg a.i. /ha rates in all the years and in the combined analysis. The seed yield decreased with decrease in application rate of the fungicide Mancozeb. The lowest seed yield thus was consistently recorded by the control. Seed yield increased by 20.7 – 56.7%, 20.1 – 60.2% and 34.1 – 77.5% in the 2006, 2007 and 2008 rainy seasons respectively, as a result of Mancozeb application at the rate of 0.8 – 3.2 kg a.i. /ha. This could be attributed to the difference in efficacy of the three application rates in reducing the incidence and severity of the disease. Efficacy of fungicides on Cercospora leaf spot of groundnut has been reported (Naab et al., 2005; Fowler and MacDonald, 1981). Contrastingly, Mathivanan and Prabavathy (2007) reported that, though spraying of carbendazim and mancozeb individually reduced Alternaria leaf blight of sunflower; it was not statistically significant when compared with unsprayed control.

Seed yield was significantly higher in 20 cm intra-row spacing than the remaining spacings. On the other hand, 25 cm recorded seed yield significantly higher than the 30 cm spacing. This might be due to the difference in plant population at the different spacings. Spacing 20x50cm gives a population of 100,000 plants per hectare, 25x50 gave 80,000 plants per hectare while 30x50cm gives a population density of 66,666 plants per hectare. This result strongly confirmed the findings of Burke (1965) who observed that wide spaced plants had larger individual plant yield than closer spaced plants, but yield per unit area was seldom increased by wide spacing. On the contrary, Ihejirika (2010) reported that, 250 000 plants/ha recorded the lowest leaf spot disease severity and highest seed yield (t/ha), while 444,444 plants/ha recorded the highest leaf spot disease severity, highest stalk yield but lower seed yield in 2003 and 2004 respectively. This explains that, diminishing returns sets in and limits the use of plant population density to increase seed yield at a particular point.

Table 7: Effects of variety, fungicidal rate and spacing on seed yield (kg/ha) of groundnut

	Seed Yield (kg/ha)			
Treatment	2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	1398.9^{c}	1166.6	1463.3	1342.9
RRB	1554.9^{b}	1161.0	1517.1	1411.0
ICGV-86024	1738.3^{a}	1148.4	1423.1	1436.3
SE (±)	44.727	73.78	100.33	48.35
Fungicidal rate (F)				
3.2 kg a.i. /ha	1819.1^{a}	1375.3^{a}	1772.8^{a}	1655.7^{a}
1.6 kg a.i. /ha	1841.7^{a}	1370.6^{a}	1760.3^{a}	1657.6^{a}
0.8 kg a.i. /ha	1418.9^{b}	1030.4^{b}	1339.3^{b}	1262.8^{b}
0 kg a.i. /ha	1175.1^{c}	858.4^{b}	998.9^{c}	1010.8^{c}
SE (±)	82.793	90.258	54.83	36.66
Spacing (S)				
20 cm	1858.8^{a}	1419.3^{a}	1771.3^{a}	1683.1^{a}
25 cm	1525.2^{b}	1141.7^{b}	1456.5^{b}	1374.5^{b}
30 cm	1307.1^{c}	914.9^{c}	1175.7^{c}	1132.6^{c}
SE (±)	72.383	49.891	27.28	22.56
Interactions				
V x F	NS	NS	NS	NS
V x S	NS	NS	NS	NS
F x S	*	NS	**	**
V x F x S	NS	NS	NS	NS

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing, ** and * = Highly Significant at 1% and Significant at 5% levels of probability

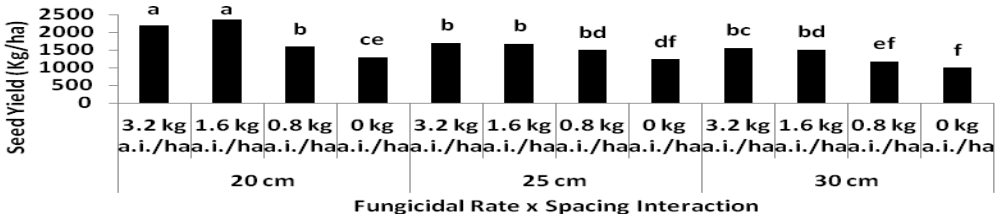

Figure 5: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut during the 2006 rainy season

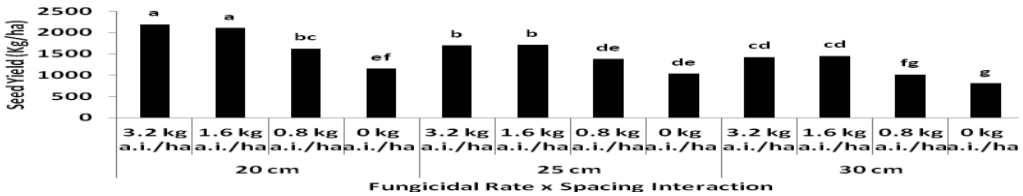

Figure 6: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut during the 2008 rainy season

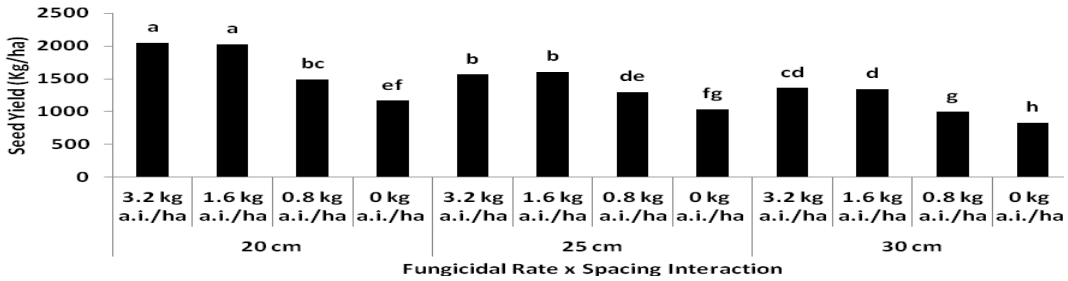

Figure 7: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut in the combined analysis

VI. Haulm Yield

Variety of groundnut did not significantly ($P<0.05$) affect haulm yield except in 2008. Ex-Dakar yielded significantly higher haulm than RRB and ICGV-86024. The haulm yields of the two varieties were similar. This might be due to the tolerance of Ex-Dakar to Cercospora leaf spot. It could also be as a result of allocating more assimilates to vegetative growth than to seed formation following destruction of the foliage by the disease. This may possibly be the reason why Ex-Dakar had the lowest seed yield among the varieties. But the haulm yield of variety ICGV-86024 reported here contradicts Kodio (2004) who reported in farmer participatory variety selection (PVS) trials in Mali that, ICGV-86024 had the lowest seed and haulm yield among the varieties studied possibly due to under utilization of resources or the poor nature of the farming inputs. Variation in terms of haulm yield among groundnut varieties has been reported (Pande and Narayana Rao, 2002; Izge et al., 2007).

Fungicidal rates of 0 kg a.i. /ha and 0.8 kg a.i. /ha had similar haulm yield. The yield significantly increased due to spraying Mancozeb at the rate of 1.6 kg a.i. /ha. Increasing the rate to 3.2 kg a.i. /ha did not significantly increase the haulm yield. This agrees closely with Bdliya and Gwio-Kura (2007) who reported that all the fungicides increased haulm weight over the control; the highest haulm yield was obtained following the application of Bentex T and Benlate 50 WP. This might be due to the effective control of the Cercospora leaf spot by the two fungicides.

In 2006 and 2008, 20 cm and 25 cm had similar haulm yields that were significantly higher than that of 30 cm. In 2007 and in combined analysis, 20 cm significantly recorded higher haulm yield than 25 cm. On the other hand 25 cm also had significantly ($P\leq0.05$) higher haulm yield than that of 30 cm spacing. The difference could be due to differences in plant populations at the three spacing. The result agrees with Pande and. Narayana Rao (2002) who reported that, haulm yields were significantly low in lower plant densities than in higher plant densities in all the cultivars irrespective of fungicide application. Haulm yields increased as the plant densities increased in all the cultivars in both sprayed and unsprayed plots. Haulm yield was generally higher in 2007 than in 2006 and 2008.

Table 8: Effects of variety, fungicidal rate and spacing on haulm yield (kg/ha)

Treatment	Haulm Yield (kg/ha) 2006	2007	2008	Combined Analysis
Variety (V)				
Ex-Dakar	3800.4	4508.7	4871.7[a]	3982.7
RRB	3678.4	5524.2	3774.6[b]	4325.7
ICGV-86024	4757.4	4839.7	3639.2[b]	4822.9
SE (±)	343.58	522.51	288.66	284.80
Fungicidal rate (F)				
4 a.i. kg/ha	4523.4[a]	6253.3a	4275.1	4945.2
2 a.i. kg/ha	4342.2[a]	5780.4[a]	4240.0	4827.8
1 a.i. kg/ha	4202.8[b]	4288.9[b]	4179.4	3740.4
0 a.i. kg/ha	3246.3[b]	3507.4[b]	3686.0	3995.1
SE (±)	288.82	389.73	213.04	232.25
Spacing (S)				
20 cm	4316.4[a]	5624.8[a]	4377.3[a]	4772.8[a]
25 cm	4311.4[a]	4937.2[b]	4184.7[a]	4477.8[b]
30 cm	3608.3[b]	4310.6[c]	3723.5[b]	3880.0[c]
SE (±)	248.77	126.47	214.11	96.48
Interactions				
V x F	NS	NS	**	NS
V x S	NS	NS	*	*
F x S	NS	NS	NS	NS
V x F x S	NS	NS	*	*

Means within same column followed by same letter(s) are not significantly different at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant; DAS = Days after sowing, ** and * = Highly Significant at 1% and Significant at 5% levels of probability

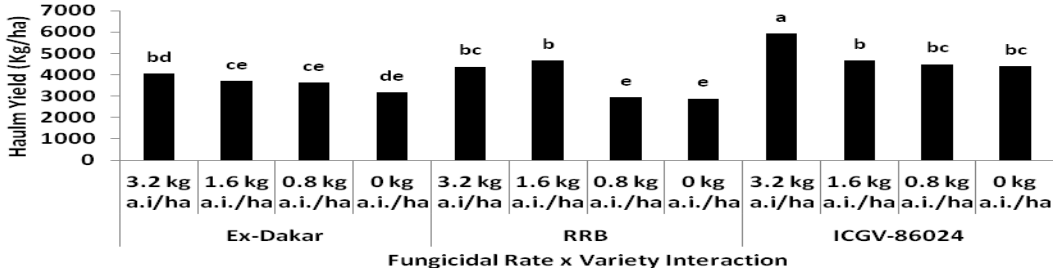

Figure 8: Interaction between variety and fungicidal rate on haulm yield (Kg/ha) of groundnut during the 2008 rainy season

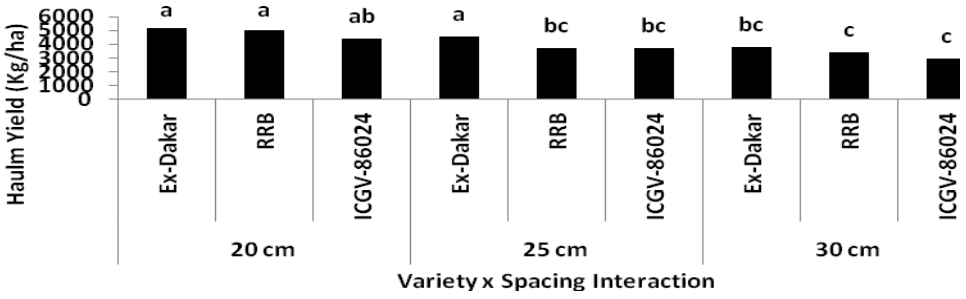

Figure 9: Interaction between variety and spacing on haulm yield (Kg/ha) of groundnut during the 2008 rainy season

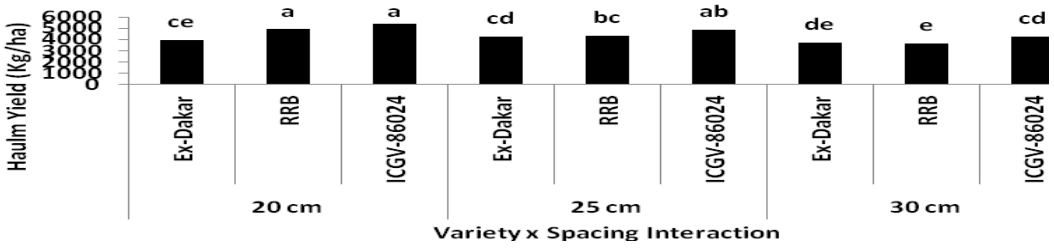

Figure 10: Interaction between variety and spacing on haulm yield (Kg/ha) in the combined analysis

VII. Conclusion

Conclusion can be drawn from the trials that all the three varieties of groundnut, (Ex-Dakar, RRB and ICGV-86024) used in the study are susceptible to cercospora leaf spot. Furthermore, the results of this study have clearly demonstrated the benefits derivable from fungicidal control of cercospora leaf spot in the Sudan savanna of Nigeria. The results have also demonstrated the superiority of 1.6 kg a.i. /ha rate of mancozeb over the other rates in controlling the disease. It can also be concluded that 20 cm intra-row spacing outperformed the other spacing used in the study in terms of yield despite the higher disease values recorded. Lastly, the interactions between all the three varieties and fungicidal rate 1.6 kg a.i. /ha (V x F), between the three varieties and intra-row spacing of 20 cm (V x S), between 1.6 kg a.i. /ha and 20 cm spacing as well as between all the three varieties and fungicidal rate 1.6 kg a.i. /ha and 20 cm intra-row spacing (VxFxS) outperformed all the remaining interactions treatment.

VIII. Recommendations

All the three varieties could be used by farmers in the study area and other similar Agro-ecological zone where cercospora leaf spot constitutes a problem to groundnut production and could be treated with 1.6 kg a.i. /ha of fungicide mancozeb and sown at 20 cm apart within the row and 50 cm between the rows.

References

[1]. Ahmad, N., Rahim, M. and Khan, U. (2007). Evaluation of various sowing dates for groundnut varieties under agro-ecological conditions of Malakand Division. Gomal University Journal of Research, 23(2): 1- 4.

[2]. Alabi, O., Olorunju, P.E., Misari, S.M., and Boye-Goni, S.R. (1993). Management of groundnut foliar diseases in Samaru, Northern Nigeria In: Summary Proceedings of the Third ICRISAT Regional Groundnut Meeting for West Africa W.F. Ntare, and J.H.Williams (eds.) 35 – 36pp.

[3]. Alabi, O. and Olorunju, P. E. (2004). Evaluation of neem seed extract, black soap and cow dung for the control of groundnut leaf spot at Samaru, Nigeria, Archives of Phytopathology and Plant Protection, 37: 2, 123 – 127

[4]. Alkali, G. (2005). Study on the efficacy of some plant extracts on the management of Cercospora leaf spot of groundnut in Sudan Savanna region of Nigeria. An Unpublished M.Sc. Crop Protection Dissertation, Submitted to Crop Protection Department, Faculty of Agriculture, University of Maiduguri. Pages112.

[5]. Bdliya, B. S. and Alkali, G. (2008). Efficacy of some plant extracts in the management of Cercospora leaf spot of groundnut in the Sudan savanna of Nigeria, Archives of Phytopathology And Plant Protection, 43: 5, 507 – 518.

[6]. Bdliya, B. S and Gwio-Kura, K. K. (2007). Efficacy of some fungicides in the management of Cercospora leaf spot of groundnut in the Sudan savannah of Nigeria. Journal of Plant Protection Research, 47(3):243 – 252.

[7]. Bdliya, B. S. and Muhammad, A. S. (2006). Effect of inter-cropping millet with groundnut on the control of Cercospora leaf spot of groundnut in the Sudan Savanna of north-eastern Nigeria. Journal of Sustainable Agriculture, 29(2): 19-41.

[8]. Burke, D. W. (1965). Plant spacing and Fusarium root rot of beans. Phytopathology, 55:757-759.

[9]. Chandrasekaran, R., Somasundaram, E., Mohamed Amanullah, M., Thirukumaran, K. and Sathyamoorthi, K. (2007). Influence of variety and plant spacing on the growth and yield of confectionery groundnut (Arachis hypogaea L.). Research Journal of Agriculture and Biological Sciences, 3(5): 525-528.

[10]. Chongo, G., L. Buchwaldt, B.D. Gossen, G.P. Lafond, W.E. May, E.N. Johnson, and T. Hogg. (2003). Foliar fungicides to manage ascochyta blight (Ascochyta rabiei) of chickpea in Canada. Canadian. Journal of Plant Pathology, 25:135- 142.

[11]. Elad, Y., Hadar, Y., Chat, I. and Hemis, Y. (1982) Prevention with Trichoderma harzianum Rifai of reinfestation by Sclerotium rolfsii Sacc. and Rhizoctonia solani Kuhn of soil fumigated with methyl bromide and improvement of disease control in tomatoes and peanuts. Crop Protection 1, 199–211.

[12]. Fowler, A .M. and McDonald, D. (1981). In: A review of controlled droplet application (CDA) spraying techniques for fungicide and insecticide application in vegetable and leguminous crops 5pp.wwww.micron.co.uk/vegleg.html

[13]. Ghewande, M. P., Shukla, A. K. and Pandey, R. N. (1986). Management of foliar diseases of groundnut through agronomic practices. Indian Bot. Rep. 5:179 - 181.

[14]. Gomez, K. A. and Gomez, A. A. (1984). Statistical procedure for Agricultural research, second edition. Pp.20-30.

[15]. Grove, M. D. (1980). Downy mildew control on susceptible cantaloupe. Plant Disease, 64:390 -391.

[16]. Ihejirika, G.O. (2010). Current options for improving leafspot disease resistance and yield of groundnut in an Ultisols. Archives of Phytopathology and Plant Protection. Vol. 43 (5): 454 – 459.

[17]. Ihejirika, G. O., Nwufo, M. I., Oputa, E., Obilo, O. P., Ogbede, K. O. and Onyia, V. N. (2006). Effects of NPK fertilizer rates and plant population on foliar diseases, insect damage and yield of groundnut. Journal of Plant Sciences, 1 (4): 362-367.

[18]. Izge, A.U., Muhammad, Z. H. and Goni, H. (2007). Level of variability in groundnut (Arachis

[19]. hypogaea L) to Cercospora leaf spot disease-implication for selection. Journal of Sustainable Development in Agriculture and Environment, Vol. 2: Issue 2.

[20]. Jacobi, J. C., and Backman. P. A. (1991). Effects of tebuconazole on seed quality and fungal colonization on two cultivars of peanut. Phytopathology, 81:812.

[21]. Kalra, G.S., Thorat, S.T. and Pawar, A.B. (1984). Response of improved groundnut varieties to different spacing under irrigated condition. Indian Journal of Agriculture and Science, 29(1): 40-42

[22]. Khalil, M. R., Khan, N. V., Younas, M., Shah, N. H. and Hassan, G. (1992). Control of downy mildew of melon (Cucumis melo) with different fungicides. Pakistan Journal of Phytopathology 4:50-53.

[23]. Ketring, D., and Melouk, H.A. (1982). Ethylene production in leaflet abscission of three peanut genotypes infected with Cercospora arachidicola. Plant Physiology, 69:789-92.

[24]. Kodio, O. (2004). Development of sustainable groundnut seed supply systems inWest Africa. Report of Project Coordinators Meeting. ICRISAT-Bamako, Mali, http://www.icrisat.org/gsp/06_ENG_GSP_2004_Coord_meeting1.pdf

[25]. Mamza, W. S., Zarafi, A. B. and Alabi, O. (2008). In vitro evaluation of six fungicides on radial mycelial growth and regrowth of Fusarium pallidoroseum isolated from castor (Ricinus communis) in Samaru, Nigeria. African Journal of Agriculture, Vol. 4:2, 65-71.

[26]. Mathivanan, N. and Prabavathy, V. R. (2007). Effect of carbendazim and mancozeb combination on Alternaria leaf blight and seed yield in sunflower (Helianthus annus L.). Archives of Phytopathology and Plant Protection, 40: 2, 90 - 96
[27]. Muhammed, Z. H. (2004). Evaluation of groundnut varieties for resistance to Cercospora leaf spot diseases in the Sudan Savanna. An Unpublished M.Sc. Crop Protection Dissertation, Submitted to Crop Protection Department, Faculty of Agriculture, University of Maiduguri. Pp -77.
[28]. Naab, J. B., Tsigbey, F. K., Prasad, P. V. V., Boote, K. J., Bailey, J. E. and Brandenburg, R. L. (2005). Effects of sowing date and fungicide application on yield of early and late maturing peanut cultivars grown under rainfed conditions in Ghana. Crop Protection. Vol: 24:4, 325-332
[29]. Nutter, F. W. Jr., and Shokes. F. M. (1995). Management of foliar diseases caused by fungi. In H. A. Melouk and F. M. Shokes (eds.) Peanut Health Management. American Phytopathological Society, St. Paul, MN. pp 43-49.
[30]. Pande, S. and Narayana Rao, J. (2002). Effect of plant population densities on the severity of late leaf spot and rust of groundnut. Plant Pathology Journal, 18(5): 271-278.
[31]. Patel, J. G. and Patel, A. J. (1980). Efficacy of systemic and non-systemic fungicides on the control of downy mildew of muskmelon. Indian Journal of Mycology and Plant Pathology 10:87.
[32]. RMRDC, (2004). Raw Materials Research and Development Council: Report on survey of selected Agricultural Raw Materials in Nigeria. www.rmrdc.Gov.nig/ Survey report 2005/Groundnut
[33]. Salako. E. A. (1985). Fungicidal control of groundnut leaf spots and rust by ultra-low volume spray.Tropical Pest Management 31:63 - 66.
[34]. Smith, D.H. and Littrell, R.H. (1980). Management of peanut foliar diseases with fungicides. Plant Disease. 64:356-61.
[35]. Subrahmanyam, P., McDonald, D. and Gibbons. R.W. (1983). Variation in Cercosporidium personatum symptoms on certain cultivars of Arachis hypogaea Peanut leaf spot disease. Oleagineux 37:63-68.
[36]. Subrahmanyam, P., McDonald, D., Waliyar, F., Reddy, L.J., Nigam, S. N.,Gibbons, R.W., Rao, V. R., Singh, A. K., Pande, S., Reddy, P M., and Rao, P.V. (1995). Screening methods and sources of resistance to rust and late leaf spot of groundnut. ICRISAT Information Bulletin No. 47. Patancheru 502 324, Andra Pradesh. 24 pp.
[37]. Yantai G., Bruce, D. G., Lin L., Greg F. and Sabine B. (2007). Cultivar Type, Plant Population, and Ascochyta Blight in Chickpea. Agronomy Journal, 99:1463–1470.
[38]. Yayock, J.Y. (1978). Yield and yield characteristics of certain varieties of groundnuts (Arachis hypogaea L.) as affected by plant population and fertilizer levels in Nigeria. Ph.D. Thesis, A.B.U. Zaria.
[39]. Yayock, J. Y. (1981). Effects of plant population density and leaf spot control on yield of groundnuts (Arachis hypogaea L.) in Nigeria. Samaru Journal of Agricultural Research. 1:3-10.
[40]. Zarafi, A. B. and Emechebe, A. M.(2006) 'Effect of intra row spacing on the incidence and severity of pearl millet downy mildew and grain yield', Archives of Phytopathology And Plant Protection, 39: 1, 9 – 14.