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

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Abstract
A field trial was conducted during 2006, 2007 and 2008 cropping seasons to evaluate the effects of 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 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) whereas 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, for an Ex-Dakar variety. Spraying was done fortnightly. The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) replicated three times. Results of the work revealed that, 3.2 kg a.i./ha and 1.6 kg a.i./ha recorded the lowest incidence and severity of the disease, followed by 0.8 kg a.i./ha, while the highest was recorded on the untreated plots. The spacing of 20cm recorded the highest disease values, followed by 25cm while the widest spacing of 30cm had the lowest disease values. The results further revealed that, 3.2 kg a.i./ha, recorded the highest yield followed by 1.6 kg a.i./ha, then 0.8 kg a.i./ha and 0 kg a.i./ha significantly had the lowest yield in all the years and combined analysis. Therefore, it is recommended that Mancozeb should be applied at the rate of 1.6 kg 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 variety and similar varieties.
Key Words: Groundnut; *Cercospora* leaf spots; Fungicidal rate; Intra-Row Spacing; Yield

1. Introduction

In Nigeria leaf spot and rosette virus are the most serious damaging diseases of groundnut (Alabi *et al*., 1993). Worldwide losses as high as 50% of the seed yield and even higher for haulms have been reported (Nyval, 1989; Dewaele and Swanevelder, 2001; Salako, 1987). Control of leaf spot diseases in Nigeria has depended on some cultural practices and on multiple applications of fungicides. Effective and long-term control of leaf spot disease can be achieved by applying recommended fungicides at the recommended time intervals. Combination of several control strategies is recommended (Kucharek, 2004). Reduction of initial inoculum is achieved through cultural measures such as crop rotation, removal of volunteer plants, and burial of groundnut residue (Shokes and Culbreath, 1997). Spraying with fungicides is required to achieve optimal yields during most years (Bailey *et al*., 1994).Various cultural practices have been reported to help reduce the incidence and severity of the disease. These include measures aimed at reducing the potential sources of pathogen such as destruction of crop residues and volunteers. Others include early sowing; wide spacing, crop rotation; host plant resistance as well as optimal fertilization will also help to control or reduce the disease (Acland, 1971; Hill and Waller, 1998; Nyval, 1989; Adipala *et al.*, 2000).

This paper reports the results of an experiment to identify the ideal 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.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was conducted at, Teaching and Research Farm of the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, Nigeria (Latitude 11°51'N; 13°15'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.

2.2 Treatments and Experimental Design

The treatments consisted of four fungicidal rates and three spacing. The fungicidal rates are, 0 kg a.i. /ha, 0.8 kg a.i. /ha, 1.6 kg a.i. /ha, 3.6 kg a.i. /ha of mancozeb which is a wettable powder (WP), whereas the spacing comprised 20 cm (S_1) 25 cm (S_2) and 30 cm (S_3) for intra-raw spacing and an inter-row spacing of 50cm. The

treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) replicated three times.

2.3 Cultural Practices

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.

2.4 Data Collection

Twenty plants were selected randomly in each sub-plot for data collection on parameters such as, disease incidence, disease severity, number of pods per stand, pods weight, 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.

2.5 Data Analysis

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).

3. RESULTS AND DISCUSSION

3.1 Disease Incidence

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 Fowler (1971), who stated that increase in plant population was found to be aggravating factor for *Cercospora* leaf spot of groundnut. It is also in line with FAO (1990) which suggested that closer spacing favours many airborne diseases because of high humidity of crop canopy and that leaf spot of groundnut is more in dense canopy.

Table1: Effects of 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
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				
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 (DMRT) NS = Not significant; DAS = Days after sowing

3.2 Disease Severity

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 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
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				
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

3.3 Number of Pods per Stand

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

	Number of pods per stand			
Treatment	2006	2007	2008	Combined
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
Interaction				
F x S	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

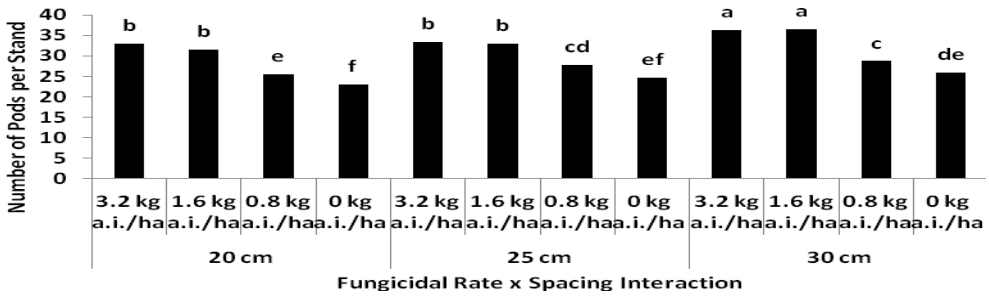

Figure 1: Interaction between fungicidal rate and spacing on number of pods per stand of groundnut in the combined analysis

3.4 Pods Yield

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 fungicidal rate and spacing on pods weight (kg/ha) of groundnut

	Pod Weight (kg/ha)			
Treatment	2006	2007	2008	Combined
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
Interaction				
F x S	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

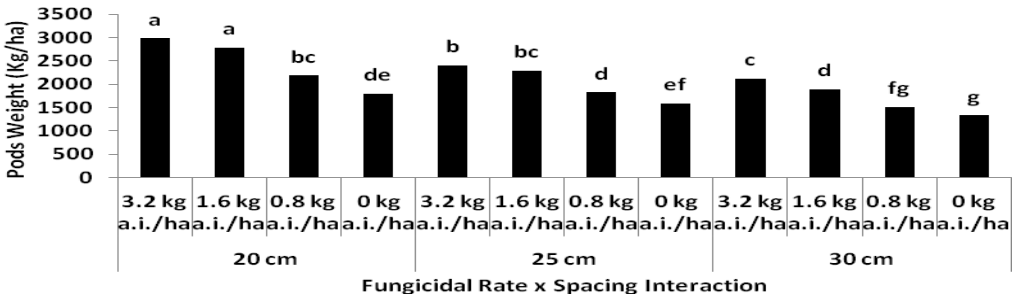

Figure 2: Interaction between fungicidal rate and spacing on pod weight (Kg/ha) in the combined analysis

3.5 100-Seed Weight

Fungicidal rate significantly (P≤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
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
Interaction				
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

3.6 Seed Yield

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
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
Interaction				
F x S	*	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

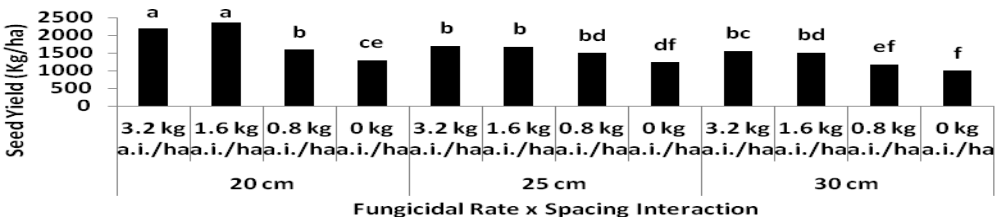

Figure 3: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut during the 2006 rainy season

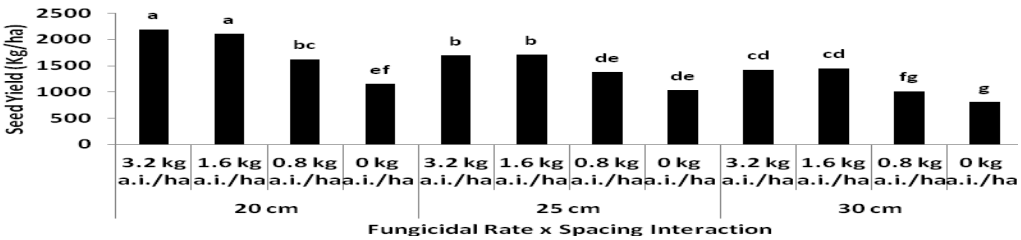

Figure 4: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut during the 2008 rainy season

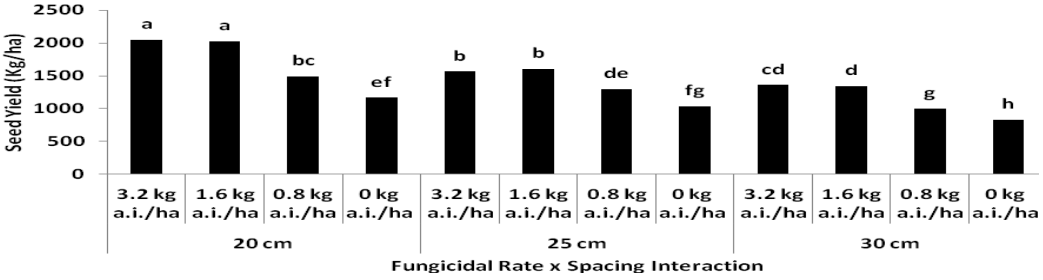

Figure 5: Interaction between fungicidal rate and spacing on seed yield (Kg/ha) of groundnut in the combined analysis

3.7 Haulm Yield

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) *w*ho 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 ($P \leq 0.05$) 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)

	Haulm Yield (kg/ha)			
Treatment	2006	2007	2008	Combined
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
Interaction				
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

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Conclusion can be drawn from that 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 1.6 kg a.i. /ha and 20 cm spacing appeared very promising.

4.2 Recommendations

For any groundnut variety used by farmers in the study area and other similar Agro-ecological zone where *cercospora* leaf spot constitutes a problem to groundnut production, it 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.

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