FUNGICIDAL CONTROL OF FOLIAR DISEASES OF GROUNDNUT IN SAMARU, NORTHERN NIGERIA

By

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DEDICATION

This thesis is dedicated to the memory of my father, Mr. James Ndedu Akpanetuk, 1924 - October 1952.

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ABSTRACT

Two experiments were carried out for the control of leafspots and rust of groundnut. The trials were conducted in 1982 and 1983 at Samaru which represents the Northern Guinea Savanna zone.

In one experiment, two formulations of mancozeb (ULV and wettable power) were applied to groundnut as ultra-low volume and medium volume sprays using the spinning disc and the CP_3 knapsack sprayer. Different rates of the fungicides were used. The application of 2,00 kg/ha of the wettable powder formulation and 4L/ha of the ULV formulation were found to be most suitable. The ultra-low volume sprays resulted in good control of leafspots and rust as did the medium volume sprays. The higher rates of fungicide formulations resulted in lower disease severity. The use of wettable powder formulation was however found to be cheaper except in cases of extreme water shortage.

In the second experiment, Calixin-M was applied to groundnut at different times of commencement and different intervals of spraying. There was no significant difference in the times of commencement in the disease control. Spraying at 7- and 14-day intervals resulted in more effective and significantly higher pod and haulm yields of groundnut than 21-day intervals. Spraying regime commencing at first appearance of disease symptoms and applied at 14-day intervals was found to be the best.

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CHAPTER 1

INTRODUCTION

Groundnut, also called peanut (*Arachis hypogaea* L.), is a member of the Papillionacaea family.

In Nigeria, groundnut is produced predominantly in the Northern Guinea and Sudan savanna zones where 90% of the crop is produced (Abalu and Harkness, 1978; Singh and Balasubrahmanian, 1978). Since the peak production years of 1965 and 1966, groundnut production in Nigeria has suffered setbacks and has progressively declined (Anon., 1979). The decline in production is attributed to several factors, the most important being the shift in weather pattern characterised by repeated drought especially between 1970 and 1973 (Yayock, 1978).

Other factors affecting groundnut yields and production are pests and diseases (Horne, 1978). According to Horne, the disease of importance affecting yields of groundnut are the rosettes which are transmitted by *Aphis craccivora* Koch, the foliar diseases which include the early and late leafspots induced by *Mycosphaerella arachidis* Deighton (*Cercospora arachidicola* Hori) and *Mycosphaerella berkeleyii* Jenkins (*Cercosporidium personatum* (Berk and Curt) Deighton) respectively and the rust incited by *Puccinia arachidis* Speg. Because *C. personatum* was formerly known as *Cercospora personata*, it is common to refer to early and late leafspots as 'Cercospora' leafspots.

Cercospora leafspots are found wherever groundnuts are grown (Woodroof, 1933), in contrast to rust that has not been reported in some areas.

At the early stages of the development of the leafspot diseases on groundnut, the symptoms are not easily distinguishable (Jenkin, 1938; Mundkur, 1967; McDonald, 1973), but as the diseases progress certain marked changes occur which make identification certain (Smart, 1961; Mercer, 1972). Spots due to the two fungi are initially very small but may grow to a diameter of 10 mm or more (McDonald and Fowler, 1976). C. arachidicola leafspots start 3 - 4 weeks earlier than those of C. personatum, hence the names 'early' and 'late' leafspots (Woodroof, 1933; Mercer, 1978).

The conidia of early leafspot are found mainly on the upper leaf surface but a few may be found on the lower leaf surface arising conspicuously from the centre of the leafspots and not in concentric cycles (Jenkins, 1938). The leafspots induced by this fungus are usually light brown, circular to irregular, about 1 - 10 mm and are often surrounded by a yellow halo (Anon., 1973; McDonald and Fowler, 1976; Kornegay et al., 1980).

Late leafspots are brown to black and are smaller (1 - 6 mm), almost circular with a less diffused margin than those of early leafspot (Anon., 1973). The lesions

rarely have halos and are abundant on leaves, stipules, petioles, stems and pegs (Anon., 1973).

The symptoms of rust on groundnut are similar to those of rust of other crops (McVey, 1965). Pustules appear first on the lower leaflet surface some 6 - 10 days after infection (Arokoyo et al., 1977). The pustules enlarge to between 0.3 - 0.6 mm in diameter and are approximately similar in shape (Anon., 1973). The leaf tissues surrounding the pustules assume a dull green to brown colour (Bhama, 1972; Shanmugam et al., 1972). Yellow halo is visible and surrounds each pustule (Bhama, 1972). Approximately 24 hours after appearance the pustules start to rupture showing a cinamon brown colour due to exposure of the masses of uredospores (Shanmugam et al., 1972), which are borne on short hyaline pedicels (Sharma and Mukherji, 1972). The uredospores are yellow, spherical or oval with two occasionally three or four equatorial germ pores (Shanmugam et al., 1972). Pustules may be formed as with leafspots on all aerial plant parts, apart from flowers and pegs (Subrahmanyam and McDonald, 1983). When the disease is severe, the pustules coalesce and the leaf tissues surrounding them die and dry out in irregular patches (Anon., 1973), thus presenting an infection site referred to by Harrison (1967) as 'Hot Spot'. The leaflet then curls up, becomes brittle and falls prematurely (O'Brien, 1974; Arokoyo et al., 1977).

'Cercospora' leafspots attack groundnut every year in all parts of Nigeria causing losses of up to 50% of seed and even higher losses of haulms (Fowler and McDonald, 1978). The arrival of rust in 1976 in Nigeria has undoubtedly increased the yield loss due to leaf diseases of groundnut (McDonald et al., 1980). Loss in yield from rust alone has been estimated at 20 - 50% (Anon., 1978; Subrahmanyam and McDonald, 1983).

Many researchers have tested a range of fungicides in many parts of the world in a bid to control leafspots and rust on groundnuts (Mehta and Mathur, 1954; Jensen and Boyle, 1965; McGill and Samples, 1969; Harrison 1973; Kumar and Khare, 1974). It has been observed that attempts to control the leafspots and rust separately have brought some problems. For example, Thompson and Smith (1972) reported that one of the reasons for the widespread distribution of rust on groundnut in Georgia was the extensive use of benomyl for the control of leafspots. Similar effect of benomyl on rust has been reported by Harrison (1971, 1973). Harrison (1973) and McDonald et al. (1980) also independently reported that plants sprayed with Bavistin and Carbendazim and related fungicides had more rust than the unsprayed check plants. For practical disease control, McDonald et al. (1980) and Salako (1982) advised that it would be necessary to look for fungicides or a mixture of fungicides which can control the leafspots and rust simultaneously.

High-volume application of several fungicides have yielded success against groundnut leafspots (Mercer, 1976); Fowler and McDonald, 1978; Littrel and Linsdsey, 1979; Melouk, 1980). Reports on rust control by high-volume foliar sprays are however few (Seshari, 1976; Fowler and McDonald, 1978; McDonald et al., 1980).

Reports on ultra-low volume application of fungicides against groundnut leafspots and rust are even fewer than the high volume application. Mercer (1976), reported the ultra-low volume application of Carbendazim for the control of leafspots and Salako (1982) reported his work on ultra-low volume application of fungicides for the control of groundnut leafspot and rust.

The application of fungicides on groundnut by high volume foliar application method requires large quantities of water as well as a great deal of time (Mercer, 1976; Salako, 1982).

The issues of when to start the first spraying and at what intervals to spray still remain matters of controversy. According to Smith and Littrel (1980), the initial and final applications of the fungicides differ widely among growing seasons in a particular location because of variable environmental conditions. Some researchers (McGill and Samples, 1969; O'Brien, 1974; Smith and Littrel, 1980) advised that spraying should

begin before or as soon as the first symptom appears at about 30 - 40 days after planting. Others (Patil and Kalekar, 1974) are of the opinion that application of fungicides made before the appearance of symptoms gave better control of groundnut leaf rust than applications made after the infection and symptoms have developed.

With regard to the correct intervals of fungicide application, Miller (1946) warned that not more than two weeks should be allowed between dust applications of sulphur dust or Bordeaux Spray. According to him, new growth is not adequately protected from leafspots when applications of fungicides are made at intervals greater than two weeks. In addition, Mercer (1975) reported that the yields of kernel increased in a sigmoid fashion with a decrease in intervals between sprays.

In view of the above controversies about previous work and because of the limited data about fungicidal control of leafspots and rust of groundnut in northern Nigeria, it was considered necessary to undertake the present study with the following objectives:

(i) To compare the ultra-low volume (ULV) spraying technique with that of the medium volume spraying for the control of leafspots and rust of groundnuts.

(ii) To evaluate the efficacy of two formulations of Mancozeb for the control of foliar diseases of groundnut.

(iii) To determine the appropriate rates of application of the two formulations of Mancozeb for the control of foliar diseases of groundnut.

(iv) To determine the appropriate spray schedule for the application of Calixin-M for the control of foliar diseases of groundnut.

CHAPTER 2

LITERATURE REVIEW

Several attempts have been made by many researchers to control the leafspot diseases of groundnut by chemical spray like Bordeaux mixture (Miller, 1946), copper sulphur (McGill and Samples, 1969; McDonald, 1973), sulphur dust (Mercer, 1975) Benlate (Backman et al., 1977), Mancozeb (McDonald, 1973; Harrison, 1973) and Calixin (Salako, 1982). These investigators obtained increased yields of groundnuts and improved quality and quantity of hay.

Reports on the control of leafspots and rust simultaneously have been few (Arneson, 1970; Harrison, 1971; McDonald et al., 1980; Salako, 1982).

2.1 Method of Application

In countries like the United States of America, fungicides are applied with various kinds of tractor propelled sprayers, fixed-wing aircraft, helicopters and sprinkler-irrigation system (Smith and Littrel, 1980). Mercer (1975) reported that the most effective fungicidal applicator for the control of leafspots used in Malawi was the knapsack sprayer which was used to spray systemic fungicides. Mercer (1976) however, reported that high increase of yield of pods, kernel and haulms of groundnut were obtained in Malawi by the use of ULV (10-15L/ha).

A comparison of ULV and MV sprays for the control of groundnut leafspots at Samaru in 1974 showed that there was no significant effect on yield from either method of application (Anon., 1975). However, trials carried out in Samaru in 1977, showed that plants given MV application of Difolatan had less rust than those sprayed with Difolatan ULV (McDonald et al., 1980). Fowler and McDonald (1978) obtained good leafspots control in groundnut using ULV fungicide application. Also, Salako (1982) obtained good control of leafspots and rust when he used micron ULV sprayer.

2.2 Fungicide Formulation

Smith and Crosby (1972) reported that foliar application of a benomyl-oil-water emulsion suppressed the development of groundnut leafspot epidemics more effectively than foliar applications of a benomyl-water suspension.

2.3 Rate of Fungicide Application

McDonald (1970) reported that application of mancozeb at the rate of 2.2 kg/ha for the control of leafspots significantly increased yields of groundnut over the control. Harrison (1973) also reported good control of leafspots and rust and increased groundnut yield when he applied mancozeb at the rate of 1.7 kg

a.i./ha. For the control of rust, O'Brien (1974) applied mancozeb at the rate of 1.6 kg a.i./ha. Recently, Salako (1982) obtained good control of leafspots and rust and increased yield of groundnut by applying ULV mancozeb at the rate of 4.5L/ha.

2.4 Time of Commencement of Spraying

Different times of commencement of fungicidal sprays have been reported for the control of leafspots and rust of groundnuts. For example, Woodroof *et al*.(1944); McGill and Samples (1969); Smith and Littrel (1980) obtained good control of foliar diseases when spraying began before, or as soon as, the first symptoms appeared at about 30 - 40 days after planting. However, Patil and Kalekar (1974) reported that prophylactic application of fungicides gave better control of groundnut leaf rust than applications made after the infection and symptom have developed. Also Kumar and Khare (1974) reported that fungicidal sprays for the control of groundnut leafspots were significantly superior over the control when first spraying was done when the plants were four weeks old. By contrast, Mercer (1975) obtained good yield increases with most fungicides used to control leafspots of groundnuts even when spraying did not commence until six weeks after groundnut emergence. Similarly, Salako (1981) reported that fungicides for

the control of both leafspots and rust were effective when spraying was started 36 days after planting.

2.5 Frequency of Application

Good control of leafspots and rust and increased yields of groundnuts have been obtained with varying intervals of spraying. For example, either leafspots alone or rust and leafspots were controlled by spraying fungicides at 14-day intervals (Harrison, 1973; Mercer, 1975; Campbell, 1978; Salako, 1982). Fowler and McDonald (1978) reported that 10-day intervals of spraying gave greater yields than treatments with comparable number of sprays spaced at 7-day intervals. O'Brien (1974) controlled rust of groundnut by spraying at weekly intervals. Kumar and Khare (1974) obtained good control of leafspots from all the fungicides they tested by spraying at an interval of 20 days.

CHAPTER 3

MATERIALS AND METHODS

The study reported in this paper was carried out in two separate experiments in two years, 1982 and 1983, at Samaru, Northern Nigeria.

3.1 Comparative Efficacy of Mancozeb Applied as Ultra-Low Volume (ULV) and Medium Volume (MV) Sprays for the Control of Groundnut Leafspots and Rust

1982 Trial

A red stem micron ULV sprayer (Micron Sprayers Ltd., Three Mills Bromyard Herefordshire HR.7, 4HU, England) and a knapsack sprayer (CP_3) (Cooper Pegler Co. Ltd., Burgess Hill, Sussex 15, RH9, England) were used to apply both the ULV and the wettable powder (WP) formulations of mancozeb. Three different rates of the fungicides were used (i.e. 2, 4 and 6l/ha for the ULV mancozeb formulation and 1.12, 2.24 and 3.36 kg/ha for the wettable powder). These rates represent 50, 100 and 150%, the manufacturers recommended rates. The fungicides were dissolved in 10 litres/ha of water for the ULV sprays, 390l/ha of water for the medium volume sprays.

A split plot design with randomized complete block replicated three times was used. The method of application was the main plot, while the formulation and the rate of application were combined and randomized to form the

sub-plots. Each plot consisted of eight ridges, each ridge being 10 m long and 0.76 m wide. Adequate controls were provided. Groundnut cultivar F452.4 was sown on 16 June, 1982 at 2 seeds per hole, 23 cm apart. Two ridges were left between plots as border rows to minimize the effect of spray drifts.

The experiment was sown on land cropped with cereal in the previous year. All plots received a basal application of 200 kg/ha single superphosphate (18% P_2O_5) before ridging. Plots were hand weeded as often as was considered necessary. A tractor disc harrow was used to remould the ridges in the first week of August.

Mancozeb (combination of zinc and maneb containing 20% manganese and 2.5% zinc) was applied at three different rates given above in either 390 l/ha of water for medium volume or 10l/ha for ultra-low volume sprays respectively. In each case the fungicide was thoroughly shaken to mix. Plots were sprayed at weekly intervals from 22 July to 21 September, 1982. To further minimize the effect of drift, the four centrally located ridges in each plot were used for disease assessment. From these four ridges, five stands of groundnuts per ridge were randomly selected and tagged a week prior to the time of commencement of disease

assessment. This enabled individual stands to be observed throughout the season. The severity of early and late leafspots and of rust were separately determined using the following visual assessment scale:

Scale		Description
1	=	None to very low disease level with only lower leaves having few small spots/pustules.
3	=	Low disease level in which few sparsely distributed spots/pustules are seen on lower leaves.
5	=	Intermediate disease level in which many spots/pustules are seen on lower and middle leaves, with defoliation starting.
7	=	High disease level, in which spots/pustules occur all over the plant, with marked defoliation.
9	=	Very high disease level, plants severely affected and almost all the leaves are covered with spots/pustules, and/or more than 50% of total leaves defoliated/withered.

The scale is a modification of that given by Anonymous (1981).

Number of leafspots on each infected leaflet was counted. The average number of leafspots per leaflet (SL) was calculated thus:

$$SL = \frac{\text{Total number of spots/plant}}{\text{Total number of leaflets/plant}}$$

Estimate number of premature leaflet fall from affected plants was recorded at weekly intervals by counting the number of abscised nodes. Percent defoliation (PD) was calculated as follows:

$$PD = \frac{\text{Number of fallen leaflet/plant}}{\text{Total number of leaflet/plant}} \times 100$$

Mature groundnuts were lifted on 6 October 1982 from the four central ridges and sun dried. The pods were later picked and weighed to obtain the unshelled pod weight. Haulm yield was also recorded.

The recorded field data were subjected to various types of statistical analysis.

1983 Trial

The experiment was repeated in 1983 with the following modifications.

There was a direct comparison of the ULV and MV sprays using the ULV spinning disc and the CP_3 knapsack sprayer respectively. Two formulations of mancozeb (i.e. the ULV and WP) were applied at two different rates (4.0 and 4.5L/ha of ULV and 2.0 and 2.5 kg/ha of WP). Four treatments and one control were replicated four times in a randomized complete block design. Groundnut was planted on 13 June 1983.

Apart from the above stated modifications, all other operations were similar to those of 1982 trial.

3.2 The Effect of Time of Commencement and Intervals of Calixin-M Spray on Leafspots and Rust of Groundnuts

1982 Trial

Two groundnut varieties F452.4 and Samaru 38 (S38) used were chosen for their susceptibility to leafspot and rust. Calixin-M (tridemorph (11% 2, 6, dimethyl -4-tridecylmorpholine) + 36% manganese ethylbisthiocarbamate) was used at the rate of 1.6 kg a.i./ha (3.5 kg/ha of the formulation). Application of the fungicide was by a ULV spinning disc sprayer. The required amount of the fungicide (proportionate quantity for three replicates) was thoroughly mixed in clean water in the receptacle of the sprayer. Two spraying commencement days (36 and 64 days after planting) were employed. In each case there were three spraying intervals (7, 14 and 21 days).

A split plot design with randomized complete block was used. The varieties of groundnut sown on 23 June 1982, served as main plot. The time of commencement and the intervals of spraying were the sub-plots. Adequate unsprayed plots were included to serve as controls. The treatments were replicated three times. Border rows were planted with groundnut and left unsprayed. These border rows served to enhance the disease pressure on

the trial plots. Seedling rate and spacing as well as all cultural operations, disease assessment, statistical analysis were carried out as earlier reported.

1983 Trial

The above experiment was repeated in 1983 with some modifications.

There were ten treatments which included two unsprayed controls. Spraying commenced at 36 days after planting and at first sight of symptoms of the diseases. Spraying at 7-day interval was discontinued since the 1982 data showed that it was not significantly different from spraying at 14-day intervals in terms of disease control. For plots that were sprayed at 36 days after planting, spraying started on 25 June and ended on 26 September. Also spraying started on 18 August to 29 September in plots that were sprayed at onset of symptoms. The experimental design used was randomized complete block and treatments were replicated three times.

Apart from the above stated modifications all other operations were similar to those already reported.

CHAPTER 4

RESULTS

4.1 The Comparative Efficacy of Ultra-Low Volume (ULV) and Medium Volume (MV) Application of Mancozeb at Three Rates on the Control of Groundnut Leafspots and Rust

The results are presented in the following sub-sections.

4.1.1 Development of Diseases

The first symptoms of infection by early leafspot were observed seven weeks after sowing while those of late leafspot appeared from the eighth week. Rust symptoms were first observed ten weeks after sowing.

4.1.2 Effect of Mancozeb on Severity of Early Leafspot

The analysis of variance for the early leafspot disease severity (Appendix 1) showed that the effects of the rates of mancozeb application were significant. The plants that received ULV sprays had significantly ($P = 0.05$) lower scores than the unsprayed ones (Table 4.1). However, there were no significant differences in scores obtained from the unsprayed plots and those obtained from plots that received 50% of the recommended dose of mancozeb when applied as medium volume sprays. Among the sprayed plots, the plants that received 150% the recommended dose of the fungicides had significantly lower scores than those obtained from plants that received 50%, the recommended dose applied as ULV sprays.

Table 4.1. Effect of Mancozeb Applied as Medium Volume (MV) and Ultra-Low Volume (ULV) at 3 Rates on the Severity of Cercospora Leafspots and Rust in 1982.

Fungicide			Visual Disease Score (Scale 1 - 9)		
Volume of Application	Formulation	Rate of Application	Early Leafspot	Late Leafspot	Rust
Medium	WP	1.12 kg/ha	3.33	3.67	4.33
		2.24 kg/ha	2.33	2.33	1.67
		3.36 kg/ha	2.33	1.67	1.67
Check (no fungicide applied)			4.33	6.33	5.67
Medium	ULV	2L/ha	3.67	4.33	4.67
		4L/ha	3.00	3.67	2.33
		6L/ha	2.67	3.33	1.67
Check (no fungicide applied)			4.67	5.00	6.33
ULV	WP	1.12 kg/ha	4.33	4.33	5.00
		2.24 kg/ha	3.33	3.67	3.67
		3.36 kg/ha	2.33	3.67	3.67
Check (no fungicide applied)			5.67	5.33	5.67
ULV	ULV	2L/ha	3.67	3.33	4.33
		4L/ha	3.00	2.33	3.67
		6L/ha	2.33	2.33	2.33
Check (no fungicide applied)			5.00	5.67	6.33
SEM_1			0.21	0.23	0.21
SEM_2			0.51	0.38	0.64
LSD_1			1.27	1.40	1.30
LSD_2			1.68	1.99	1.90
CV_1%			44.4	48.4	26.8
CV_2 %			25.7	14	28.6

Note: Mean refers to the mean of three replicates.
- SEM_1 and LSD_1 = Standard error of mean and least significant difference between treatments on the same mode of application.
- SEM_2 and LSD_2 = Standard error of mean and least significant difference between sub-plot treatments for different main plot treatments.
- CV_1% = Coefficient of variation for main plot treatments.
- CV_2% = Coefficient of variation for the sub-plot treatments.

However, there were no significant differences between the severity of disease in plots that received 50, 100 and 150% the recommended rate when applied as medium volume sprays.

Appendix 1 revealed that the fungicide formulation had no significant effect on disease severity. It also showed that all the possible interactions (i.e. fungicide x rate, fungicide x mode of application, rate of fungicide application x mode of application and fungicide x rate x method of application) were not significant.

When the number of lesions of early leafspot per leaflet was analysed (Appendix 2) the result shows that the effects of different rates of mancozeb were significant ($P = 0.05$). The mean number of early leafspot lesions per leaflet was generally significantly lower for the treated crops than the untreated ones (Table 4.2).

Among the sprayed plots, there were significant differences in the number of lesions of early leafspot per leaflet in most plots that received the different rates of mancozeb irrespective of the formulation and the mode of application of the fungicide. However, there were no significant differences in the number of lesions obtained from plots that were sprayed with 50 and 100% the recommended rate of mancozeb ULV when applied as ULV sprays. Similar results were obtained from plots that were sprayed with 100 and 150% the recommended

Table 4.2. Effect of Mancozeb Applied as Medium Volume (MV) and Ultra-Low Volume (ULV) at three Rates on Number of Leaflet Lesion and Defoliation Percentage in 1982.

Fungicide			Number of Leaflet Lesion for*		Percentage
Volume of Application	Formulation	Rate of Application	Early Leafspot Lesion/leaflet	Late Leafspot Lesion/leaflet	Defoliation*
Medium	WP	1.12 kg/ha	8.00	7.67	29.00
		2.24 kg/ha	6.67	5.67	26.3
		3.36 kg/ha	6.33	5.33	25.73
Check (no fungicide applied)			12.67	10.33	37.00
Medium	ULV	2l/ha	8.67	8.33	30.33
		4l/ha	7.33	6.33	26.3
		6l/ha	6.67	6.00	26.13
Check (no fungicide applied)			11.00	9.67	38.33
ULV	WP	1.12 kg/ha	10.00	6.67	31.00
		2.24 kg/ha	9.00	6.33	27.00
		3.36 kg/ha	7.67	5.17	26.53
Check (no fungicide applied)			11.33	12.00	36.67
ULV	ULV	2l/ha	8.33	6.67	30.47
		4l/ha	8.00	5.67	28.33
		6l/ha	7.00	5.43	26.67
Check (no fungicide applied)			11.7	10.00	35.67
SEM_1			0.09	0.14	0.09
SEM_2			0.68	0.54	0.63
LSD_1			0.55	1.41	0.50
LSD_2			2.00	1.78	1.86
CV_1%			7.2	41.6	20.0
CV_2 %			13.7	38.6	37.00

Note: *Mean of 3 replicates.

SEM_1 and LSD_1 = Standard error of the mean and least significant difference between treatments on the same main plot treatment.

SEM_2 and LSD_2 = Standard error of the mean and least significant difference between sub-plot treatments for different main plot treatment.

CV_1% = Coefficient of variation for the main plot treatments.

CV_2% = Coefficient of variation for the sub-plot treatments.

dose of mancozeb WP when applied as medium volume spray.

4.1.3 Effect of mancozeb on Severity of Late Leafspot

The analysis of variance for the visual disease severity score of late leafspot (Appendix 3) indicated that only effects of the rates of fungicide application were significant. As shown in Table 4.1, the plots that received the wettable powder formulation of mancozeb applied as medium volume sprays had significantly lower severity of disease than the unsprayed plots. Similar results were obtained from the plots that received the ULV formulation applied as ULV sprays. Among the sprayed plots, the plot that received 150% the recommended dose of mancozeb WP formulation applied as medium volume sprays had significantly ($P = 0.05$) lower disease severity than the plots that received 50% the recommended rate.

The result (Table 4.2) showed that most of the sprayed plots had significantly lower number of late leafspot lesions per leaflet than the unsprayed plots. As shown in Appendix 4, the effects of the rates of fungicides applied were significant ($P = 0.05$). For example, when the ULV and the WP formulations of mancozeb were applied as MV, some plots had significantly

lower number of leafspots per leaflet than others. But when the two formulations of mancozeb were applied as ULV, there was no significant difference in the number of lesions. However, data not presented in this study, showed that lesions on the leaflets of plants that received minimum dose of the fungicide were generally larger than those on leaflets from plants that received higher doses.

4.1.4 Effect of Mancozeb on Rust

The analysis of variance of the rust disease severity (Appendix 5) indicated that the effects of the rates of application of mancozeb were significant ($P = 0.05$). The sprayed plots had significantly lower disease severity than the unsprayed ones (Table 4.1). The severity of rust in plots that received 50% the recommended dose of mancozeb as MV spray was higher than that in plots that received the field dose and 150% of the field dose of the same formulation; the differences between plots that received 100 and 150% the recommended doses were not significant. Essentially, similar results were obtained when the fungicide formulation were applied as ULV. The only difference was that the severity of disease in plots sprayed with 100% the recommended dose was significantly higher than that in plots sprayed with 150% the recommended rate. Also, mancozeb WP sprayed as MV at field and

150% the recommended field dose resulted in significantly (P = 0.05) lower disease scores than their counterparts that were sprayed as ULV.

4.1.5 Effect of Mancozeb on Rate of Defoliation Caused by Leafspot and Rust

Analysis of variance (Appendix 6) showed that the effects of the rates of fungicide application on defoliation were highly significant (P = 0.01). The interaction between the rate and the mode of application of the fungicide was also significant (P = 0.05). The results (Table 4.2) showed that defoliation was significantly lower in sprayed than in unsprayed plots. There were significant differences in defoliation percentage between most of the sprayed plots, regardless of the type of fungicide formulation and the mode of application. For example, the plots that received 50% of the recommended dose of the fungicide had higher percentage defoliation than those that received 100% and 150% of the recommended dose; the defoliation percentage in plots that received 150% of the recommended dose were in most cases lower than that in those that received 100% of the recommended dose.

4.1.6 Effect of Mancozeb on Groundnut Yield

The analysis of variance (Appendix 7) showed that the effect of mancozeb on pod yield was highly significant (P = 0.01). The effect of applying different rates of

the fungicide formulations was highly significant ($P = 0.01$). There was also a significant interaction between the rate and the mode of application of the fungicide. The pod yields (Table 4.3) of sprayed plots were much higher than those of unsprayed control plots. When the two formulations of mancozeb were applied as medium volume spray, the plots that were sprayed with 50% the recommended dose had the lowest yield. There were no significant differences in most cases in yields obtained from plots that received 100 and 150% the recommended doses of the same formulation and mode of application. Though the differences in pod yields of plots that received similar rates of fungicide applied as MV or ULV were not significant, the MV application of the fungicide tended to produce higher pod yields than the ULV application. The ULV application gave its highest pod yield when the fungicide was applied at the recommended dose.

The haulm yields are presented in Table 4.3. Analysis of variance of the effect of mancozeb on haulm yields (Appendix 8) indicated that the effects of the mode and the rate of fungicide application were significant as were those of the formulation of the fungicide. Also the interaction between the rate and the mode of application as well as that between the fungicide formulation, rate and method of application were significant.

Table 4.3. Effect of Mancozeb Applied as Medium Volume (MV) and Ultra-Low Volume (ULV) at Three Rates on the Yield of Groundnut in 1982.

Fungicide			Yields of Groundnut (kg/ha)			
Volume of Application	Formulation	Rate of Application	Pod yield kg/ha actual yield	Increase over control yield	Haulm yield actual haulm yield	Increase over control yield
Medium	WP	1.12 kg/ha	3004.42	1118.41	4769.78	1995.61
		2.24 kg/ha	4122.84	2236.83	6699.63	3925.46
		3.36 kg/ha	4177.67	2291.66	7247.87	4473.70
Check (no fungicide applied)			1886.01	-	2774.17	-
Medium	ULV	2L/ha	3003.40	1303.83	4386.01	1436.73
		4L/ha	3860.40	2161.07	6469.37	3570.09
		6L/ha	3980.30	2280.72	6996.11	4046.83
Check (no fungicide applied)			1669.58	-	2949.28	-
ULV	WP	1.12 kg/ha	2774.15	745.62	3839.75	1039.71
		2.24 kg/ha	3870.64	1842.11	4714.95	1914.91
		3.36 kg/ha	3519.77	1491.24	5625.05	2825.01
Check (no fungicide applied)			2028.53	-	2800.04	-
ULV	ULV	2L/ha	2894.76	921.06	4177.67	1370.07
		4L/ha	3947.4	1973.70	5745.66	2938.06
		6L/ha	3771.96	1798.26	5986.89	3179.29
Check (no fungicide applied)			1973.70	-	2807.60	-
SEM_1			44.18		67.64	
SEM_2			139.8		269.78	
LSD_2			268.9		411.59	
LSD_1			421.81		822.3	
$CV_1\%$			6.9		9.6	
$CV_2\%$			7.7		9.6	

Note: Multiplication factor = 328.95. •Mean refers to mean of 3 replicates.

SEM_1 and LSD_1 = Standard error of the mean and the least significant difference between treatments on the same main plot treatment.

SEM_2 and LSD_2 = Standard error of the mean and the least significant difference between sub-plot treatments for different main plots treatments.

$CV_1\%$ = Coefficient of variation for the main plot treatments.

$CV_2\%$ = Coefficient of variation for the sub-plot treatments.

The yields from sprayed plots were significantly higher than those from unsprayed plots. Haulm yields obtained from plots that were sprayed by MV were higher than those obtained from plots sprayed by ULV for corresponding formulation and rates of application. Mancozeb WP applied at 150% the recommended dose gave the highest haulm yield. However, there was no significant difference in the haulm yield from this plot and that obtained from the plot that was sprayed with mancozeb ULV formulation for the corresponding rate and method of application.

4.1.7 Correlation and Regression Analysis of the Relationship between Disease Severity Parameters and Groundnut Yield

The summary of the analysis of correlation between pairs of parameters recorded in the field in 1982 is shown in Table 4.4. The correlation between visual disease severity scores and defoliation percentage on the one hand and pod and haulm yields on the other were negative and highly significant ($P = 0.01$). When the severity scores for early and late leafspots and rust as well as defoliation percentage were separately correlated with pod yield, the correlation coefficients (r) were -0.79, -0.62, -0.85 and -0.97 respectively. These negative (r) values indicated that the higher the severity of leafspots and rust the lower the pod yield. The negative correlation

coefficients between severity scores for early leafspot, late leafspot and rust and haulm yields shown in Table 4.4 also indicated that the higher the severity of the three diseases the lower the groundnut haulm yields.

Linear regressions of yield on those disease severity parameters that had significant (P = 0.05) correlation coefficients were calculated. The regression equations are presented in Appendix 31. The linear regressions of pod and haulm yields on early leafspot, late leafspot and rust severity respectively indicated that there would be significant decreases in pod and haulm yields as the severity of the three diseases increased.

4.2 Effects of Medium Volume (MV) and the Ultra-Low Volume (ULV) Application of Two Formulations of Mancozeb Applied at 2 Rates in 1983

The results are presented in the following sub-sections.

4.2.1 Development of Diseases

Generally, the diseases appeared late in the seasons. The first symptoms of early leafspot were observed seven weeks after sowing while those of late leafspot were observed from the eighth week. Rust was not observed in the trial.

Table 4.4. Correlation Coefficients between Disease Severity Scores (including defoliation percentage) and Pod and Haulm Yields of Groundnut in 1982.

Pairs of Parameters	Correlation Coefficient (r)
Early leafspot severity and pod yield	-0.79**
Early leafspot severity and haulm yield	-0.66**
Late leafspot severity and pod yield	-0.62**
Late leafspot severity and haulm yield	-0.60**
Rust severity and pod yield	-0.85**
Rust severity and haulm yield	-0.84**
Defoliation percentage and pod yield	-0.97**

** Significant at P = 0.01.

4.2.2 Effect of Mancozeb on Severity of Early Leafspot

Analysis of variance for the effect of mancozeb on the mean disease score of early leafspot is given on Appendix 9. The effects of the treatments were highly significant (P = 0.01). The results (Table 4.5) indicated that the severity of early leafspot in sprayed plots were significantly lower than the severity in unsprayed plot. In contrast, severity in sprayed plots were not significantly different from each other.

Analysis of variance for the effect of mancozeb on the number of early leafspot lesions per leaflet (Appendix 10) indicated that the treatments were highly significant (P = 0.01). The lesions per leaflet were much fewer in the sprayed plots than in unsprayed plots (Table 4.6). The wettable powder formulation of mancozeb applied as MV at 2.0 and 2.5 kg/ha resulted in fewer lesions per leaflet than those in plots sprayed with ULV formulation.

4.2.3 Effect of Mancozeb on Severity of Late Leafspot

The effect of treatments on the disease severity score was highly significant (P = 0.01) as shown in Appendix 11. The results showed that the sprayed plots had significantly lower scores than the unsprayed ones (Table 4.5). There was no significant difference among the sprayed plots.

Table 4.5. Effect of Mancozeb Applied as Medium Volume (MV) and Ultra-Low Volume (ULV) at 2 Rates on Groundnut Leafspot Severity in 1983.

Fungicide			Visual Disease Score for (scale 1-9)*	
Volume of Application	Formulation	Rate of Application	Early Leafspot	Late Leafspot
Medium	WP	2.00 kg/ha	3.5 b	5.5 b
Medium	WP	2.5 kg/ha	3.5 b	4.5 b
ULV	ULV	4.0L/ha	4.5 b	6.00b
ULV	ULV	4.5L/ha	3.5 b	5.5 b
Check (no fungicide applied)			5.5 a	7.5 a
SEM			0.224	0.32
CV%			11.1	10.9

Note: *Mean of four replicate.
SEM = Standard error of the mean.
CV% = Coefficient of variation.
Figures followed by the same letter in the same column are not significantly different at P = 0.05 according to Duncan's Multiple Range Test.

Table 4.6. Effect of Mancozeb Applied as Medium Volume (MV) and Ultra-Low Volume at 2 Rates on the Number of Leaflet Lesions and Defoliation Percentage in 1983.

Fungicide			Number of Leaflet Lesion*		Percentage Defoliation*
Volume of Application	Formulation	Rate of Application	Early Leafspot Lesion/Leaflet	Late Leafspot Lesion/Leaflet	
Medium Volume	WP	2.0	11.00 cd	8.75 bc	27.05 cd
Medium Volume	WP	2.5	9.5 d	7.75 c	24.8 d
ULV	ULV	4.0	13.75 b	10.0 b	31.20 b
ULV	ULV	4.5	12.75 bc	9.5 b	28.88 bc
Check (no fungicide applied)			17.75 a	14.5 a	36.54 a
SEM			0.56	0.36	0.68
CV%			8.7	7.1	10.9

Note: *Mean of four replicates.
SEM = Standard error of the mean.
CV% = Coefficient of variation.
Figures followed by the same letter in the same column are not significantly different at P = 0.05 according to Duncan's Multiple Range Test.

Analysis of variance for the effect of mancozeb on late leafspot lesions per leaflet is presented in Appendix 12, There were significant differences between the treatments. The results (Table 4.6) indicated that the sprayed plots had significantly fewer lesions per leaflet than the unsprayed plot. Among the sprayed plots, there was no significant difference between the number of lesions on leaflets of plots that were sprayed with mancozeb WP at 2.5 kg/ha and those on leaflets of plots that were sprayed at 2.0 kg/ha. Similar results were obtained from plots that were sprayed with ULV. But application of mancozeb (WP at the rate of 2.5 kg/ha resulted in significantly fewer lesions per leaflet than application of the ULV formulation of the fungicide.

4.2.4 Effect of Mancozeb on Rate of Defoliation Caused by Leafspots

The analysis of variance for the effect of mancozeb on the defoliation percentage is shown in Appendix 13 which indicated that there were significant ($P = 0.01$) differences between the treatments. The data (Table 4.6) showed that the sprayed plots were significantly less defoliated than the unsprayed control plot. There were no significant differences in defoliation percentage in plots sprayed with mancozeb at the two rates applied as MV. Similar results were obtained for plots that were sprayed with ULV. However, mancozeb WP at 2.5

kg/ha applied as MV resulted in significantly less defoliation than mancozeb ULV at 4.5l/ha applied as ULV.

4.2.5 Effect of Mancozeb on Yields of Groundnut in 1983

The effect of mancozeb on pod yield was highly significant (P = 0.01) as indicated in Appendix 14. Pod yields of the sprayed plots were significantly higher than those of unsprayed control. There was no significant difference between the two rates of application of mancozeb WP (Table 4.7). These two treatments significantly outyielded the ULV treated plots. Mancozeb ULV applied at 4.0l/ha resulted in significantly (P = 0.05) higher yield than mancozeb ULV at 4.5l/ha.

Analysis of variance (Appendix 15) indicated that the effects of mancozeb on haulm were also highly significant (P = 0.01). Here again the sprayed plots produced significantly higher haulm yield than the unsprayed plot (Table 4.7). Mancozeb WP at 2.5 kg/ha significantly outyielded mancozeb ULV at 4.0l/ha.

4.2.6 Correlation and Regression Analysis

The summary of the analysis of the correlation between pairs of parameters recorded in the field in 1983 is shown in Table 4.8. The visual severity scores

Table 4.7. *Effect of Mancozeb* Applied as Medium Volume (MV) and Ultra-Low Volume (ULV) at 2 Rates on Yields of Groundnuts in 1983.

Fungicide			Yields of Groundnut for*			
			Pod Yield/ha		Haulm Yield kg/ha	
Volume of Application	Formulation	Rate of Application	Actual Yield	Increase over control	Actual Yield	Increase over control
Medium	WP	2.0 kg/ha	2672.73a	1340.47	5674.41ab	2057.96
Medium	WP	2.5 kg/ha	2853.65a	1521.39	5921.13a	2304.68
ULV	ULV	4.0l/ha	2335.55b	1002.29	5164.52b	1546.07
ULV	ULV	4.5l/ha	2031.27c	699.01	5583.93ab	1967.48
Check (no fungicide applied)			1332.26d		3618.45c	
SEM			61.8		218.8	
CV%			5.5		8.4	

Note: *Mean of four replicates.
Multiplication factor 328.95.
SEM = Standard error of the mean
CV% = Coefficient of variation
Figures followed by the same letters are not significantly different at P = 0.05 according to Duncan's Multiple Range Test.

Table 4.8. Correlation Coefficients between Disease Severity Scores (including Defoliation Percentage) and Pod and Haulm Yields of Groundnuts in 1983.

Pairs of Parameters	Correlation Coefficient (r)
Early leafspot severity and pod yield	-0.95**
Early leafspot severity and haulm yield	-0.81**
Late leafspot severity and pod yield	-0.93**
Late leafspot severity and haulm yield	-0.89**
Defoliation percentage and pod yield	-0.96**

** = highly significant (P = 0.01).

of early and late leafspots and defoliation percentage were significantly negatively correlated with pod yields, indicating that pod yield decreased as the severity of the disease (visual severity scores and percentage defoliation) increased. Similarly, haulm yield decreased as the severity of the two diseases increased.

Linear regression of pod and haulm yields on the severity of early and late leafspot that had significant ($P = 0.05$) correlation coefficients were calculated. The linear regression equations (Appendix 32) revealed that significant reductions in pod and haulm yields were associated with severity of the two diseases.

4.3 Effect of Time of Commencement and Intervals of Calixin-M Spray on Leafspots and Rust of Groundnut in 1982

The results are shown below.

4.3.1 Development of Diseases

The first symptoms of early and late leafspots appeared seven and eight weeks after planting respectively. Rust was observed nine weeks after planting.

4.3.2 Effect of Calixin-M Sprays on the Severity of Early Leafspot

The results are presented in Table 4.9. Analysis of variance of the effects of time of commencement and intervals of spraying of Calixin-M on the visual severity

Table 4.9. Effect of Time of Commencement and Intervals of Calixin-M Sprays on Leafspots and Rust of Groundnuts in 1982.

Treatments				Visual Disease Severity (Scale 1-9) for*		
Variety of groundnut	Time of Commencement of spray (days after sowing)	Spraying intervals (days)	Total Number of sprays	Early Leafspot	Late Leafspot	Rust
F452.4	36	7	10	3.67	4.33	3.33
	36	14	6	4.33	4.33	3.67
	36	21	4	5.00	5.00	4.67
	No fungicide applied	-	-	7.33	7.00	6.33
	64	7	6	4.33	4.33	3.67
	64	14	3	4.33	4.67	4.33
	64	21	2	5.67	5.67	5.67
	No fungicide applied	-	-	6.33	6.33	7.00
S38	36	7	10	3.33	3.67	3.67
	36	14	6	3.67	4.33	3.67
	36	21	4	4.33	5.67	5.33
	No fungicide applied	-	-	6.33	7.00	7.00
	64	7	6	5.00	4.33	3.67
	64	14	3	5.67	5.00	4.33
	64	21	2	6.33	5.67	5.00
	No fungicide applied	-	-	6.67	6.33	6.33
SEM_1				0.11	0.07	0.17
SEM_2				0.66	0.57	0.53
LSD_2				0.67	0.44	1.03
LSD_1				1.76	1.66	1.69
CV_2				14.8	9.40	24.00
$CV_{1\%}$				22.6	13.40	18.00
$CV_{2\%}$						

Note: *Mean of 3 replicates.

SEM_1 and LSD_1 = Standard error of the mean and least significant difference between the same main plot treatments

SEM_2^1 and LSD_2^1 = Standard error of the mean and least significant difference between sub-plot treatments for different main plot treatments.

$CV_{1\%}$ = Coefficient of variation for the main plot treatments.

$CV_{2\%}$ = Coefficient of variation for the sub-plot treatments.

scores of early leafspot (Appendix 16) were significant (P = 0.05). There were no significant differences between the early leafspot severity in unsprayed variety F452.4 and those sprayed with Calixin-M at 21-day intervals beginning at 64 days after sowing. Similarly, there were no significant differences in disease severity in unsprayed variety S38 plots and those of plots sprayed at 14- and 21-day intervals beginning from 64 days after sowing (DAS). Among the sprayed plots, there were no significant differences in disease scores in variety F452.4 sprayed at 7- and 14-day intervals irrespective of the time of commencement of spraying. Disease severity in plots sprayed at these two intervals were significantly lower than those in plots sprayed at 21-day intervals. Plots of variety S38 sprayed at 7- and 14-day intervals, commencing from 36 (DAS), had significantly lower disease severity than plots that were sprayed at 64 DAS, irrespective of the spraying interval.

The analysis of variance (Appendix 17) of the effect of Calixin-M sprays on number of early leafspot lesions per leaflet showed that the effect of spraying intervals were highly significant (P = 0.01). The spraying frequency x time of commencement of spray interaction was significant as was the interaction between time of commencement of spraying and the groundnut variety.

The sprayed plots had significantly (P = 0.05) lower number of lesions per leaflet than the unsprayed ones (Table 4.10). Also, irrespective of when spraying commenced, plants in plots sprayed at 7-day intervals had significantly fewer leafspots than those in plots sprayed at longer intervals. However, spraying at 14-day intervals resulted in fewer lesions than spraying at 21-day intervals. The results also indicated that F452.4 plants sprayed at 7-day intervals commencing from 36 DAS had the fewer number of leafspots than plants of the same variety sprayed at the same interval but commencing from 64 DAS. There was no significant difference in the number of lesions obtained from plants in plots that were sprayed at 14-day intervals regardless of when spraying started. Similarly, the number of lesions observed in plots sprayed at 21-day intervals were not significantly different, regardless of the time of commencement of spraying.

4.3.3 Effect of Calixin-M Sprays on Severity of Late Leafspot

The results are presented in Table 4.9. The analysis of variance (Appendix 18) showed that the effects of time of commencement and the intervals of spraying on visual severity disease scores of early late leafspot were significant (P = 0.05). The sprayed plants had signific lower disease severity than the unsprayed plants. There

Table 4.10. Effect of Time of Commencement and Intervals of Calixin-M Sprays on Number of Leaflet Lesions and Defoliation Percentage in 1982.

Treatments				Number of Leaflet Lesion*		Defoliation* Percentage
Variety of groundnut	Time of Commencement of spray (days after sowing)	Spraying intervals (days)	Total Number of sprays	Early Leafspot	Late Leafspot	
F452.4	36	7	10	8.70	7.67	28.8
	36	14	6	10.00	8.33	32.00
	36	21	4	11.70	9.33	34.80
	No fungicide applied	-	-	13.3	15.33	40.9
F452.4	64	7	6	9.30	7.01	30.2
	64	14	3	10.30	8.25	32.40
	64	21	2	12.00	9.67	35.1
	No fungicide applied	-	-	15.70	12.67	41.7
S38	36	7	10	9.00	6.33	30.7
	36	14	6	9.67	7.33	32.00
	36	21	4	10.00	9.33	36.00
	No fungicide applied	-	-	13.70	11.33	41.0
S38	64	7	6	10.7	7.12	31.2
	64	14	3	11.3	8.67	32.5
	64	21	2	12.67	9.2	37.1
	No fungicide applied	-	-	14.37	10.67	41.5
SEM_1				0.07	0.03	0.18
SEM_2				0.41	0.60	0.94
LSD_2				0.44	1.01	1.10
LSD_1				1.21	1.82	2.8
CV_2				14.5	12.5	13.8
$CV_{1\%}$				16.5	11.2	15.0
$CV_{2\%}$						

Note: *Mean of 3 replicates.

SEM_1 and LSD_1 = Standard error of the mean and least significant difference between treatments on the same groundnut cultivar (i.e. same main plot treatments)

SEM_2 and LSD_2 = Standard error of the mean and least significant difference between sub-treatments for different main plot treatments.

$CV_{1\%}$ = Coefficient of variation for the main plot treatments.

$CV_{2\%}$ = Coefficient of variation for the sub-plot treatments.

was no significant difference in disease severity obtained from variety F452.4 plants sprayed at 7- and 14-day intervals at the two times of commencement of spraying. These two treatments resulted in significantly lower disease severity scores than the same variety sprayed at 21-day intervals. In contrast, when variety S38 was sprayed, the results indicated significant differences in the intervals as well as the time of commencement of spraying.

The analysis of variance for the effects of Calixin-M sprays on number of late leafspot lesions per leaflet is presented in Appendix 19. The effects of intervals of spraying was significant ($P = 0.05$). The results shown in Table 4.10 indicated that the sprayed plants had significantly fewer lesions per leaflet than plants in the unsprayed plots. There was no significant difference in the number of lesions per leaflet obtained in plants from plots that were sprayed at 7- and 14-day intervals, at the two times of commencement of spraying, except in variety S38 sprayed from 64 DAS. In these treatments plants from plots that were sprayed at 7-day intervals had significantly fewer lesions than those plants that were sprayed at 14-day intervals.

4.3.4 Effect of Calixin-M Sprays on Severity of Rust

The results are presented in Table 4.9. The analysis of variance (Appendix 20) revealed that the effects of the intervals of spraying were highly significant ($P = 0.01$). The interaction between the time of commencement of spraying and the varieties of groundnut was also highly significant.

Plants in sprayed plots had significantly lower visual rust severity scores than the unsprayed plants. The results also indicated that there were no significant differences between rust severity in plots sprayed at 7- and 14-day intervals regardless of the time of commencement of spraying. These two treatments resulted in significantly lower rust severity than those in plots sprayed at 21-day intervals.

4.3.5 Effect of Calixin-M Sprays on Rate of Defoliation Caused by Leafspots and Rust

The results (Table 4.10) and the analysis of variance (Appendix 21) for the defoliation percentage showed that the effects of intervals of spraying on defoliation were highly significant ($P = 0.01$). Thus, the sprayed plants were significantly less defoliated than the unsprayed ones. Among the sprayed plots, there were significant differences in all the treatments. Generally, defoliation decreased with decrease in spraying intervals.

4.3.6 Effect of Calixin-M Sprays on Groundnut Yields ⟶

Groundnut pod yield (Table 4.11) was significantly (P = 0.01) affected by intervals of spraying as shown in the analysis of variance (Appendix 22). The sprayed plants produced significantly higher yields of pods than unsprayed plants. Yields of variety F452.4 sprayed at 7- and 14-day intervals, beginning from 36 DAS, were significantly higher than those of plots that were sprayed at 21-day intervals. However, when spraying of the same variety started at 64 DAS, there were significant differences in yields obtained from the three intervals of spraying. Pod yields increased with decrease in intervals of spraying.

In respect of variety S38, there were no significant differences in pod yields of plots sprayed at 7- and 14-day intervals starting from 36 DAS. By contrast, when spraying commenced at 64 DAS, plots sprayed at 7-day intervals yielded significantly more than those sprayed at 14-day intervals.

The results for haulm yields (Table 4.11) and the analysis of variance (Appendix 23) showed that the effects of spraying intervals and the time of commencement of spraying were significant. Haulm yields from sprayed plots were significantly higher than those from unsprayed plots. There was no significant difference in haulm yields obtained by spraying the two varieties from 36 DAS at 7- and 14-day intervals. However, these two treatments significantly outyielded plots that were sprayed at 21-day intervals. In contrast, when the two varieties were sprayed from 64 DAS, the plots that were sprayed at 7-day intervals had significantly higher haulm yields than plots that were sprayed at 14- and 21-day intervals. Similarly, plots that were sprayed at 14-day intervals also significantly outyielded those sprayed at 21-day intervals.

4.3.7 Correlation and Regression Analysis of the Relationship between Disease Severity Parameters and Groundnut Yield in 1982

The summary of the analysis of correlation between pairs of parameters recorded in the field in 1982 is

Table 4.11. Effect of Time of Commencement and Intervals of Calixin-M Sprays on Yields of Groundnut in 1982.

Treatments				Yields of Groundnut (kg/ha) for*			
				Pod Yield		Haulm Yield	
Variety of groundnut	Time of Commencement of spray (days after sowing)	Spraying Intervals	Total Number of Sprays	Actual yield	Increase over control	Actual yield	Increase over control
F452.4	36	7	10	2774.15	1215.19	5138.77	2298.82
	36	14	6	2708.36	1149.40	5124.71	2284.76
	36	21	4	1962.73	403.77	3903.57	1063.62
	No fungicide applied	-	-	1558.96	-	2839.95	-
F452.4	64	7	6	2697.18	964.71	4627.68	2138.61
	64	14	3	2598.73	866.26	4501.82	2012.75
	64	21	2	1951.78	219.31	3528.11	1039.04
	No fungicide applied	-	-	1732.47	-	2489.07	-
S38	36	7	10	2620.65	943.00	5016.34	1913.23
	36	14	6	2609.68	932.03	4975.08	1871.97
	36	21	4	2105.30	427.65	3904.21	801.1
	No fungicide applied	-	-	1677.65	-	3103.11	-
S38	64	7	6	2423.28	844.32	4821.03	1893.36
	64	14	3	2302.66	723.70	4448.77	1521.10
	64	21	2	1820.22	241.26	3640.38	712.71
	No fungicide applied	-	-	1578.96	-	2927.67	-
SEM_1				13.44		11.39	
SEM_2				113.76		178.72	
LSD_2				81.8		69.3	
LSD_1				333.4		520.13	
CV_2				14.26		19	
$CV_{1\%}$				9.2		7.9	
$CV_{2\%}$							

Note: *Mean of 3 replicates. Multiplication factor = 328.95.

SEM_1 and LSD_1 = Standard error of the mean and least significant difference between treatments on the same main plot.

SEM_2 and LSD_2 = Standard error of the mean and least significant difference between sub-plot treatments for different main plot treatments.

$CV_{1\%}$ = Coefficient of variation for the main plot treatments.

$CV_{2\%}$ = Coefficient of variation for the sub-plot treatments.

shown in Table 4.12. The correlation between visual disease severity score and percentage defoliation on the one hand and pod and haulm yields on the other were negative and highly significant (P = 0.01).

When the disease score for early and late leafspots and of rust as well as defoliation percentage were separately correlated with pod yields, the correlation coefficients (r) were -0.79, -0.78, -0.81 and -0.94. These negative values indicated that the higher the severity of leafspots and rust, the lower the pod yields. Similarly, the negative correlation coefficients between the severity of the three diseases and haulm yields shown in Table 4.12 also indicated that the higher the severity of the diseases the lower the haulm yields of groundnuts.

Linear regression of pod and haulm yields on the severity of early and late leafspots and of rust that had significant (P = 0.05) correlation coefficients were calculated. The linear regression equations shown in Appendix 33 indicated that significant reductions in pod and haulm yields were associated with leafspots and rust diseases of groundnuts.

4.4 The Effect of Time of Commencement and Intervals of Calixin-M Sprays on Leafspots and Rust on Groundnut in 1983

The results are presented below.

Table 4.12. Correlation Coefficients between Disease Severity Scores (including defoliation percentage) and Pod and Haulm Yields of Groundnut in Trial 2, 1982.

Pairs of Parameters	Correlation Coefficient (r)
Early leafspot severity and pod yield	-0.79**
Early leafspot severity and haulm yield	-0.66**
Late leafspot severity and pod yield	-0.78**
Late leafspot severity and haulm yield	-0.68**
Rust severity and pod yield	-0.81**
Rust severity and haulm yield	-0.84**
Defoliation percentage and pod yield	-0.94**

** = highly significant (P = 0.01)

4.4.1 Development of the Diseases

The disease symptoms for early and late leafspots were observed at seven and eight weeks after sowing. Again, rust was not observed in the trial.

4.4.2 Effect of Calixin-M Sprays on Severity of Early Leafspot

The results on effects of Calixin-M sprays on the visual severity scores of early leafspot are presented in Table 4.13. The analysis of variance shown in Appendix 24 indicated that the effects of the treatments were highly significant (P = 0.01). The sprayed plants had significantly lower disease severity than the unsprayed plants except variety S38 sprayed at 21-day intervals at 36 days after sowing and at first appearance of symptoms. There were no significant differences in variety F452.4 plants regardless of the time of commencement and intervals of spraying. Similar results were obtained in variety S38 plants.

Analysis of variance for the effects of Calixin-M sprays on the number of early leafspot lesions per leaflet (Appendix 25) showed that there were highly significant differences between the treatments. For example, plants sprayed at 14-day intervals had significantly fewer lesions than those sprayed at 21-day intervals regardless of the time of commencement of spraying.

Table 4.13. Effect of Time of Commencement and Intervals of Calixin-M Sprays on Leafspots of Groundnut in 1983.

Treatments				Visual Disease Severity Score (scale 1-9)*	
Variety of groundnut	Time of Commencement of spray (days after sowing)	Spraying intervals (days)	Total Number of Sprays	Early Leafspot	Late Leafspot
F452.4	36	14	6	2.33 e	3.0 d
	36	21	4	3.33 de	3.0 d
	At first appearance of symptom	14	4	3.67 cde	3.33 d
	"	21	3	4.33 bcde	4.67 b
	No fungicide applied	-	-	7.0 a	6.33 a
S38	36	14	6	3.33 de	3.67 d
	36	21	4	5.67 abc	4.33 b
	At first appearance of symptom	14	4	3.67 cde	5.0 b
	"	21	3	5.33 abcd	5.67 ab
	No fungicide applied	-	-	6.33 a	6.83 a
SEM				0.64	0.45
CV%				24.5	8.5

Note: *Mean of 3 replicates.
SEM = Standard error of the mean.
CV% = Coefficient of variation
Figures followed by the same letters are not significantly different according to Duncan's Multiple Range Test.

4.4.3 Effect of Calixin-M Sprays on Severity of Late Leafspot

Analysis of variance for the effects of Calixin-M sprays on visual severity scores of late leafspot shown on Appendix 26 indicated that the effects of the treatments were highly significant (P = 0.01). The results (Table 4.13) indicated that with exception of the plots sprayed at 21-day intervals, beginning at first appearance of symptoms, the sprayed plots had significantly lower disease severity scores than unsprayed plots. Also, there were no significant differences in disease severity from all plots sprayed at 14-day intervals except plot of variety S38 sprayed at first appearance of symptoms. Above treatments had significantly lower disease severity than plants sprayed at 21-day intervals.

The effects of Calixin-M sprays on the number of late leafspot lesions per leaflet are presented in Table 4.14. The analysis of variance (Appendix 27) indicated that there were highly significant differences between the treatments. The sprayed plots had significantly fewer lesions per leaflet than the unsprayed plots except variety F452.4 sprayed at 21-day intervals, starting at first appearance of symptoms. Among the sprayed plots, there was no significant difference in the number of lesions on leaflet of plants sprayed at 14-day intervals, irrespective of the groundnut

Table 4.14. Effect of Time of Commencement and Intervals of Calixin-M Sprays on Number of Leaflet Lesions and Defoliation Percentage in 1983.

Treatments				Number of Leaflet Lesion*		Percentage Defoliation*
Variety of groundnut	Time of Commencement of Spray (days after Sowing)	Spraying intervals (days)	Total Number of Sprays	Early Leafsopt	Late Leafspot	
F452.4	36	14	6	8.5 d	7.83 de	25.51 c
	36	21	4	12.83 c	11.17 bcd	28.17 c
	At first appearance of symptoms	14	4	8.17 d	8.33 de	26.6 c
	"	21	3	14.17 c	12.17 bc	34.5 b
	No fungicide applied	-	-	19.5 a	13.5 b	42.81 a
S38	36	14	6	8.83 d	9.17 de	26.36 c
	36	21	4	14.5 bc	10.50 cde	35.41 b
	At first appearance of systems	14	4	8.15 d	10.17 cde	26.62 c
	"	21	3	12.5 c	10.20 cde	36.37 b
	No fungicide applied	-	-	17.17 ab	15.83 a	40.9 a
SEM				0.62	0.57	0.96
CV%				8.5	14	13.5

Note: *Mean of 3 replicates.
SEM = Standard error of the mean
CV% = Coefficient of variation
Figures followed by the same letters are not significantly different according to Duncan's Multiple Range Test.

variety and the time of commencement of spraying; leaflets of these treatments had fewer lesions than those of plots sprayed at 21-day intervals.

4.4.4 Effect of Calixin-M Sprays on Rate of Defoliation Caused by Leafspots

Analysis of variance (Appendix 28) showed that the effects of Calixin-M sprays on defoliation were highly significant (P = 0.01). The results (Table 4.14) indicated that defoliation was significantly lower in sprayed than in unsprayed plots. Plots sprayed at 14-day intervals resulted in significantly less defoliation than spraying at 21-day intervals, regardless of the time of commencement of spraying except plants of variety F452.4 sprayed at first appearance of symptoms.

4.4.5 Effect of Calixin-M Sprays on Yield of Groundnut

The effect of Calixin-M sprays on pod yield was highly significant (P = 0.01) as shown by the analysis of variance (Appendix 29). The data (Table 4.15) indicated that plots sprayed at 14-day intervals significantly outyielded those sprayed at 21-day intervals as well as those of the unsprayed plots.

The haulm yields are shown in Table 4.15. Analysis of variance for the effects of Calixin-M sprays on haulm yields (Appendix 30) showed that the effects of treatments were highly significant (P = 0.01). The

Table 4.15. Effect of Time of Commencement and Interval of Calixin-M Sprays on Yields of Groundnut in 1983.

Treatments				Yields of Groundnut (kg/ha)*			
				Pod Yield		Haulm Yield	
Variety of groundnut	Time of Commencement of Spray (days after Sowing)	Spraying Intervals (days)	Total Number of Sprays	Actual yield	Increase over control	Actual yield	Increase over control
F452.4	36	14	6	2642.54 a	1025.30	5811.47 a	2028.54
	36	21	4	1973.71 b	356.50	4959.2 bcde	1176.3
	At first appearance of symptoms	14	4	2489.06 a	871.81	5526.36 abc	1743.43
	"	21	3	1864.12 b	246.87	4835.60 cde	1052.70
	No fungicide applied	-	-	1617.25 bc		3782.93 fa	
S38	36	14	6	2585.74 a	1332.50	5603.12 ab	2313.62
	36	21	4	1864.06 b	608.80	4802.66 ed	1513.2
	At first appearance of symptoms	14	4	2445.18 a	1188.90	5241.20 abcd	1951.70
	"	21	3	1809.23 b	553.95	4309.30 ef	1019.80
	No fungicide applied	-	-	1255.28 c		3289.5 g	
SEM				117.52		215.52	
CV%				9.9		7.7	

Note: *Mean of 3 replicates.
SEM = Standard error of the mean
CV% = Coefficient of variation
Figures followed by the same letters are not significantly different according to Duncan's Multiple Range Test.
Multiplication factor = 328.95.

sprayed plots produced significantly higher haulm than unsprayed plots except variety S38 sprayed at 21-day intervals, beginning at first appearance of symptoms. Also, regardless of the groundnut variety, plots sprayed at 14-day intervals significantly outyielded those of variety S38 sprayed at 21-day intervals irrespective of the time of commencement of spraying.

4.4.6 Correlation Analysis of the Relationship between Disease Severity Parameters and Groundnut Yield in 1983

The summary of the analysis of the correlations between pairs of parameters recorded in the field in 1983 is shown in Table 4.16. The correlation between visual disease severity scores and percentage defoliation on the one hand and pod yields on the other were negative and non-significant ($P = 0.05$). Similar results were obtained on the visual disease severity scores and haulm yield. These results indicated that the disease severity was not significantly correlated with pod and haulm yields.

Table 4.16. Correlation Coefficients between Disease Severity Score (including defoliation percentage) and Pod and Haulm Yields of Groundnut in 1983.

Pairs of Parameters	Correlation Coefficient (r)
Early leafspot visual severity score and pod yield	-0.18 n.s
Early leafspot visual severity score and haulm yield	-0.34 n.s
Late leafspot visual severity score and pod yield	-0.1 n.s
Late leafspot visual severity and haulm yield	-0.22 n.s
Defoliation percentage and pod yield	-0.29 n.s

n.s. = not significant.

CHAPTER 5

DISCUSSION

Results of the present study showed that effective fungicidal control of early and late leafspots and of rust resulted in increases in pod and haulm yields over those of check plots. These findings are in agreement with those of previous workers (Harrison, 1971 and 1972; Fowler and McDonald, 1978; Salako, 1982). There were however some differences between the results obtained in 1982 and those obtained in 1983 probably due to some changes in weather conditions. In both years the leafspots incidence was late in the season while rust was not observed in any of the trials in 1983. However, the relatively low severity of the diseases in both years were probably related to the late start and poor distribution of the rain during the two seasons.

Nevertheless, the relative effectiveness of fungicidal sprays against the leafspots and rust was still obvious. Thus the comparison of the efficacies of mancozeb formulations applied as ultra-low volume (ULV) and the medium volume (MV) sprays revealed that disease control obtained by the application of the fungicide as ULV compared favourably with that obtained when it was applied as MV. The higher rates of the fungicide formulations resulted in lower disease scores and fewer and smaller lesions on the leaflet.

The differences in disease severity between fungicide rates is directly manifested in yields. The plots that received the higher rates produced more pods and haulm. These differences are however only significant between the 50% recommended field dose and the other higher doses. Between the 100 and 150% the recommended field doses the differences were not significant. In 1983, the application of 4l/ha ULV formulation even significantly outyielded the application of 4.5l/ha of the same formulation in pod. From the present result however, 2.00 kg/ha and 4l/ha of mancozeb (wettable powder and ULV formulations respectively) are the best rates.

Regardless of the formulation of mancozeb used, for corresponding rates of fungicide, the MV sprays resulted in higher pod and haulm yields than the ULV sprays. These differences are not significant however. Using carbendazim, Mercer (1976) also found that there was no significant difference in groundnut yields when sprayed in either ULV or MV mode.

The wettable powder (WP) formulation is presently ₦8.00 per kilogram while the ULV formulation is ₦15.00 per litre. For ten applications per season of wettable powder at the rate of 2 kg per hectare, the cost of the chemicals would be ₦160. Similarly the cost of applying ULV at the rate of 4 litres per hectare would be ₦600.00. The difference of ₦440 per hectare per season in cost

of chemicals would make the use of the WP, applied as MV spray more attractive to farmers, except in cases of extreme water shortage.

Results of the effects of Calixin-M sprays on the severity of early and late leafspots and of rust showed that disease severity for the three diseases was significantly less on the two groundnut varieties when spraying commenced 36 days after sowing (DAS) instead of 64 DAS for similar intervals of spraying.

The results from this investigation showed that irrespective of the time spraying commenced, spraying at 7- and 14-day intervals resulted in significantly lower disease severity for the three diseases than spraying at 21-day intervals. Similar results were obtained for pod and haulm yields.

Again, the findings from the 1983 study showed that pod and haulm yields from plots sprayed at 14-day intervals commencing from the first appearance of symptoms were significantly higher than those from plots sprayed at 21-day intervals. The times of commencement and intervals of spraying had no significant effect on the visual severity scores of early and late leafspot. This was probably why the correlation coefficients between the visual severity scores of the diseases and yields of groundnut were very low and not significant.

The first symptoms of early leafspot were observed 49-days after planting during the two years of this investigation. Other workers have reported earlier appearance of the disease symptoms. McDonald and Fowler (1976), Salako (1981) reported that early leafspot may be observed 28 days after planting.

Various spraying regimes have been employed in fungicidal control of groundnut foliar diseases. The manufacturers of Calixin-M suggested spraying intervals of 21 - 28 days. Woodroof et al. (1944); Smart (1964); Littrel and Lindsey (1979) applied fungicides when the first symptoms appeared on the basal leaves at 10 - 14 and 7-day intervals. Kumar and Khare (1974) sprayed from 36 days after emergence at 21-day intervals. Mercer (1975) commenced the application of systemic fungicides 28 - 35 days after emergence and sprayed at 14-days intervals. He found that this spraying regime was advantageous in economic terms. The findings from this study showed that commencing spraying at the first appearance of symptoms would save spraying cost especially in years when the diseases occur late, as was the case in this study. In years when the disease occur early, say 28 days after sowing (McDonald and Fowler, 1976; Salako, 1981), it will ensure that the diseases are taken care of early. The 21 to 28-day intervals suggested by the manufacturer of Calixin-M is not

advisable on the strength of this study, since it was not found adequate as spraying interval for the control of the diseases.

A possible problem that the farmers may encounter is how to recognise the symptoms of early and late leafspots and rust so as to know when to start spraying. The farmers have to be aided by the extension workers to be familiar with the symptoms of these diseases. Once this is possible then they will be able to start spraying as soon as first symptoms appear.

CHAPTER 6

SUMMARY

Two experiments were carried out in two seasons, 1982 and 1983 in Samaru which represents the Northern Guinea Savanna zone in Nigeria.

The first trial was designed to compare the efficacies of ultra-low volume (ULV) and the medium volume (MV) sprays of two formulations (i.e. wettable powder and ultra-low volume) of mancozeb applied at different rates. The ULV sprays were applied with the spinning disc while the MV sprays were applied with CP_3, knapsack sprayer.

Results from this experiments indicated that the ULV and MV sprays were equally effective in controlling leafspots and rust of groundnuts. Though the MV sprays resulted in higher pod yields, the differences were not significant. There was also no significant difference in the performance of the two mancozeb formulations. The effects of the rates of fungicide application significantly affected the severity of leafspots and rust in this study. Better control of the diseases was obtained when mancozeb was applied at high rates, such as 3.36 kg/ha wettable powder (WP) and 6L/ha ultra-low volume (ULV) formulation in respect of MV sprays. However, equally good control of the diseases was obtained

with lower rates as 2.24 kg/ha (WP) and 4.01/ha (ULV) formulations applied as ULV spray in 1982 trial. In 1983 trial, there was no significant difference in disease severity when the two rates i.e. 2.0 - 2.5 kg/ha (WP or 4.0 - 4.51/ha (ULV) formulations were used.

In both years, the correlation coefficients between the visual disease severity scores and yields of groundnuts were negative and highly significant.

In the second experiment, the effects of different times of commencement (i.e. 36 days after sowing, 64 days after sowing and at first appearance of symptoms) of spraying Calixin-M were tested. Three different intervals (i.e. 7-, 14- and 21-days) were also tested.

The results of this study indicated that the three times of commencement were equally effective in the control of the diseases. Also, spraying at 7- and 14-day intervals resulted in better control of the diseases than 21-day intervals.

In 1982 trial the correlation coefficients between the disease severity and yields of groundnut were negative and highly significant. In contrast, in the 1983 trial, the correlation coefficients between the disease parameters and yields were negative but not significant.

The first symptoms of early leafspot were observed 49 days after planting during the two years of this study. Rust was observed in the tenth week in 1982 and was not observed in 1983 trial.

Spraying regime of Calixin-M commencing at first appearance of symptoms and applied at 14-day intervals was found to be the best. This spraying regime will take care of the unpredictable time of appearance of the diseases. This will reduce the cost of spraying in the event of the diseases appearing late. If however the diseases appear early (earlier than 36 days after sowing) spraying would commence immediately to effectively control them.

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APPENCIDES

Appendix 1. Analysis of Variance for the Effect of Mancozeb on the Visual Severity Score of Early Leafspot in 1982.

Source of Variation	DF	MS
rep	2	0.25
m	1	0.33 n.s
Error a	2	2.08
f	1	0 n.s
r	3	9.44**
f x r	3	0.22 n.s
f x m	1	0 n.s
r x m	3	0.56 n.s
f x r x m	3	0.22 n.s
Error b	28	0.70
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 2. Analysis of Variance for the Effect of Mancozeb on Early Leafspot Lesions per Leaflet in 1982.

Source of Variation	DF	MS
rep	2	0.64
m	1	6.11 n.s
Error a	2	0.4
f	1	0.02 n.s
r	3	48.69**
f x r	3	2.41 n.s
f x m	1	1.70 n.s
r x m	3	2.19 n.s
f x r x m	3	1.41 n.s
Error b	28	1.45
Total	47	

m = *method of application*
rep = replication
f = formulation
r = rate of fungicide application
** = *highly significant* (P = 0.01)
n.s = not significant.

Appendix 3. Analysis of Variance for the Effect of Mancozeb on the Visual Severity Score of Late Leafspot in 1982.

Source of Variation	DF	MS
rep	2	5.58
m	1	8.33 n.s
Error a	2	2.58
f	1	0.33 n.s
r	3	9.11**
f x r	3	0.56 n.s
f x m	1	1.33 n.s
r x m	3	1.89 n.s
f x r x m	3	0.22 n.s
Error b	28	1.04
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
** = highly significant
n.s = not significant.

Appendix 4. Analysis of Variance for the Effect of Mancozeb on the Number of Late Leafspot Lesions per Leaflet in 1982.

Source of Variation	DF	MS
rep	2	1
m	1	3.52 n.s
Error a	2	2.58
f	1	0.02 n.s
r	3	50.13**
f x r	3	1.74 n.s
f x m	1	0.19 n.s
r x m	3	0.91 n.s
f x r x m	3	2.24 n.s
Error b	28	0.74
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 5. Analysis of Variance for the Effect of Mancozeb on the Visual Severity Score of Rust in 1982.

Source of Variation	DF	MS
rep	2	1.58
m	1	8.61 n.s
Error a	2	1.09
f	1	0
r	3	33.44**
f x r	3	1.11 n.s
f x m	1	1.35 n.s
r x m	3	1.90 n.s
f x r x m	3	0.22 n.s
Error b	28	1.24
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
** = highly significant (P = 0.01)
n.s = not significant

Appendix 6. Analysis of Variance for the Effect of Mancozeb on Defoliation Percentage in 1982.

Source of Variation	DF	MS
rep	2	1.15
m	1	0.73 n.s
Error a	2	0.38
f	1	0.39 n.s
r	3	283.70**
f x r	3	2.34 n.s
f x m	1	0.54 n.s
r x m	3	5.21*
f x r x m	3	1.42 n.s
Error b	28	1.25
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 7. Analysis of Variance for the Effect of Mancozeb on Pod Yield in 1982.

Source of Variation	DF	MS
rep	2	53042.2
m	1	171519 n.s
Error a	2	46851.5
f	1	107351 n.s
r	3	11085400*
f x r	3	41470.8 n.s
f x m	1	54145 n.s
r x m	3	209680*
f x r x m	3	19455.7 n.s
Error b	28	59397.39
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of application
* = significant (P = 0.05)
n.s = not significant.

Appendix 8. Analysis of Variance for the Effect of Mancozeb on Haulm Yield in 1982.

Source of Variation	DF	MS
rep	2	553587
m	1	8143170*
Error a	2	219584
f	1	1100930*
r	3	31815200 **
f x r	3	211601 n.s
f x m	1	203497 n.s
r x m	3	1231110*
f x r x m	3	663499**
Error b	28	218258.2
Total	47	

m = method of application
rep = replication
f = formulation
r = rate of fungicide application
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 9. Analysis of Variance for the Effect of Mancozeb on Visual Severity Score of Early Leafspot in 1983.

Source of Variation	DF	MS
Blocks	3	0.20
Treatments	4	3
Error	12	0.20
Total	19	

Appendix 10. Analysis of Variance for the Effect of Mancozeb on Early Leafspot Lesions per Leaflet in 1983.

Source of Variation	DF	MS
Blocks	3	1.38
Treatments	4	39.44**
Error	12	1.26
Total	19	

Appendix 11. Analysis of Variance for the Effect of Mancozeb on Visual Severity Score of Late Leafspot in 1983.

Source of Variation	DF	MS
Blocks	3	0.73
Treatments	4	4.80**
Error	12	0.40
Total	19	

Appendix 12. Analysis of Variance for the Effect of Mancozeb on the Number of Late Leafspot Lesions per Leaflet in 1983.

Source of Variation	DF	MS
Blocks	3	4.13
Treatments	4	30.58**
Error	12	0.51
Total	19	

Appendix 13. Analysis of Variance for the Effect of Mancozeb on Defoliation Percentage in 1983.

Source of Variation	DF	MS
Blocks	3	6.69
Treatments	4	80.68**
Error	12	1.82
Total	19	

Appendix 14. Analysis of Variance for the Effect of Mancozeb on Pod Yield in 1983.

Source of Variation	DF	MS
Blocks	3	26320
Treatments	4	1440370**
Error	12	15176.7
Total	19	

Appendix 15. Analysis of Variance for the Effect of Mancozeb on Haulm Yield in 1983.

Source of Variation	DF	MS
Blocks	3	879701
Treatments	4	3394750**
Error	12	190336
Total	19	

Appendix 16. Analysis of Variance for the Effect of Calixin-M on Visual Severity Score of Early Leafspot in 1982.

Source of Variation	DF	MS
rep	2	1.58
v	1	0.41
Error a	2	0.59
f	3	12.22 **
t	1	12.0 **
f x t	3	0.67 n.s
f x v	3	0.57 n.s
t x v	1	3.04 n.s
f x t x v	3	1.45 n.s
Error b	28	1.37
Total	47	

v = variety
f = intervals of spraying (days)
t = time of commencement of spraying
rep = replication
** = highly significant (P 0.01)
n.s = not significant.

Appendix 17. Analysis of Variance for the Effect of Calixin-M on Number of Early Leafspot Lesions per Leaflet in 1982.

Source of Variation	DF	MS
rep	2	1.33
v	1	0.19
Error a	2	0.25
f	3	51.74**
t	1	0.19
f x t	3	3.19*
f x v	3	1.63
t x v	1	11.04**
f x t x v	3	1.02
Error b	28	
Total	47	

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 18. Analysis of Variance for the Effect of Calixin-M on Visual Severity Score of Late Leafspot in 1982.

Source of Variation	DF	MS
rep	2	1.58
v	1	0
Error a	2	0.25
f	3	12.33**
t	1	5.33*
f x t	3	0.01 n.s
f x v	3	0.89 n.s
t x v	1	0.06 n.s
f x t x v	3	0.89
Error b	28	1.01
Total	47	

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant

Appendix 19. Analysis of Variance for the Effect of Calixin-M on the Number of Late Leafspot Lesions per Leaflet in 1982.

Source of Variation	DF	MS
rep	2	0.65
v	1	0.75 n.s
Error a	2	1.31
f	3	53.5 **
t	1	0 n.s
f x t	3	1.83 n.s
f x v	3	0.81 n.s
t x v	1	0.81 n.s
f x t x v	3	0.75 n.s
Error b	28	1.05
Total	37	

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 20. Analysis of Variance for the Effect of Calixin-M on the Visual Severity Score of Rust in 1982.

Source of Variation	DF	MS
rep	2	1.08
v	1	2.18 n.s
Error a	2	1.43
f	3	24.31 **
t	1	0.08 n.s
f x t	3	1.20 n.s
f x v	3	0.94 n.s
t x v	1	18.94 **
f x t x v	3	0.46 n.s
Error b	28	0.82
Total	47	

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 21. Analysis of Variance for the Effect of Calixin-M on Defoliation Percentage in 1982.

Source of Variation	DF	MS
rep	2	6.69
v	1	7.68 n.s
Error a	2	1.59
f	3	270.19 **
t	1	0.52 n.s
f x t	3	1.02 n.s
f x v	3	5.50 n.s
t x v	1	8.0 n.s
f x t x v	3	0.44 n.s
Error b	28	2.7
Total	47	

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 22. Analysis of Variance for the Effect of Calixin-M on Pod Yield in 1982.

Source of Variation	DF	MS	
rep	2	51560	
v	1	134189	n.s
Error a	2	8675.48	
f	3	2726490	**
t	1	147200	n.s
f x t	3	7362.79	n.s
f x v	3	49472.5	n.s
t x v	1	148618	n.s
f x t x v	3	31554.9	n.s
Error b	28	40833.5	
Total	47		

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
** = highly significant (P = 0.01)
n.s = not significant

Appendix 23. Analysis of Variance for the Effect of Calixin-M on Haulm Yield in 1982.

Source of Variation	DF	MS	
rep	2	33630.9	
v	1	88843.1	n.s
Error a	2	6225.09	
f	3	11129800	**
t	1	466865	*
f x t	3	64796.5	n.s
f x v	3	133950	n.s
t x v	1	861583	n.s
f x t x v	3	158886	n.s
Error b	28	101790.5	
Total	47		

f = intervals of spraying
t = time of commencement of spraying
v = variety
rep = replication
* = significant (P = 0.05)
** = highly significant (P = 0.01)
n.s = not significant.

Appendix 24. Analysis of Variance for the Effect of Calixin-M on the Visual Severity Score of Early Leafspot in 1983.

Source of Variation	DF	MS
Blocks	2	0.93
Treatments	9	6.83 **
Error	18	1.23
Total	29	

Appendix 25. Analysis of Variance for the Effect of Calixin-M on the Severity of Early Leafspot Lesions per Leaflet in 1983.

Source of Variation	DF	MS
Blocks	2	1.43
Treatments	9	47.29 **
Error	18	1.14
Total	29	

** = highly significant (P = 0.01).

Appendix 26. Analysis of Variance for the Effect of Calixin-M on the Visual Severity Score of Late Leafspot in 1983.

Source of Variation	DF	MS
Blocks	2	2.53
Treatments	9	2.07 *
Error	18	0.61
Total	29	

Appendix 27. Analysis of Variance for the Effect of Calixin-M on Number of Late Leafspot Lesions per Leaflet in 1983.

Source of Variation	DF	MS
Blocks	2	2.03
Treatments	9	16.89 **
Error	18	
Total	29	

* = significant (P = 0.05)
** = highly significant (P = 0.01).

Appendix 28. Analysis of Variance for the Effect of Calixin-M on Defoliation Percentage in 1983.

Source of Variation	DF	MS
Blocks	2	7.9
Treatments	9	178.23 **
Error	28	
Total	29	

Appendix 29. Analysis of Variance for the Effect of Calixin-M on Pod Yield in 1983.

Source of Variation	DF	MS
Blocks	2	186324
Treatments	9	646916 **
Error	18	41186.7
Total	29	

** = highly significant (P = 0.01).

Appendix 30. Analysis of Variance for the Effect of Calixin-M on Haulm Yield in 1983.

Source of Variation	DF	MS
Blocks	2	14336
Treatments	9	1990120**
Error	18	138517
Total	29	

** = highly significant (P = 0.01).

Appendix 31. Regression Equations of the Relationship between Disease Severity Parameters and Groundnut Yield in 1982.

Pod yield = 4911.05 - 539.63 early leafspot severity

Haulm yield = 6284.84 - 566.45 early leafspot severity

Pod yield = 4601.55 - 393.90 late leafspot severity

Haulm yield = 6100.84 - 451.90 late leafspot severity

Pod yield = 4738.21 - 403.63 rust severity

Haulm yield = 6300.47 - 474.03 rust severity

Appendix 32. Regression Equations for the Effect of Mancozeb on the Relationship between Disease Severity Parameters and Groundnut Yield in 1983.

Pod yield = 4536 - 582.512 early leafspot severity

Haulm yield = 9114.02 - 999.20 early leafspot severity

Pod yield = 5701.11 - 582.513 late leafspot severity

Haulm yield = 11112.40 - 999.19 late leafspot severity

Appendix 33. Regression Equations for the Effect of Calixin-M on the Relationship between Disease Severity Parameters and Groundnut Yield in 1982.

Pod yield	=	3466.97 - 246.54	early leafspot severity
Haulm yield	=	6145.05 - 403.19	early leafspot severity
Pod yield	=	3653.86 - 273.51	late leafspot severity
Haulm yield	=	6558.08 - 467.48	late leafspot severity
Pod yield	=	3415.42 - 250.31	rust severity
Haulm yield	=	6524.02 - 505.05	rust severity