Response of six groundnut (*Arachis hypogaea* L.) cultivars to fungicidal control of leaf spots in Niger[1]

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The response of six groundnut cultivars to fungicidal control of leaf spots was examined at three different locations in 1987 and 1988 crop seasons in Niger. In 1987, leaf spots were not severe at Sadoré and Maradi due to low rainfall conditions and the fungicidal control of these diseases resulted in only a marginal increase in pod (5%) and haulm (10%) yields. However, in 1988 leaf spots were severe, causing almost 100% defoliation and control of these diseases substantially increased the yields, at Sadoré by 48% in pod yield and 53% in haulm yield, and at Maradi by 24% in pod yield and 21% in haulm yields. In Bengou, leaf spots were destructive in both years and fungicidal control markedly increased the yields of pods by 44% in 1987 and 67% in 1988 and haulms by 31% in 1987 and 62% in 1988. Some cultivars responded more to leaf spot control than others and the response varied considerably between locations and years, suggesting that specific genotype × environment × disease interaction may have occurred. The cultivars ICGV 87123 (formerly ICGS 11) and 796 consistently out-yielded all other cultivars in both years and spray treatments at Bengou and Maradi, respectively.

Keywords: Groundnuts; Peanut; Fungicidal control; Leaf spots

Leaf spots caused by *Cercospora arachidicola* Hori (early leaf spot) and *Phaeoisariopsis personata* (Berk. & Curt.) v. Arx (late leaf spot) are the most important fungal diseases of groundnut (*Arachis hypogaea* L.) in Niger, often causing 20% reduction in yield (Soumana, 1982). In 1986 and 1987 surveys, both leaf spots were commonly observed throughout the country, but late leaf spot was dominant and more destructive (Subrahmanyam *et al.*, 1988). These pathogens damage the plant by reducing available photosynthetic area, lesion formation and by stimulating leaflet abscission. In addition, they also produce lesions on petioles, stems and pegs. When disease attack is severe, the affected leaflets first become chlorotic, then necrotic, the lesions often coalesce and leaflets are shed (Smith, 1984). Leaf spots can be effectively controlled by the application of fungicides such as benomyl, captafol, chlorothalonil, copper ammonium carbonate, copper hydroxide, fentin hydroxide, carbendazim, mancozeb and maneb (McDonald and Fowler, 1976; Smith and Littrell, 1980; Subrahmanyam *et al.*, 1984; McDonald *et al.*, 1985; Salako, 1985a, b). All groundnut cultivars currently grown in Niger are susceptible to both leaf spots. Very little is known about the response of these cultivars to fungicidal control of leaf spots in Niger.

The present study was conducted to examine the response of six groundnut cultivars to fungicidal control of the leaf spot pathogens at three different locations in the 1987 and 1988 crop seasons in Niger.

Materials and methods

Field trials were conducted in the 1987 and 1988 rainy seasons at the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Centre research farm at Sadoré (13°29′ N, 2°10′ E, 221 m alt.), INRAN (Institut de Recherches Agronomiques du Niger) research stations at Bengou (11°59′ N, 3°33′ E, 172 m alt.) and Maradi (13°28′ N, 7°25′ E, 368 m alt.). Annual rainfall averages 560 mm at Sadoré, 840 mm at Bengou and 640 mm at Maradi, most of it being received June–September. At Sadoré and Maradi, rainfall exceeds potential evapotranspiration for a very short period; at Bengou, potential evapotranspiration is met by rainfall over 80 days (Sivakumar *et al.*, 1988). The soils are sandy at Sadoré and Maradi and loamy at Bengou.

Five regionally grown and one introduced cultivars (Table 1) were tested, all susceptible to both leaf spots. Seeds of the six cultivars were obtained

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Table 1 Description of groundnut cultivars used in the experiment

Cultivar	Botanical type	Cycle (days)	Orgin
55–437	Spanish	90	Selected in Senegal from a population probably received from South America
TS 32–1	Spanish	90	From a cross between Spantex and TE 3 in Burkina Faso
796	Spanish	90	Introduced into Niger from Burkina Faso
IGCV 87123	Spanish	110	Selected from Robut 33–1 in India
28–206	Virginia bunch	120	Selected in Senegal from a population received from Mali
47–16	Virginia runner	130	Selected in Senegal from an Indian variety Ingris 37–6 received from Madagascar

from Mr A. Mounkaila, Groundnut Breeder, INRAN, Maradi. Seeds were treated with a protectant fungicide (Thiram in 1987 and Captan in 1988) at the rate of 3 g Kg^{-1} seed just before sowing.

Field plots were arranged in a split-plot design with spray treatments as main-plots, cultivars as sub-plots and replicated four times. Seeds were sown singly at 10 cm spacing along 40 cm (in 1987) or 50 cm (in 1988) rows at about the optimum time (end of June). All trials were conducted under rainfed conditions.

Fungicides were applied as water-based sprays, using a conventional low-pressure knapsack sprayer. A total of five sprays were given. In 1987, the first three sprays were given with carbendazim (as Bavistin WP 50% w/w; BASF, India Ltd.) at the rate of 500 g in 500 l of water ha^{-1}, and the last two sprays with chlorothalonil (as Daconil 2787 W-75; Diamond Shamrock Corporation, USA) at the rate of 1.6 kg in 800 l of water ha^{-1} to control leaf spots. In 1988, all applications were made with chlorothalonil. Control plots were sprayed with water at the rate of 500 l ha^{-1}. Sprays were first applied 30 days after sowing and subsequently at 15-day intervals. Two sprays of an insecticidal mixture (dimethoate and cypermithrin), were given to all plots to control foliar feeders at all locations in both years.

At maturity, five plants were selected at random within each plot and their main stems were assessed for the proportion of leaf area destroyed by leaf spots, using a schematic diagram depicting leaves with known proprotions of their areas affected. Plants were harvested at optimum maturity, and yields of dried pods and haulms and shelling percentages were recorded. Rainfall data were collected from all locations. Statistical analysis was carried out for each location and year using conventional methods of analysis of variance for split-plot designs.

Leaf spot development was monitored at all locations in 1987; and in 1988, on the susceptible cultivar 55–437. Seed were also planted in unreplicated 100 m^2 plots adjacent to the fungicide trials as described above. At 40 days after sowing and subsequently at 15-day intervals until harvest, 10 plants were collected at random from each plot and assessed for leaf damage as described above. The area (A) under a disease-progress curve (AUDPC) was calculated for each location using the formula,

$$A = \sum_{i=1}^{k} (S_i + S_{i-1})/2$$

where S_i is the disease severity at the end of week i, and k is the number of successive evaluations.

Results

1987 rainy season

Leaf spot development

Total rainfall during the 1987 crop season (June to October) was higher at Bengou (541 mm) than at Sadoré (427 mm) and Maradi (281 mm). The number of rainy days was greater and the distribution of rainfall during the crop season was satisfactory at Bengou (Figure 1). This resulted in the early appearance and rapid development of leaf spots in Bengou, leading to extensive damage of the foliage. The appearance of leaf spots at Sadoré and Maradi was considerably delayed and caused only limited damage to the foliage (Figure 2) because of dry climatic conditions during the crop season. The AUDPC was significantly higher in Bangou (A, 3214) than in Sadoré (A, 367) and Maradi (A, 250). Late leaf spot was predominant in Sadoré and Maradi, but at Bengou both early and late leaf spots were severe.

The mean proportion of leaf area affected for all cultivars in the control plots at maturity was only 10.5% at Sadoré and 12.2% at Maradi, but at Bengou it was as high as 96.5%. Fungicide spray significantly reduced leaf spot severity on all cultivars at all locations. The mean leaf area affected for all cultivars in treated plots was 0.8% at Sadoré, 0.3% at Maradi and 7.6% at Bengou (Tables 2, 3, and 4).

Pod and haulm yields

Pod yields were generally low in control plots at Sadoré (mean of 0.62 t ha^{-1}) (Table 2) and Maradi (mean of 0.58 t ha^{-1}) (Table 4) due to low and erratic rainfall patterns during the 1987 rainy season. At Sadoré, the situation was further complicated by an inherent variability in crop growth in the field, leading to a high coefficient of variation (28–29%). In Bengou, pod yields in control plots were high, ranging 2.57–4.49 t ha^{-1} (Table 3). Fungicidal control of leaf spots resulted in only marginal increases in pod yields from all cultivars at Sadoré (5.2%) and Maradi (5.2%); but at Bengou it ranged 11–49% (mean 44%). The cultivar 55–437 gave the highest (49%) yield response at Bengou, followed by ICGV 87123. The cultivars TS 32–1 and 796

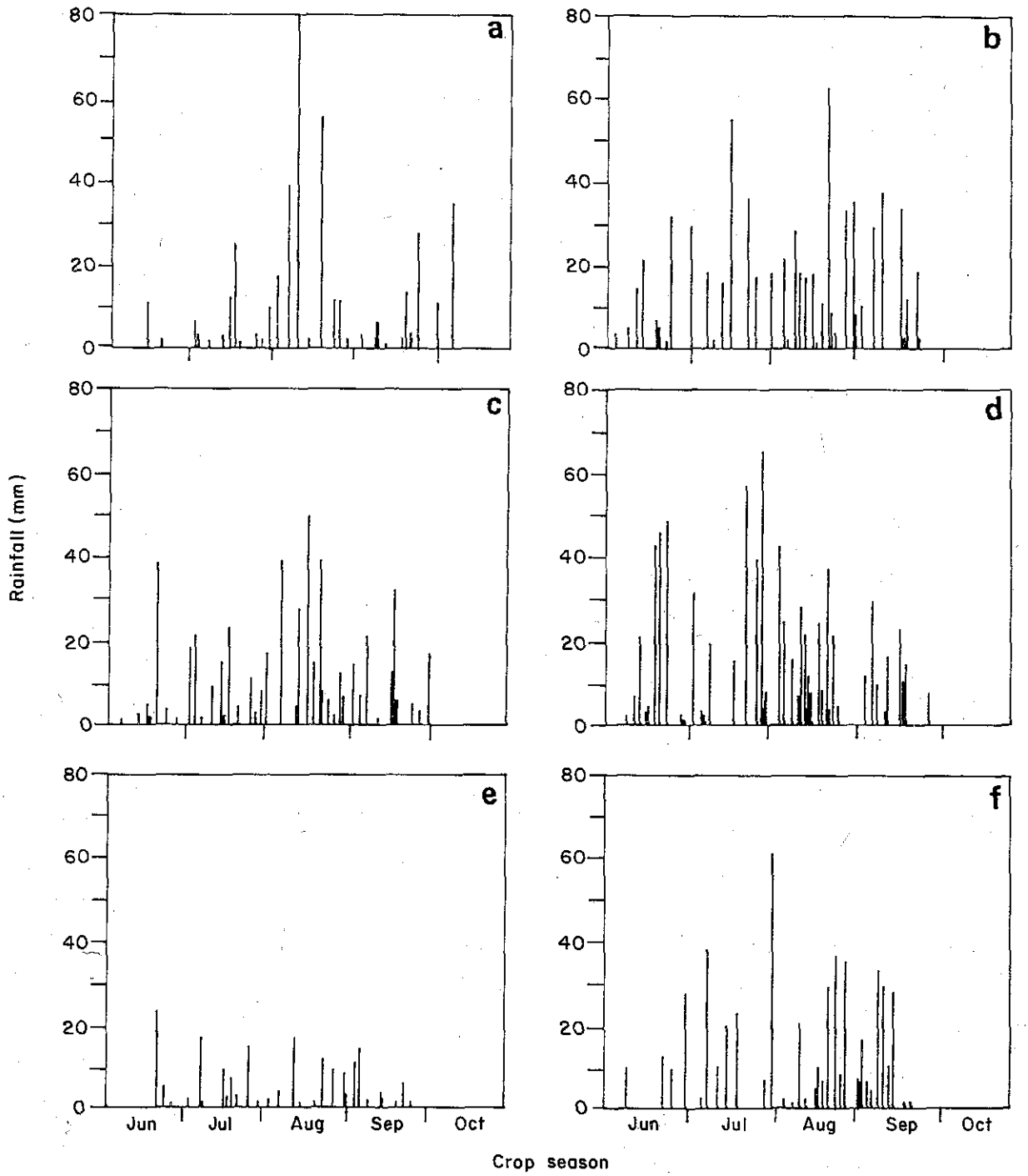

Figure 1 Rainfall during the 1987 and 1988 crop seasons (June–October) at Sadoré, Bengou and Maradi, Niger. a, Sadoré 1987; b, Sadoré, 1988; c, Bengou, 1987; d, Bengou, 1988; e, Maradi, 1987; f, Maradi, 1988

gave the highest pod yields at Sadoré (Table 2) and Maradi (Table 4), respectively, and ICGV 87123 significantly out-yielded all other cultivars at Bengou in both spray treatments (Table 3).

Haulm yields were also generally low in Sadoré (1.10 t ha^{-1} in the control plot and 1.22 t ha^{-1} in the fungicide spray treatments) (Table 2). In Maradi (1.55 t ha^{-1} in the control plots and 1.70 t ha^{-1} in the fungicide spray treatments) (Table 4), due to poor vegetative growth. However, in Bengou the haulm yields were very high and ranged 3.91–5.51 t ha^{-1} in the control plots and 4.17–7.84 t ha^{-1} in the fungicide spray treatments (Table 3). The haulm yield increase from control of leaf spot for all cultivars was 31% in Bengou but only about 10% in Sadoré and Maradi.

Shelling percentages were low in Sadoré (mean 58) (Table 2) and Maradi (mean 62, Table 4) because of drought stress during the pod-filling stage. Shelling percentage was high in Bengou (mean 77, Table 3). Leaf spot control showed only a marginal improvement in shelling percentages at all locations.

1988 rainy season

Leaf spot development

Rainfall during the 1988 crop season was satisfactory at Sadoré (689 mm), Bengou (857 mm) and Maradi (514 mm) (Figure 1), resulting in severe epiphytotics of late leaf spot (Figure 2). Although early leaf spot and rust (*Puccinia arachidis* Speg.) were observed at all locations, they were not severe. The onset of late leaf spot came very early in the season and progressed rapidly, especially at Bengou, causing extensive damage to the foliage (Figure 2). The AUDPC was also very large at Sadoré (A, 2100), Bengou (A, 3907) and Maradi (A, 2168). Mean percentages of leaf areas affected in the controls were very high at all locations; Sadoré (92), Bengou (97) and Maradi (92). Fungicide spray significantly reduced the disease severity at all locations (Tables 5, 6 and 7).

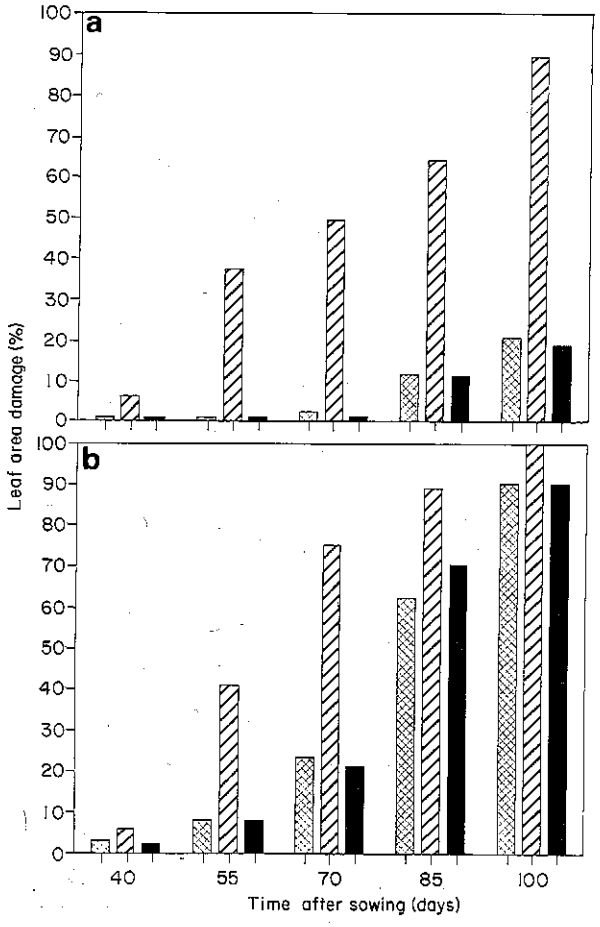

Figure 2 Development of leaf spots on a susceptible groundnut cultivar 55–437 during the 1987 and 1988 crop seasons at Sadoré, Bengou and Maradi, Niger. a, 1987 rainy season; b, 1988 rainy season; ⊡, Sadoré; ▨, Bengou; ■, Maradi

Pod and haulm yields

Pod yields were generally high at Sadoré (mean of 2.59 t ha^{-1} in the control plots and 3.81 t ha^{-1} in fungicide spray) (Table 5); and at Bengou (mean of 2.37 t ha^{-1} in the controls and 3.85 t ha^{-1} in fungicide spray) (Table 6). Pod yields in Maradi in 1988 were higher (mean of 0.99 t ha^{-1} in the control plots and 1.23 t ha^{-1} under fungicide spray) (Table 7) than the 1987 yields (Table 4), but lower than other locations because of frequent dry spells, especially towards maturity of the crop. Control of leaf spot has resulted in a substantial increase in pod yield at all locations, especially in Sadoré and Bengou. Percentage increase in pod yields due to control of leaf spot ranged 32–61 (mean 48) at Sadoré, 37–133 (mean of 67) at Bengou but only 18–37 (mean 24) at Maradi. The cultivar 796 showed the highest yield response at Bengou and Maradi, and TS 32–1 was best at Sadoré. The cultivars 28–206, ICGV 87123 and 796 gave the highest pod yields at Sadoré, Bengou and Maradi, respectively, in both spray treatments (Tables 5, 6 and 7).

Haulm yields were high at Sadoré (2.68 t ha^{-1} in the controls and 4.09 t ha^{-1} in fungicide spray) (Table 5); Bengou (3.05 t ha^{-1} in the control plots and 4.94 t ha^{-1} in fungicide spray) (Table 6); and Maradi (3.34 t ha^{-1} in the control and 4.04 t ha^{-1} in fungicide spray) (Table 7). Although pod yields at Maradi were lower than at Sadoré and Bengou, haulm yields were not markedly different from these locations. The response of haulm yields to leaf spot control was substantial at Sadoré (53%), Bengou (62%) and Maradi (21%). The cultivars 28–206 gave the highest haulm yield at all locations (Tables 5, 6 and 7).

Shelling percentages were high in Sadoré (75) and Bengou (77) but only 72 at Maradi. In general, leaf spot control did not markedly influence the shelling percentages.

Table 2 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1987 rainy season at Sadoré, Niger

Cultivar	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	11	1	0.65	0.72	0.54	0.62	62	65
TS 32–1	18	2	0.88	0.93	1.00	1.22	60	59
796	10	2	0.53	0.53	0.54	0.58	59	65
ICGV 87123	9	1	0.70	0.71	1.54	1.58	58	58
28–206	7	1	0.43	0.46	1.38	1.74	45	45
47–16	10	0	0.53	0.53	1.58	1.56	59	63
SE		± 1.2		± 0.09		± 0.15		± 2.8
Mean	10.5	0.8	0.62	0.65	1.10	1.22	57	59
SE		± 0.1		± 0.03		± 0.03		± 0.9
CV (%)		46		29		28		10

Table 3 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1987 rainy season at Bengou, Niger

	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
Cultivar	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	100	11	3.66	5.44	4.25	6.10	76	78
TS 32–1	100	7	3.84	5.05	4.22	5.74	76	77
796	100	3	3.63	4.93	3.91	4.17	79	80
ICGV 87123	97	9	4.49	6.18	5.05	6.10	76	75
28–206	94	11	3.07	4.02	5.51	6.52	72	73
47–16	89	5	2.57	2.85	4.96	7.84	76	76
SE		± 1.7		± 0.26		± 0.45		± 1.0
Mean	96.5	7.6	3.54	4.74	4.65	6.08	76	77
SE		± 0.8		± 0.15		± 0.13		± 0.4
CV (%)		7		11		18		3

Table 4 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1987 rainy season at Maradi, Niger

	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
Cultivar	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	16	1	0.75	0.77	1.18	1.31	63	64
TS 32–1	11	0	0.81	0.85	1.18	1.35	63	63
796	11	2	1.11	1.17	1.48	1.62	69	69
ICGV 87123	11	0	0.50	0.53	1.84	2.00	61	61
28–206	14	0	0.10	0.11	1.65	1.74	50	58
47–16	9	0	0.24	0.25	1.96	2.15	60	60
SE		± 1.4		± 0.05		± 0.09		± 1.5
Mean	12.2	0.3	0.58	0.61	1.55	1.70	61	63
SE		± 0.5		± 0.02		± 0.01		± 0.2
CV (%)		47		19		12		5

Table 5 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1988 rainy season at Sadoré, Niger

	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
Cultivar	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	100	10	2.65	3.51	2.58	3.52	75	75
TS 32–1	98	9	2.43	3.92	2.69	4.17	76	75
796	96	10	2.59	4.01	2.43	3.70	77	78
ICGV 87123	89	8	2.25	3.59	2.82	4.09	72	73
28–206	81	8	3.02	4.03	3.81	4.88	73	68
47–16	88	8	2.59	3.78	2.36	4.18	76	75
SE		± 1.5		± 0.19		± 0.20		± 0.9
Mean	92	9	2.59	3.81	2.68	4.09	75	74
SE		± 0.7		± 0.07		± 0.10		± 0.5
CV (%)		6		12		12		2

Discussion

Rainfall was erratic during the 1987 crop season at Sadoré and Maradi, resulting in low pod and haulm yields. Leaf spots were not severe at these locations and their control did not result in marked increases in yield. However, in 1988 at Sadoré, the rainfall was almost optimum for crop growth and yields were high. Leaf spots were severe, causing extensive damage to the foliage. This resulted in a signficant increase in yield when leaf spots were controlled. Although leaf spots were severe in Maradi in 1988, there was only a 24% increase in yield with their control because of erratic rainfall towards crop maturity. At Bengou, rainfall was high and well distributed in both years. Severe epiphytotics of leaf spots occurred in both years and resulted in the highest yield increase when they were controlled by the fungicide.

The measure of response to protection is the loss attributable to the disease. It has been reported that the associated yield loss from leaf spots in Niger is at about 20% (Soumana, 1982) of the potential. However, it is largely dependent on disease pressure which in turn is dependent on climatic factors. For instance, the loss in pod yield at Sadoré was only marginal in 1987 but was as high as 32% in 1988. In Bengou, the disease pressure was high in

Table 6 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1988 rainy season at Bengou, Niger

	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
Cultivar	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	100	12	1.98	3.61	3.10	4.31	77	77
TS 32–1	100	10	2.57	3.88	2.85	4.65	77	77
796	100	9	1.48	3.45	2.03	4.17	79	79
ICGV 87123	98	11	3.52	5.59	2.95	4.73	74	76
28–206	90	11	2.48	3.53	3.77	6.52	74	77
47–16	95	13	2.21	3.03	3.58	5.29	75	75
SE	± 1.3		± 0.22		± 0.30		± 0.9	
Mean	97	11	2.37	3.85	3.05	4.94	76	77
SE	± 0.7		± 0.09		± 0.16		± 0.2	
CV (%)	5		14		14		2	

Table 7 Effect of fungicide spray on leaf spot severity, yield of pods and haulms (t ha^{-1}) and shelling percentages of six groundnut cultivars during the 1988 rainy season at Maradi, Niger

	Leaf area damage (%)		Yield				Shelling percentage	
			Pods		Haulms			
Cultivar	Control	Sprayed	Control	Sprayed	Control	Sprayed	Control	Sprayed
55–437	98	11	0.97	1.16	3.47	4.27	70	70
TS 32–1	95	9	1.06	1.34	3.24	4.15	74	75
796	95	9	1.39	1.90	3.17	3.97	74	74
ICGV 87123	91	9	0.94	1.15	2.73	3.34	69	71
28–206	85	14	0.76	0.90	3.89	4.40	66	67
47–16	88	7	0.79	0.94	3.54	4.10	75	75
SE	± 1.8		± 0.55		± 0.20		± 1.1	
Mean	92	10	0.99	1.23	3.34	4.04	71	72
SE	± 0.7		± 0.12		± 0.13		± 0.1	
CV (%)	7		11		9		4	

both years and the losses in pod yield were high (25% in 1987 and 38% in 1988).

Some cultivars responded more positively to leaf spot control than others, and they differed considerably over locations and years due, possibly, to the low yield potential of some of the genotypes. Yield increases with leaf spot control depend on disease severity. When the disease level is low, the potential for yield increase is also low, as observed in Sadoré in 1987. These results clearly suggest that specific genotype × environment × disease interactions may have occurred. Since each genotype has its own unique response to leaf spot control, this must be carefully considered when formulating protection practices. Plant protection may not be economical if a cultivar has low response potential with chemical disease control.

Overall, cultivar performance for pod yield was not consistent at Sadoré because of large variations in climatic and edaphic factors. For instance, the cultivar 28–206 was the lowest yielder in 1987 but was the highest in 1988. However, the cultivars ICGV 87123 (medium cycle) and 796 (short cycle) consistently out-yielded all other entries in both years at Bengou and Maradi, respectively, in both spray treatments. These cultivars may be made available to farmers in those areas to achieve high yields.

References

McDonald, D. and Fowler, A.M. (1976) Control of cercospora leaf spot disease of groundnuts (*Arachis hypogaea*) in Nigeria, *Nigerian J. Plant Prot.* **2** 43–59

McDonald, D., Subrahmanyam, P., Gibbons, R.W. and Smith, D.H. (1985) Early and late leaf spots of groundnut, *Infor. Bull.* **21** International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India, 1–9

Salako, E.A. (1985a) Fungicidal control of groundnut leaf spot and rust in Nigeria, *Crop Prot.* **4** 33–37

Salako, E.A. (1985b) Fungicidal control of groundnut leaf spots and rust by ultra-low volume spray *Trop. Pest Management* **31** 63–66.

Sivakumar, M.V.K., Lascano, R.J. and Upchurch, D.R. (1988) Hydraulic properties of four soils in Niger and implications for water balance studies, *Paper presented at the UNESCO/IWRA International Symposium on the State of the Art of Hydrology and Hydrogeology in the Arid and Semi-Arid Areas in Africa*, 7–12 November 1988, Ouagadougou, Burkina Faso

Smith, D.H. (1984) Early and late leaf spots, in: *Compendium of Peanut Diseases* (eds Porter, D.M., Smith, D.H. and Rodriguez-Kabana, R.), Amer. Phytopath. Soc., St. Paul, MN., USA, pp 5–7

Smith, D.H. and Littrell, R.H. (1980) Management of peanut foliar diseases with fungicides, *Plant Dis.* **64** 356–361

Soumana, I. (1982) Control of groundnut pests and diseases. *Proc. Intl. Symposium in Africa on Production, World Oilseeds Market and Intra-African Trade in Groundnuts and Products*, June 7–11, 1982, Banjul, Gambia, 383–385

Subrahmanyam, P., Hassane, H., Smith, D.H., Mounkaila, A. and Ndunguru, B.J. (1988) Diseases of groundnut in Niger, *Oléagineux* (under review)

Subrahmanyam, P., Williams, J.H., McDonald, D. and Gibbons, R.W. (1984) The influence of foliar diseases and their control by selective fungicides on a range of groundnut (*Arachis hypogaea* L.) genotypes, *Ann. Appl. Biol.* **104** 467–476