Assessment of yield losses due to early and late leaf spots of groundnut (*Arachis hypogaea* L.)

S. K. NUTSUGAH, C. OTI-BOATENG, F. K. TSIGBEY & R. L. BRANDENBURG

(S. K. N.: CSIR-Savanna Agricultural Research Institute, P. O. Box 52, Tamale, Ghana; C.O.-B.: Ministry of Food and Agriculture, P. O. Box AH 9351, Ahinsan-Kumasi, Ghana; F. K. T.: University of Florida, NFREC, Quincy FL 32351, USA; R. L. B.: North Carolina State University, Raleigh, NC 27695, USA)

ABSTRACT

Early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*) are major limiting factors to groundnut productivity in northern Ghana. Fourteen groundnut entries were evaluated for two seasons (2003 and 2004) at Nyankpala with and without tebuconazole fungicide application. The objective of this study was to determine the yield losses due to combined attack of both diseases, with and without using tebuconazole (Folicur 3.6F) at 0.22 kg a.i. ha^{-1}. The experiments were established in a split-plot design with three replications. Disease rating and pod yield were recorded at harvest maturity. Yield losses varied considerably, depending on entry and its yield potential. Pod yield losses due to both diseases ranged from 9.7 to 81.2 per cent in 2003, and from 19.5 to 65.9 per cent in 2004 when yield of protected entries was compared with yield of unprotected entries. The application of fungicide was effective in controlling leaf spots and improved pod yields across the two seasons. Some entries treated with fungicide produced pod yield of 1,860 to 2,081 kg ha^{-1}, which is more than 2 to 2½-fold increase over present average yields in Ghana. Based on the high yield losses, chemical control and host-plant resistance options for managing both diseases in the north are recommended to enhance groundnut production.

Original scientific paper. Received 26 Jul 04; revised 08 Sep 05.

RÉSUMÉ

NUTSUGAH, S. K., OTI-BOATENG, C., TSIGBEY, F. K. & BRANDENBURG, R. L.: *Evaluation des pertes de rendement dues aux taches à feuille précoces et tardives d'arachide.* La tache à feuilles précoce (*Cercospora arachidicola)* et la tache à feille tardice (*Cercosporidium personatum)* sont des facteurs contraignants majeurs à la productivité d'arachide dans le nord du Ghana. Quartorze variétés d'arachide étaient évaluées pour deux saisons (2003 et 2004) à Nyankpala avec ou sans application de fongicide. Le but de ce travail de recherche était de déterminer les pertes de rendement en raison d'attaque combinée des deux maladies en utilsant tébuconazole (Folicur 3.6F) à 0.22 kg a. i./ha. Les expériences étaient établies dans un dessin de lot-divisé avec trois répétitions. L'indice de maladie et le rendement de cosse dues aux deux maladies variant entre 9.7 et 81.2% en l'année 2003 et entre 19.5 et 65.9% en l'année 2004 lorsque le rendment des varétés protégées avec fongicide était comparé avec le rendement des variétés non protégées. Application de fongicide était efficace dans la lutte contre les taches à feuille et améliorait également les rendements de cosse au cours de deux saisons. Quelques variétés traitées de fongicide donnaient un rendement de cosse de 1,860 à 2,081 kg/ha qui est plus 2 ou 2½ fois d'augmentation par rapport aux randements moyens actuels au Ghana. Fondé sur les pertes de tendement élevées, l'enrayement chimique et les options de plante-hôte résistante sont recommandés pour la lutte contre les deux maladies dans le nord afin d'améliorer la production d'arachide.

Introduction

Early leaf spot (ELS) of groundnut (*Arachis hypogaea* L.) caused by *Cercospora arachidicola* Hori is an economically important foliar disease in most countries where groundnut is grown. This disease reduces the green leaf area available for photosynthesis and stimulates leaflet abscission, leading to extensive defoliation (McDonald *et al.*, 1985). The damage is more serious when the crop is attacked by ELS and late [*Phaeoisariopsis personata* (Berk. & Curt.) van Arx (syn. *Cercosporidium personatum*) (Berk. & Curt.) Deighton] leaf spot (LLS) pathogens. Leaf spots can cause yield losses of 50 to 70 per cent in West Africa (Waliyar, 1991; Waliyar, Adomou & Traore, 2000) and up to 50 per cent worldwide (Smith, 1984; McDonald *et al.*, 1985).

Leaf spots are the most common and serious diseases of groundnut in northern Ghana. The incidence and severity of leaf spots vary from one locality to the other, and from season to season. Each disease alone can cause substantial yield loss, but when they occur together yield losses are further increased. Pod yield of groundnut crops in Ghana averages only 840 kg ha^{-1}, which is low compared to yields of 2,500 kg ha^{-1} in developed countries (FAO, 2002). Previous research on identifying yield gaps in northern Ghana showed that ELS and LLS together cause pod yield losses in the range of 10 to 50 per cent (Nutsugah, Tsigbey & Marfo, 1998; Tsigbey, Bailey & Nutsugah, 2001 a, b). These diseases also have an adverse influence on seed quality as well as on quality of haulms (SARI, 2002).

Quantitative data on yield losses caused by leaf spot in groundnut are scarce in Ghana. The data provided by previous studies (Nutsugah *et al.*, 1998; Tsigbey *et al*., 2001 a, b) were only estimates because the relationships between ELS and LLS intensity and actual reduction in crop yield were based on limited experimentation. It is important to estimate yield losses due to leaf spots to convince farmers to adopt disease management practices, because farmers associate leaf loss caused by leaf spots as a symptom of maturity. Therefore, the need is to demonstrate the benefits of fungicide sprays to farmers.

Leaf spot can be managed by applying fungicides during the most vulnerable periods of fungal infection; that is, when excessive moisture and humidity occur (Smith & Littrell, 1980). Fungicides should be applied before infections occur. A few studies have shown that applying fungicides can reduce the severity of leaf spot and improve yields in West Africa (Kannaiyan & Haciwa, 1990; Waliyar *et al.*, 2000). In many West African countries including Ghana, the use of fungicidal sprays is not common owing to lack of credit, low yield potential under rain-fed conditions, and difficulty in obtaining fungicides (McDonald *et al.*, 1985). In recent years, fungicides have become available in certain parts of West Africa. Therefore, it is important to re-confirm the benefits of applying fungicide on groundnut yields under the rain-fed and presumed low yield potential production in Ghana.

This investigation assessed yield losses caused by ELS and LLS of groundnut by conducting a specially designed field trial in which yields of plants receiving fungicide treatment were compared with those without fungicide at Nyankpala in the Guinea Savanna zone of northern Ghana.

Materials and methods

The same field was used for the experiments during the rainy seasons (June-October) in 2003 and 2004 at the Savanna Agricultural Research Institute Farm at Nyankpala (9° 42' N latitude, 0° 92' W longitude, and 184 m altitude). During the 2-year study, only groundnut crops were grown during the season and fields remained fallow during the off-season. The sowing dates were 3rd June 2003 and 11th June 2004. Ten entries were provided by the Peanut Collaborative Research Support Program; namely N 92074 L, 6 PNC 343, GK 7, GA Green, AT-120, NC 12C, 93 B, NC 10C, ANDRU 93, and NCV 11. Four entries were provided from local germplasm source as local checks; namely ICGV-92099, F-mix × ICG 66-3-36, Chinese, and ICG 20-1-45. The experiments were laid out in a split-plot

design with fungicide sprays as main plots and entries as sub-plots, and conducted under natural infection by early and late leaf spots. The treatments were replicated three times.

Seeds were sown at a spacing of 50 cm × 10 cm with individual plots consisting of eight rows (4 m × 4 m each). Fungicide protection consisted of five applications of tebuconazole (Folicur 3.6F) at 0.22 kg a. i. ha^{-1}. Plots were sprayed at 14-day intervals starting at 30 days after sowing (DAS), using back-mounted 15 L knapsack sprayer. Spray volume used was 150 l ha^{-1}. Incidence of leaf spot was recorded from 30 DAS until harvest maturity. Severity of leaf spot was rated on a scale of 1 to 10 (Chiteka *et al.*, 1997) based on visual observation. Pod yields were also estimated at harvest. The yield determined for the protected entries was taken as a base for computing the losses. The loss in yield was calculated as:

$$\text{Percent loss in yield} = \frac{Y1\text{-}Y2}{Y1} \times 100$$

Results and discussion

The early and late leaf spots were present in each cropping season, but in different proportions. The ELS dominated the foliar disease complex over the 2 years. Tables 1 and 2 show the effects of fungicide application and entry on visual disease scores and pod yields at harvest maturity. The differences observed in the results are discussed only for treatments, which were significantly different. The results showed seasonal variation in disease severity to fungicide treatment on the entries. Applying fungicide increased pod yield and decreased disease scores across the two seasons. The mean yields of protected entries for both years were 1,339 and 1,574 kg ha^{-1}, while those of unprotected entries were 662 and 792 kg ha^{-1}. Fungicide applications significantly decreased ELS from 2.9 to 2.3 in 2003, and from 6.2 to 3.7 in 2004. The decrease was highly significant for LLS from 4.7 to 2.6 in 2004. The interaction was significant between fungicide application and entries on pod yield in 2003.

Over the 2 years, all the entries responded positively to the fungicide treatment. In 2003, AT-120, Chinese, 93 B, NC 10C and NCV 11 recorded substantial yield losses of 81.2, 73.5, 71.8, 69.3 and 58.1 per cent, respectively, in untreated plots as against fungicide-treated plots; while GA Green, ICGV-92099, ICG 20-1-45, NC 12C, N 92074 L, 6 PNC 343, and ANDRU 93 recorded moderate to high yield losses of 19.4, 22.2, 29.1, 31.1, 38.0, 39.4 and 46.4 per cent, respectively. The GK 7 and F-Mix × ICG 66-3-36 entries recorded the least yield losses of 13.7 and 9.7 per cent, respectively (Table 1). Disease score for ELS was slightly higher for untreated plots than for fungicide-treated plots (Table 1).

In 2004, NC 12C, AT-120, NC 10C, GK 7, Chinese, 93 B and ICG 20-1-45 recorded substantial yield losses of 65.9, 63.4, 63.4, 59.8, 58.0, 53.4 and 50.1 per cent, respectively, when yield of unprotected plots was compared with yield of protected plots. The N 92074 L, GA Green, ANDRU 93, 6 PNC 343, F-Mix × ICG 66-3-36 and NCV 11 entries recorded high yield losses of 49.7, 49.0, 44.9, 44.4, 40.3 and 39.7 per cent, respectively, in untreated plots as against fungicide-treated plots. The ICGV-92099 entry recorded the least yield loss of 19.5 per cent (Table 2). Disease score for ELS and LLS was higher for untreated plots compared to fungicide-treated plots. These observations confirm the earlier findings (Nutsugah *et al*., 1998; Tsigbey *et al.*, 2001 a, b) that pod yield losses due to combined attack of ELS and LLS of groundnut range between 10 and 50 per cent in northern Ghana.

The findings of this study indicate that applying fungicide can improve groundnut pod yields by 50.6 and 49.7 per cent as shown by the mean yield losses for the 2 years (Tables 1 and 2). Studies have shown that fungicide sprays could be applied to successfully control leaf spot and improve crop yields up to 80 per cent in some parts of western and southern Africa (Kannaiyan & Haciwa, 1990; ICRISAT, 1991; Waliyar *et al*., 2000; Naab *et al.*, 2005). Research in developed countries has shown that three to four applications of

TABLE 1

Fungicide Effect on Yield of Groundnut Entries Under Early and Late Leaf Spots Disease Pressure (2003 rainy season)[1]

Disease intensity[2]	*Early leaf spot*			*Late leaf spot*			*Pod yield (kg ha^{-1})*[3]			*Yield loss*
Entry	*T*	*NT*	*Mean*	*T*	*NT*	*Mean*	*T*	*NT*	*Mean*	
N 92074 L	2.3	2.9	2.6	2.3	2.2	2.3	1,123	696	910	38.0
6 PNC 343	2.1	2.9	2.5	2.1	2.4	2.3	1,148	696	922	39.4
GK 7	2.1	3.0	2.6	2.1	2.5	2.3	775	669	722	13.7
GA Green	2.3	3.3	2.8	2.0	2.3	2.2	602	485	544	19.4
AT-120	1.9	3.3	2.6	2.1	2.1	2.1	2,069	390	1230	81.2
NC 12C	2.1	3.0	2.6	2.1	2.4	2.3	1,013	698	856	31.1
ICGV-92099	2.6	3.0	2.8	2.3	2.1	2.2	913	710	812	22.2
93B	2.2	2.9	2.6	2.2	2.3	2.3	1,860	525	1193	71.8
NC 10C	2.5	2.6	2.6	2.2	2.1	2.2	1,629	500	1,065	69.3
F-Mix × ICG 66-3-36	2.1	2.9	2.5	2.1	2.2	2.2	983	888	936	9.7
ANDRU 93	2.4	2.6	2.5	2.2	2.1	2.2	1,540	825	1,183	46.4
NCV 11	2.4	2.9	2.7	2.2	2.1	2.2	1,865	781	1,323	58.1
Chinese	2.5	3.0	2.8	2.2	2.1	2.2	1,965	521	1,243	73.5
ICG 20-1-45	2.1	2.8	2.5	2.0	2.2	2.1	1,256	890	1,073	29.1
Means[4]	2.3	2.9	2.6	2.2	2.2	2.2	1,339	662	1,001	50.6
F-test[5]										
F1 (treatments)			*						*	
F2 (entries)			NS			NS			NS	
Fl × F2			NS			NS			*	

[1]Split-plot design with three replications: T = fungicide-treated; NT = untreated
[2]Leaf spot scoring system used for plant appearance score (Florida Scale) where 1 = no disease, 2 = very few lesions (none on upper canopy), 3 = few lesions (very few on upper canopy), 4 = some lesions with more on upper canopy and slight defoliation noticeable, 5 = lesions noticeable even on upper canopy with noticeable defoliation, 6 = lesions numerous and very evident on upper canopy with significant defoliation ≥ 50%), 7 = lesions numerous on upper canopy with much defoliation (≥ 75%), 8 = upper canopy covered with lesions with high defoliation (≥ 90%), 9 = very few leaves remaining and those covered with lesions (some plants completely defoliated), and 10 = dead plants
[3]Sun-dried weight of pods
[4]Mean of three replications
[5]Significance at the *F*-test*:* * = significant at the 5% level; NS = not significant at the 5% level

tebuconazole were shown to be best for controlling disease and maximizing yield (Bowen, Hagan & Weeks, 1997). Resource-poor farmers of Ghana will be unable to spray that frequently. For resource-poor farmers, applications of two sprays at 55 and 70 DAS for late-maturing varieties and at 49 and 55 DAS for early-maturing varieties were beneficial and resulted in greater yields and net profits (Waliyar *et al*., 2000).

Economic analyses of fungicide schedules showed maximum yields would be derived by applications of four sprays at 40, 55, 70 and 85 DAS in most varieties. In this study, five sprays at 30, 44, 58, 72 and 86 DAS were used to give comparable yields to those recorded in developed countries. The potential to improve groundnut yield in northern Ghana is seemingly considerable, and efforts in technology transfers to groundnut farmers is recommended, especially to control leaf spot diseases. Thus, to avoid the huge yield losses reported in this investigation, the need is felt more strongly to promote control interventions in

TABLE 2

Fungicide Effect on Yield of Groundnut Entries Under Early and Late Leaf Spots Disease Pressure (2004 rainy season)[1]

Disease intensity[2]	*Early leaf spot*			*Late leaf spot*			*Pod yield (kg ha^{-1})*[3]			*Yield loss*
Entry	*T*	*NT*	*Mean*	*T*	*NT*	*Mean*	*T*	*NT*	*Mean*	
N 92074 L	3.3	6.3	4.8	2.0	4.0	3.0	1,453	731	1,092	49.7
6 PNC 343	3.6	6.0	4.8	3.0	4.6	3.8	1,244	692	968	44.4
GK 7	4.0	6.0	5.0	3.0	5.0	4.0	1,431	575	1,003	59.8
GA Green	4.0	7.0	5.5	3.0	5.0	4.0	1,450	739	1,094	49.0
AT-120	4.0	6.3	5.1	2.3	5.0	3.6	1,569	575	1,072	63.4
NC 12C	4.0	6.3	5.1	3.0	5.0	4.0	1,417	483	950	65.9
ICGV-92099	4.0	5.6	4.8	3.0	4.3	3.6	2,000	1,611	1,806	19.5
93 B	4.0	6.3	5.1	3.0	5.0	4.0	1,392	649	1,020	53.4
NC 10C	4.0	6.3	5.1	2.3	5.0	3.6	1,928	706	1,317	63.4
F-Mix × ICG 66-3-36	4.0	6.0	5.0	2.3	4.6	3.5	2,081	1,242	1,661	40.3
ANDRU 93	3.3	6.6	5.0	3.0	5.0	4.0	1,256	692	974	44.9
NCV 11	3.3	6.6	5.0	2.6	5.0	3.8	1,175	708	942	39.7
Chinese	4.0	7.0	5.5	2.6	6.0	4.3	1,581	664	1,122	58.0
ICG 20-1-45	3.0	5.0	4.0	2.0	2.6	2.3	2,061	1,028	1,544	50.1
Mean[4]	3.7	6.2	4.9	2.6	4.7	3.6	1,574	792	1,183	49.7
F-test[5]										
F1 (treatment)			**			**			*	
F2 (entry)			**			**			**	
FI × F2			*			**			NS	

[1]Split-plot design with three replications: T = fungicide-treated; NT = untreated
[2]Leaf spot scoring system used for plant appearance score (Florida Scale) where 1 = no disease, 2 = very few lesions (none on upper canopy), 3 = few lesions (very few on upper canopy), 4 = some lesions with more on upper canopy and slight defoliation noticeable, 5 = lesions noticeable even on upper canopy with noticeab1e defoliation, 6 = lesions numerous and very evident on upper canopy with significant defoliation (≥ 50%), 7 = lesions numerous on upper canopy with much defoliation (≥ 75%), 8 = upper canopy covered with lesions with high defoliation (≥ 90%), 9 = very few leaves remaining and those covered with lesions (some plants completely defoliated), and 10 = dead plants
[3]Sun-dried weight of pods
[4]Mean of three replications
[5]Significance at the *F*-test: *, ** = significant at the 5 and 1% levels, respectively; NS = not significant at the 5% level

groundnut production in northern Ghana.

Acknowledgement

The authors are grateful to the Food Crops Development Project (financed by the African Development Bank) for partly supporting this work. They are also thankful to the Peanut Collaborative Research Support Program for providing 10 peanut entries for the resistance screening, and to the field technical staff for their assistance.

REFERENCES

Bowen, K. L., Hagan, A. K. & **Weeks, J. R.** (1997) Number of tebuconazole applications for maximizing disease control and yield of peanut in growers' fields in Albama. *Plant Dis.* **81**, 927-931.

Chiteka, Z. A., Gorbet, D. W., Shokes, F. M. & **Kucherek, T. A.** (1997) Components of resistance to early leaf spot in peanut–genetic variability and heritability. *Soil Crop Sci. Soc. Fl. Proc.* **56**, 63-68.

FAO (2002) *Food and Agricultural Organization Crop Production Statistics*. Rome, Italy.

Ghuge, S. S., Mayee, C. D. & **Godbole, G. M.** (1981) Assessment of losses in peanut due to rust and tikka leaf spots. *Indian Phytopath*. **34,** 179-182.

ICRISAT (1991) *ICRISAT West Africa Programme Annual Report 1991*. International Crops Research Institute for the Semi-Arid Tropics, Sahelian Center, Niamey, Niger.

Kannaiyan, J. & **Haciwa, H. C.** (1990) Economic benefits of spraying fungicides to control groundnut foliar disease in Zambia. *Trop. Pest Mgmt* **36**, 21-22.

McDonald, D., Subrahmanyam, P., Gibbons, R. W. & Smith, D. H. (1985) Early and late leaf spots of groundnut. *Information Bulletin* **21**, ICRISAT, Patancheru, AP 502324, India. 24 pp.

Naab, J. B., Tsigbey, F. K., Prasad, P. V. V., Boote, K. J., Bailey, J. E. & **Brandenburg, R. L**. (2005) Effects of sowing date and fungicide application on yield of early and late maturing peanut cultivars grown under rainfed conditions in Ghana. *Crop Prot.* **24**, 325-332.

Nutsugah, S. K., Tsigbey, F. K. & **Marfo, K. O.** (1998) Effect of neem extract and two systemic fungicides on foliar diseases of groundnut in a savannah zone of Ghana (Abstract). *Int. Arachis Newsl.* **18**, 44-45.

SARI (2002) *Annual -In-House Review Meeting,* March 25-27, 2002. Savanna Agricultural Research Institute.

Smith, D. H. (1984) Early and late leaf spots. In *Compendium of peanut diseases* (ed. D. M. Porter, D. H. Smith and R. Rodriguez-Kabana). American Phytopath. Soc., St. Paul, Minnesota, USA.

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

Tsigbey, F. K., Bailey, J. E. & **Nutsugah, S. K.** (2001 a) The lost harvests: Impact of groundnut diseases in northern Ghana and their management (abstr.). *Proceedings of the 39th Congress of the Southern African Society for Plant Pathology Disease Control*, pp. 10-11.

Tsigbey, F. K., Bailey, J. E. & **Nutsugah, S. K.** (2001 b) Managing groundnut leaf diseases in northern Ghana with fungicides, neem seed extract and local soap (abstr.). *Proc. Am. Peanut Res. Educ. Soc*. **33**, 38.

Waliyar, F. (1991) Evaluation of yield losses due to groundnut leaf diseases in West Africa. In *Summary Proceedings of the 2nd ICRISAT Regional Groundnut Meeting for West Africa*, pp. 32-33. September 11-14, 1990, Niamey, Niger. ICRISAT, Patancheru, India.

Waliyar, F., Adomou, M. & **Traore, A.** (2000) Rational use of fungicide applications to maximize peanut yield under foliar disease pressure in West Africa. *Plant Dis*. **84**, 1203-1211.