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Management of Leaf Spot Diseases of Peanut with Fungicides and Local Detergents in Ghana

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Abstract: Early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*) of peanut (*Arachis hypogaea*) are a major constraint to peanut production in northern Ghana. To develop suitable disease management options, field trials were conducted from 2003 to 2005 at Nyankpala, Yendi and Damongo to compare the efficacy of the fungicides thiophanate methyl, benomyl and tebuconazole and the local detergents black soap and alata samina either alone or as a mixture. Final leaf spot ratings were recorded 72 days after sowing while biomass and pod yields were recorded at harvest. Leaf spot ratings, biomass and pod yields in local detergents and untreated control treatments did not differ across the three locations in 2003. However, fungicides suppressed disease and increased biomass and pod yields. In 2004 and 2005, leaf spot severity was reduced and biomass and pod yields increased compared to untreated control when local detergents were applied in combination or alternation with fungicides. Tebuconazole applied alone was the most effective fungicide in reducing leaf spot severity, resulting in significantly higher biomass and pod yields compared to most of the treatments.

Key words: *Arachis hypogaea*, *Cercospora arachidicola*, *Cercosporidium personatum*, disease management, Alata Samina, Ghana

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important legume that increases the diversity of the cereal-based cropping systems of the savanna zone of Ghana. It is used extensively as a source of cooking oil and in confectionery products for human consumption. Peanut hay (vine) constitutes important fodder resources for livestock production and fodder trading in northern Ghana, particularly in the dry season when green forage is not available (Tsigbey *et al*., 2004; Naab *et al*., 2005).

During the 2003 cropping season, 439030 metric tons of peanut was produced in Ghana from a land area of 464710 ha (Statistics, Research and Information Directorate (SRID), 2004). The northern sector (Northern, Upper West and Upper East Regions) produced 91.4% of the national production (SRID, 2004). Pod yield of peanut crops in Ghana averages only 840 kg ha^{-1}, which is low compared to yields of 2500 kg ha^{-1} in developed countries (FAO, 2002). The low yields in Ghana and other parts of West Africa are particularly attributed to foliar diseases. Early leaf spot caused by *Cercospora arachidicola* Hori and late leaf spot caused by *Cercosporidium personatum* (Berk. and Curt) Deighton, are among the major diseases of peanut worldwide, including West Africa (Subramanyam *et al*., 1991; Waliyar *et al*., 2000). Leaf spot can cause yield losses of 50-70% in West Africa (Waliyar, 1991; Waliyar *et al*., 2000; Naab *et al*., 2004) and up to 50% worldwide (McDonald *et al*., 1985). The yield losses caused by leaf spot are mainly because of decrease in photosynthetic leaf area caused by necrotic spots and defoliation (Boote *et al*., 1980; Bourgeois and Boote, 1992; Naab *et al*., 2005). Loss of mature pods due to leaf spot damage to pegs can also lead to yield losses during harvest. Both early and late leaf spot diseases are widely distributed and occur in epidemic proportions in northern Ghana. Annual yield losses of up to 50% are common over wide areas of the region (Nutsugah *et al*., 1998, 2006; Tsigbey *et al*., 2001).

Farmers in northern Ghana are not aware that leaf spot cause defoliation and perceive leaf loss as a symptom of maturity. Further, they do not use disease control measures in peanut cultivation. Therefore, it is necessary to develop suitable crop management practices

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for peanut crops in Ghana. A few studies in West Africa have shown that application of fungicide can reduce the severity of leaf spot and improve peanut yields (Kannaiyan and Haciwa, 1990; Waliyar *et al*., 2000). In many West African countries including Ghana, use of fungicidal sprays is not common due to lack of credit, low yield potential under rainfed conditions and difficulty in obtaining fungicides (McDonald *et al*., 1985). Our earlier studies showed the benefits of fungicide application on peanut yields under the rainfed and presumed low yield potential production in Ghana (Nutsugah *et al*., 1998, 2006; Tsigbey *et al*., 2000, 2001). Previous attempts for the management of peanut leaf spot diseases in northern Ghana from 1997 to 2002 indicated that neem seed extract (20%, w/v), alata samina (2.5%, w/v), thiophanate-methyl (0.35 kg a.i. ha^{-1}), carbendazim (Bavistin, 0.3 kg a.i. ha^{-1}), tebuconazole (Folicur 3.6F, 0.22 kg a.i. ha^{-1}) mixed with azoxystrobin (Abound 2.08F, 0.45 kg a.i. ha^{-1}) effectively reduced leaf spots severity and maximized peanut yield (Nutsugah *et al*., 1998; Tsigbey *et al*., 2000, 2001). In the southeastern United States, leaf spot diseases have been managed with multiple applications of fungicides (Culbreath *et al*., 2002).

In the search for effective and safe fungicides, benomyl was tested for the first time with the already known fungicides in combination with local detergent in the hope of improving the efficiency of leaf spots control in peanut in northern Ghana.

MATERIALS AND METHODS

Experimental details: Research was conducted from 2003 to 2005 at the Savanna Agricultural Research Institute experimental sites at Nyankpala, Yendi and Damongo, which are representative peanut production sites in the Guinea Savanna zone. During the experimental period of three years, only peanut crop was grown during the season and fields remained fallow during the off-season. The cultivar Chinese (90 days duration) was grown for the three seasons. In 2003, the experiment was designed to evaluate efficacy of local detergents, black soap and alata samina at 2.5% w/v (0.375 kg 15 L^{-1}) for the control of leaf spot diseases. The detergents are traditionally manufactured in Ghana from a blend of plantain peels, palm kernels and coconut oil. Both detergents have been analysed and found to possess antifungal activity against *Candida albicans* (Nutsugah and Gadzekpo, unpublished). The fungicides thiophanate methyl (Topsin-M 70% WP, Cerexagri, Inc., USA at 0.35 kg a.i. ha^{-1}) and tebuconazole (Folicur 3.6F, Bayer CropScience, USA at 0.22 kg a.i. ha^{-1}) were also used. Sowing dates in 2003 were 4 June, 8 July and 18 July at Nyankpala, Yendi and Damongo, respectively. During 2004 and 2005, the treatments were modified to include thiophanate methyl in combination with alata samina at 1.0% w/v (0.15 kg 15 L^{-1}) and in alternation with alata samina at 2.5% w/v (0.375 kg 15 L^{-1}). Thiophanate methyl was applied first and alternated with alata samina during the second round of application. Other treatments were benomyl (Benlate 350 WP, Du Pont, Wilmington, Delaware, USA at 0.2 kg ha^{-1}) in combination with alata samina at 1.0% w/v (0.15 kg 15 L^{-1}), tebuconazole and untreated control. Sowing dates were 7 June, 16 June and 24 June 2004 at Nyankpala, Yendi and Damongo, respectively. In 2005, the trial was conducted only at Nyankpala and the sowing date was 29 June. Fungicides and local detergents were applied at 14 day intervals starting at 30 days after sowing (DAS) using 15 L knapsack sprayer. Spray volume used was 150 L ha^{-1}. A total of four sprays were made during each year. The experimental design was a randomized complete block with four replications. In each treatment, eight rows each of 4 m length were considered as a single replication with spacing of 10 cm between plants and 50 cm between the rows.

Data collection and analysis: Incidence of leaf spot was recorded starting from 30 DAS until harvest maturity and severity of leaf spot was rated on the Florida scale of 1-10 (Chiteka *et al*., 1997) based on visual observation. At optimum pod maturity, plants from the middle six 4 m long rows of each plot were hand-harvested and weight of the above-ground foliage and underground pods were determined. All the biomass and pod yields data are expressed in kilograms per hectare. Data were subjected to analysis of variance (Anonymous, 1998). Means were separated using Fisher's Protected LSD at $p \le 0.05$. Correlations were used to identify relations between disease scores, biomass and pod yields.

RESULTS

In 2003, leaf spot ratings varied with treatments and locations. Early leaf spot ratings were more severe at Yendi than Damongo and Nyankpala while late leaf spot ratings were lowest at Yendi (Table 1). Across locations, leaf spot ratings in local detergents black soap and alata samina were similar ($p = 0.05$) to or lower than the untreated control (Table 1). Thiophanate methyl and tebuconazole significantly ($p = 0.05$) lowered leaf spot ratings at all locations compared to other treatments. Application of fungicides consistently resulted in greater biomass and pod yields compared to detergents and untreated control (Table 1). Across locations, thiophanate

Table 1: Effect of local detergents and fungicides on disease score, biomass and pod yield at harvest of peanut cultivar Chinese at Nyankpala, Yendi and Damongo during 2003 rainy season

	Disease score[1]			
Location/Treatment[4]	Early leaf spot	Late leaf spot	Biomass yield (kg ha^{-1})[2]	Pod yield (kg ha^{-1})[3]
Nyankpala				
Control	6.8	5.3	7,590	1,030
Black soap	6.0	4.5	10,260	1,440
Alata samina	6.0	4.5	9,070	1,420
Thiophanate methyl	4.0	3.8	16,000	3,100
Tebuconazole	4.3	4.0	16,750	3,180
Mean[5] (5 treatments)	5.5	4.5	11,934	2,034
LSD (p = 0.05)	0.5	0.8	2,845	523
Yendi				
Control	7.0	5.0	7,360	1,130
Black soap	7.0	4.5	10,320	1,300
Alata samina	7.0	4.5	12,000	1,370
Thiophanate methyl	4.8	4.0	16,980	2,150
Tebuconazole	4.8	3.3	16,530	2,640
Mean[5] (5 treatments)	6.2	4.3	12,638	1,718
LSD (p = 0.05)	0.5	0.5	4,779	326
Damongo				
Control	7.0	5.3	3,070	1,130
Black soap	6.3	5.3	5,110	1,500
Alata samina	6.8	5.0	6,550	1,600
Thiophanate methyl	4.5	4.0	16,160	2,880
Tebuconazole	4.3	3.8	20,300	3,590
Mean[5] (5 treatments)	5.8	4.7	10,238	2,140
LSD (p = 0.05)	0.7	0.6	3,508	398

[1]:On the Florida scale of 1-10, where 1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spot, [2]: Fresh weight, [3]: Sun-dried weight, [4]:Local detergents rate was 2.5% w/v (0.375 kg 15 L^{-1}) while fungicides rates were 0.35 kg a.i. ha^{-1} (thiophanate methyl) and 0.22 kg a.i. ha^{-1} (tebuconazole), [5]:Mean of four replicates

Table 2: Effect of fungicides combinations with local detergent on disease score, biomass and pod yield at harvest of peanut cultivar Chinese at Nyankpala, Yendi and Damongo during 2004 rainy season

	Disease score[1]			
Location/Treatment[4]	Early leaf spot	Late leaf spot	Biomass yield (kg ha^{-1})[2]	Pod yield (kg ha^{-1})[3]
Nyankpala				
Control	7.5	6.5	9,380	720
Thiophanate methyl +Alata samina	5.0	4.0	16,750	1,310
Thiophanate methyl/Alata samina alternate	6.5	5.0	14,470	1,090
Benomyl+Alata samina	5.0	4.8	15,910	1,410
Tebuconazole	4.0	3.0	16,500	1,840
Mean[5] (5 treatments)	5.6	4.7	14,602	1,274
LSD (p = 0.05)	0.6	0.6	4,346	277
Yendi				
Control	6.5	4.5	11,970	1,380
Thiophanate methyl +Alata samina	3.8	3.0	17,530	1,770
Thiophanate methyl/Alata samina alternate	5.5	3.8	14,750	1,760
Benomyl+ Alata samina	5.0	4.0	16,810	1,780
Tebuconazole	4.0	2.5	17,310	1,790
Mean[5] (5 treatments)	5.0	3.6	15,674	1,696
LSD (p = 0.05)	0.7	0.7	1,734	326
Damongo				
Control	4.5	7.0	9,160	950
Thiophanate methyl + Alata samina	2.8	3.5	14,880	1,750
Thiophanate methyl/Alata samina alternate	3.3	5.0	12,220	1,730
Benomyl+Alata samina	2.0	4.8	13,340	1,790
Tebuconazole	2.5	4.3	22,500	2,470
Mean[5] (5 treatments)	3.1	5.0	14,420	1,738
LSD (p = 0.05)	0.9	0.9	2,777	634

[1]: On the Florida scale of 1-10, where 1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spot, [2]: Fresh weight, [3]: Sun-dried weight, [4]:Local detergents rates were 1.0% w/v (0.15 kg 15 L^{-1}) in combination and 2.5% w/v (0.375 kg 15 L^{-1}) in alternation while fungicides rates were 0.35 kg a.i. ha^{-1} (thiophanate methyl), 0.2 kg ha^{-1} (benomyl) and 0.22 kg a.i. ha^{-1} (tebuconazole), [5]: Mean of four replicates

methyl and tebuconazole increased both biomass and pod yields significantly (p = 0.05) compared to other treatments.

In 2004, early leaf spot ratings were more severe at Nyankpala than Damongo and Yendi while late leaf spot ratings were lowest at Yendi (Table 2). Leaf spot ratings

Table 3: Effect of fungicides combinations with local detergent on disease score, biomass and pod yield at harvest of peanut cultivar Chinese at Nyankpala during 2005 rainy season

	Disease score[1]			
Location/Treatment[4]	Early leaf spot	Late leaf spot	Biomass yield (kg ha^{-1})[2]	Pod yield (kg ha^{-1})[3]
Control	7.3	6.0	5,660	1,090
Thiophanate methyl +Alata samina	4.3	3.3	9,590	1,780
Thiophanate methyl/Alata samina alternate	5.3	4.5	8,840	1,790
Benomyl+Alata samina	4.8	4.3	10,160	2,590
Tebuconazole	3.8	3.3	13,780	2,310
Mean[5] (5 treatments)	5.1	4.3	9,606	1,912
LSD (p = 0.05)	0.8	0.6	2,477	670

[1]: On the Florida scale of 1-10, where 1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spot, [2]: Fresh weight, [3]Sun-dried weight, [4]: Local detergents rates were 1.0% w/v (0.15 kg 15 L^{-1}) in combination and 2.5% w/v (0.375 kg 15 L^{-1}) in alternation while fungicides rates were 0.35 kg a.i. ha^{-1} (thiophanate methyl), 0.2 kg ha^{-1} (benomyl) and 0.22 kg a.i. ha^{-1} (tebuconazole), [5]Mean of four replicates

were significantly (p = 0.05) lower in fungicide combinations treatments than in the untreated control at all locations. Similarly, tebuconazole alone lowered leaf spot ratings (p = 0.05) at all locations. Biomass and pod yields were greater among the fungicides combinations treatments than the untreated control across all locations (Table 2). Biomass and pod yields were significantly (p = 0.05) higher in the tebuconazole alone treatment than other treatments in Damongo and for pod yield at Nyankpala (Table 2). There were slight differences in biomass and pod yields among the three fungicides combinations treatments.

In 2005, the results for leaf spot ratings, biomass and pod yields followed the same trend as reported in 2004. Leaf spot ratings of 7.3 and 6.0 recorded for early and late leaf spot in untreated control at Nyankpala, respectively, were significantly (p = 0.05) higher than the other treatments (Table 3). Combinations of fungicides and alata samina or tebuconazole alone lowered leaf spot ratings. Biomass and pod yields were significantly (p = 0.05) higher in treatments that included fungicides compared to untreated control (Table 3). Among treated plots, tebuconazole alone and benomyl plus alata samina treatments produced significantly (p = 0.05) higher pod yields than the other treatments (Table 3).

Biomass yield was negatively correlated with early (R^2 = 0.578, p<0.0001) and late (R^2 = 0.563, p<0.0001) leaf spot ratings across locations. Similarly, pod yield was negatively correlated with early (R^2 = 0.706, p<0.0001) and late (R^2 = 0.423, p<0.0001) leaf spot ratings across locations. The results followed the same trend in 2004 and 2005.

DISCUSSION

Traditionally, farmers in northern Ghana do not use any management practices to control leaf spot and farmers generally associate canopy defoliation caused by leaf spot with optimum pod maturity (Naab *et al*., 2005). The CROPGRO-peanut model analysis (Naab *et al*., 2004) recommended fungicide trials in Ghana to document yield increases when fungicides are applied to peanut. The standard fungicide program for peanut growers in Georgia, US includes an initial application 30 days after sowing (DAS), followed by additional sprays at 14 day intervals, resulting in seven or more applications per season (Culbreath *et al*., 2002; Kemerait *et al*., 2005). Four applications of tebuconazole, the most effective fungicide in the present study, are known to reduce leaf spots severity and maximize peanut yield (Bowen *et al*., 1997). In our study, four sprays at 30, 44, 58 and 72 DAS were used to give comparable yields to those obtained in developed countries. Considerable efforts have been directed at fungicidal control of leaf spot diseases of peanut in northern Ghana. Tebuconazole mixed with azoxystrobin sprays resulted in decreased leaf spot rating and increased biomass and pod yields 2 to 3-fold each over untreated control (Tsigbey *et al*., 2001). Also, thiophanate methyl lowered leaf spot rating compared to alata samina, neem (*Azadiractin indica*) and untreated control (Tsigbey *et al*., 2001). Results from the present study corroborate previous reports that tebuconazole and thiophanate methyl are effective for leaf spot control in peanut. However, from our field tests that included a range of leaf spot ratings, mixtures of benomyl and alata samina have the potential to provide control of leaf spot diseases of peanut comparable to that achieved with tebuconazole. Combination of benomyl plus alata samina effects on leaf spot ratings and biomass and pod yields were consistent across the three locations and had the advantage among the three fungicides combinations treatments. The reason for mixing fungicides and local detergents in the field trials during 2004 and 2005 was to use it as spray adjuvant to improve the efficiency of leaf spot control in peanut. Results from our trials document the potential impact of utilizing fungicides to effectively manage foliar diseases in Ghana.

The variation in pod yields obtained in the different fungicide treatments compared to control seems to be not just because of reduced leaf spots severity. In 2003, the severity of late leaf spot in control and tebuconazole treatments at Nyankpala was 5.3 and 4.0, but the pod yield in these two treatments differed by 300%. The 3-fold increase in pod yield in the fungicide treatment was unlikely to be due solely to the slight decrease in disease, some other factors might have contributed. Leaf spot severity in the experimental fields varied over the three years. The variation can be explained by differences in the amount of rainfall during these years with mean rainfall of 968, 1429 and 1066 mm recorded at Nyankpala, Yendi and Damongo, respectively when averaged across years. Leaf spot severity is highly dependent upon weather, especially rainfall and associated canopy humidity (Shokes and Culbreath, 1997).

The negative relationships between early and late leaf spot ratings and biomass and pod yields observed across locations and years, suggest that both diseases are limiting factors in peanut productivity in northern Ghana. Yield advantages of the fungicide treatment intervention may be due to reduced biomass damage.

In conclusion, thiophanate methyl significantly increased pod yield over untreated control by 58% across locations in 2003 and tebuconazole by 56% over three years. The corresponding biomass increase was 63 and 55%, respectively for thiophanate methyl and tebuconazole. These data suggest that fungicides should be included in integrated management strategies for peanut to control early and late leaf spot. Additional research is needed to compare thiophanate methyl and benomyl plus detergent treatments and fungicide treatments to evaluate advantage of the detergent presence and also determine interactions of fungicide and detergent spray program and host-plant resistance in peanut production systems in northern Ghana.

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