CONTROL OF SESAME *Cercospora sp* INFECTION BY USE OF VARIETIES AND PLANT EXTRACTS IN ARDO-KOLA AND GASSOL, TARABA, NIGERIA

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Abstract: Field trial was conducted at Ardokola and Gassol in 2012 to investigate the influence of four cultivars (Yandev 55, NCRIBEN 01M, E8 and NCRIBEN-03L) and five plants extracts (*Azadirachtaindica*, *Jatrophacurcas* Linn., *Aliumsativum*, *Ocimumgratissimum* L., *Chromolaenaodorata*) and Benomyl including unsprayed control on *Cercosporasesami* on sesame growth parameters. The trial was designed using randomized complete block design (RCRD) in a split plot arrangement in allocating treatments to plots which was replicated four times. In both locations sesame plants were sprayed with 10% extracts once in every two weeks using hand sprayer from 4 to 10 weeks after sowing. Results obtained showed that Sesame variety E8, which was statistically the same with NCRIBEN-01M, gave the lowest combined analysis incidence of 60.39 %, than Yandev 55 (71.63 %) and NCRIBEN-03L (71.50 %). Furthermore, the synthetic fungicide Benomyl, which was statistically similar to the plant extracts (*Ocimumgratissimum*, *Chromolaenaodorata*), produced the lowest combined analysis incidence (61.99%) than unsprayed control (78.90 %). Similarly, interaction effect indicated that E8 seedlings sprayed with plant extract from *Ocimumgratissimum* and *Chromolaenaodorata* gave the lowest incidence (56.94%) and infection rate (0.026 units per day), compared with the highest incidence (87.43 %) and infection rate (0.0028 units per day) obtained from unsprayed plants of Yandev 55 variety. This had resulted in highest increase of plant height from 108.88 to 160.33 cm and branches per plant from 1.96 to 4.04. In this study it could be seen that the performance of the plant extracts is comparable to the synthetic fungicide Benomyl, and therefore this has given the farmers ample opportunities to try many alternatives that are user friendly.

Keywords: *Cercospora* sp., growth, incidence, plant extracts, sesame, varieties.

Introduction

Sesame (*Sesamumindicum* L.) is considered to be the oldest of the oilseed plants and has been under cultivation in Asia for over 5000 years (Bisht, 1998). Among oil crops, sesame is one of the highest in oil content (50 to 52 %), protein (17 – 19 %) and 16 – 18 % carbohydrates (Uzoh, 1998, Baydar*et al*., 1999; Uzun *et al*., 2002; Were *et al*., 2006). Sesame is suitable for use in resin production because of its low cholesterol level and presence of unsaturated fatty acids (43 % each of oleic and linoleic). Therefore, because of the high unsaturated fat and methionine contents, sesame seed and oil are in high demand in Nigeria as export materials (Schilling and Catan, 1991; Enikuomehin, 2005). Despite its great export potential, the yields of sesame in Nigeria and elsewhere is still dismally low, averaging 300 - 430 kg ha^{-1} as opposed to research seed yield as high as 2000 kg ha^{-1} (Mkamilo and Bedigian, 2007). The low seed yield could be due to damage by insect pests and diseases, insufficient weed control, and poor management practices. Fungal diseases are major constraints militating against optimal growth and development (Kolte, 1985). Amongst these, Cercospora leaf spot (*Cercosporasesami* Zimm) has been identified as the most prevalent in Nigeria and other parts of Africa, of which there are no satisfactory control methods being, evolved yet (Kolte, 1985; Poswal and Misari, 1994; Nyanapah *et al*., 1995). Over the years, synthetic fungicides like Benomyl and Mancozeb had been effectively used to control the disease.

However, pesticides have been found to create a myriad of problems which include pest resistance, resurgence of pests, pesticide residues, secondary pest development, destruction of beneficial fauna, environmental pollution, toxicity posed to man and high costs that forbid their use by ordinary farmers (Gerken *et al*., 2001; Obeng – Ofori *et al*., 2002; AVRDC, 2003). Under such debilitating circumstances, interest in organic farming has been growing and, therefore, exploring alternatives to control Cercospora Leaf Spot (CLS) of sesame is a fundamental means of supporting the smallholder farmer to diversify into organic production and be able to tap into the high profits associated with organic products. This, in turn, necessitates the search for alternatives in plant products, many of which have been reported to be effective in the control of several plant diseases (Okigbo and Emoghene, 2003). This study was, therefore, aimed at determining the influence of varieties and plant extracts on *Cercospora* sp. and subsequent growth of sesame in Northern (Ardo-kola) and Southern (Gassol) Guinea Ecological areas of Taraba State, Nigeria.

Materials and Methods

Field layout and experimental design

The field experiment in Ardo-Kola (Latitude 08^{o}51′N - 08^{o} 53′N and Longitude 011^{o}17′E - 11^{o} 19′E) and Gassol (Latitude 08^{o} 31′N and Longitude 10^{o} 33′E) were laid out using Randomized Complete Block Design (RCBD) in a split plot arrangement. Four sesame varieties (Yandev 55, NCRIBEN-01M, E8 and NCRIBEN-03L) recommended for Northern Guinea and Southern Guinea Savanna (Table 1), obtained from National Cereals Research Institute Badegi, were assigned to the main-plots; while water extracts from Neem leaf (*Azadirachtaindica*Juss), Jatropha leaf (*Jatrophacurcas* Linn.), Garlic bulb (*Aliumsativum* L.), African Basil leaf (*Ocimumgratissimum* L.) and Siam weed leaf (*Chromolaenaodorata* (Linn.) King and Robinson), a synthetic fungicide, Benomyl 50 WP (500 g a.i kg^{-1}) and an unsprayed control (7 treatments) were assigned to subplots. Both main and subplots were replicated four (4) times. Subplot size was 5 m x 4 m with inter-and intra-row spacings of 50 cm and 10 cm respectively. A total of 112 subplots were laid out on the field. About six seeds were sown in each planting hole and at two weeks after sowing, the emerging seedlings were thinned to two plants per stand. Hoe weeding was carried out at 3 and 7 weeks after sowing. Field insects were controlled by applying Super plus (Cypermethrin 100 EC) at the rate of 30 ml l^{-1} of water at 3 and 5 WAS. Compound fertilizer (15:15:15 NPK) was broadcasted over the areas at the rate of 200 kg ha^{-1} before the land was marked out (Uwala, 1998).

Table 1: Origin and description of sesame varieties used for the experiments

Variety	Source/ Developing Institute	Description
Yandev 55	IAR, Samaru, Zaria	A local variety improved through selection, grown in derived, southern and northern ecological zones of Nigeria. Tall (about 125 cm), 2-3 branches and late maturing (125 days). Moderately resistant to leaf spot disease and potential seed yield of 600 kg ha^{-1}.
NCRIBEN-01M	India/ IAR, Samaru, Zaria; NCRI, Badeggi	Originally named 530-6-1, recommended for all ecological zones. Medium height (111.5 cm), about 3.0 branches and with medium maturity (102-115 days). Resistant to leaf spot, attractive seed colour and potential seed yield of 1000 kg ha^{-1}.
E8	Sudan/ IAR, Samaru, Zaria	Early maturing (90 days), about 116 cm tall, profuse branching (4.0). Resistant to leaf spot and potential seed yield of about 1000 kg ha^{-1}.
NCRIBEN-03L	Sudan/ NCRI, Badeggi	Original name was GOZA-25. Late maturing (125-140 days), moderately resistant to leaf spot, about 125 cm tall and branching of about 3.0. Drought tolerant, good seed quality and potential yield of about 600 kg ha^{-1}.

Source: National Centre for Genetic Research and Biotechnology (14, 15, 8).

Pathogen isolation

The causal organism *Cercospora* sp. was isolated from leaves showing typical leaf spot symptoms of *Cercospora* leaf spot (CLS). With the aid of forceps flamed and cooled in methylated spirit, the leaves were carefully transferred unto humid chambers made up of petri dishes that were under laid with filter papers at both covers and wetted thoroughly. The whole process was carried out under sterile conditions in a laminar flow chamber. The plates were then kept on the bench in a previously fumigated clean room where they could access sunlight at room temperature for 72 h, and examined for sporulation under trinocular microscope.

Purification and examination

After 72 h of incubation pieces of leaves around the spot areas were cut using sterile needles and transferred unto glass slides containing cotton blue stain. The slides were then covered with lids, pressed tightly with fingers to eliminate air bubbles and mounted on a trinocular microscope. Observed conidia from separate conidiophores were picked using glass needle (that was previously flamed and cooled in methylated spirit) and transferred aseptically in to six different plates containing V8 agar using single spore technique as part of the culture purification process. The process was carried out under sterile condition. The plates were placed in an incubator for 7 days. After that the plates were removed and kept on the bench in a previously fumigated clean room where they could access sunlight at room temperature for 3 weeks where morphological characteristics of the fungus were observed daily during the growth period until the cultures had fully sporulated. Detailed microscopic examinations were carried out during the growing stages to reveal the organism.

Pathogenicity test

Pathogenicity study was conducted on sesame plants using cv. Yandev 55 variety (Dunkle and Levy, 2000; Eman, 2011). Seedlings were raised by sowing seeds in 25 cm diameter plastic buckets (10 seedlings /bucket) and later thinned to 5 seedlings/bucket. At 3 weeks after sowing, the seedlings were sprayed with spore suspension of 1 x 10^4 spores/ml in distilled water of the pathogen. Such inoculated plants were then covered with perforated transparent polythene sheets to build relative humidity and maintained for 24 h. At the end of 24 h, the pots were kept in screenhouse under natural humidity. The plants were watered regularly and observations were made for the appearance and development of symptoms. Symptoms of cercospora leaf spot were observed as from 4 to 12 weeks after sowing. Symptoms started 1 week after inoculation as small brown spots, which later turned to dark brown colour. Advanced leaf lesion characterized by a dark to dark-brown spots with a whitish to straw-coloured or perforated centre was observed 7 weeks after inoculation. The fungus was re-isolated from the leaves that exhibited symptoms and the cultures obtained were compared with the original to confirm the identity according to Kock's postulates. This confirmation was done before inoculation of the isolated pathogen for the field experiments.

Source and preparation of extracts

Plant extracts from leaves of *Azadirachtaindica, Jatrophacurcas* Linn., *Aliumsativum* (bulbs), *Ocimumgratissimum* (L.), and *Chromolaenaodorata* that were obtained from within and around ModibboAdama University of Technology, Yola were used for the screenhouse trials. The crude extracts were obtained by first of all sterilizing plant parts in 10% Sodium hypochlorite (NaOCl) for 1 min, washed 5 times in distilled water and air dried for 3 weeks. Thereafter, the plant materials were ground using mortar and pestle and sieved in a 40 mm sieve into a fine powder. To obtain extracts 100 g of the grounded powder (packaged according to plant species) were weighed in to conical flasks. After, 100 mls distilled water was added to form a ratio of 1:1 weight over volume basis. This was then corkedand shaken well for 20 min to mix and allow to stand overnight (24 hours) at room temperature and the content filtered using a muslin cloth. To obtain 10% concentration for spray, 100 mls of the filtered extract suspension was added to 900 mls distilled water to make up to 1 litre. This was then kept in glass bottles until needed.

Inoculation and application of plant extracts

The seedlings in the field were inoculated with spore suspension of 1 x 10^4 conidial/ml for even distribution of the pathogen at 3 weeks after sowing (WAS). This is to ensure adequate contact between the pathogen and the sesame plants. Thereafter, plant extracts (10%) were sprayed as from 4 WAS using hand sprayer and repeated at two weeks intervals until 10 WAS. The synthetic fungicide, Benomyl 50 WP (500 g a.i./kg) was sprayed at the recommended rate of 2 kg ha^{-1} at 4 WAS and 8 WAS, while the control was left unsprayed.

Disease assessment

The incidence of CLS infection (percentage calculated on the basis of diseased plants over the total plants) was obtained at fortnight intervals from 4 to 12 WAS. This was intended to show the progress of the disease in each treatment.

Logistic infection rate

This was determined using the modified Van der Plank (1963) formula and according to (Zadocks and Schein, 1979) as follows:

$$r = \left[\frac{1\text{logit}\, x_2 - \text{logit}\, x_1}{t_2 - t_1} \right]$$

Where: X_1 and X_2 are the incidences of diseases at the days t_1 and t_2, respectively. This was expected to measure the speed of the epiphytotic process in each treatment.

Growth parameters' measurement

Determinations of agronomic traits were done using the five plants that were maintained per pot. The parameters measured included:

Plant height (cm): This was done at 4, 6, 8, 10, 12 weeks after sowing (WAS) and at harvest by measuring distance from ground level to the tip of all the 5 plants and finding average for each plant.

Number of branches: The number of branches was determined by counting number of branches at 4, 6, 8, 10, 12 weeks after sowing (WAS) and at harvest on the 5 plants and finding average per plant.

Weeks to 50% flowering: It was achieved by counting number of plants to determine when 50% of plants per each plot have flowered.

Weeks at harvest: Weeks to harvest was estimated when 90 % of the plants in each plot had two thirds of their capsules way up fully matured by turning yellow.

Statistical analysis

The data obtained from disease incidence, infection rate and growth parameters were subjected to analysis of variance (ANOVA) for split plot design using the generalized linear model (GLM) procedure of SAS Version 9 (SAS, 2005).

Results and Discussion

Effects of varieties and plant extracts on Cercospora leaf spot (CLS) incidence at 12 WAS

There was a highly significant cultivar effects on the disease incidence. Sesame variety E8, which was significantly at par with NCRIBEN-01M, recorded reduced/lowered incidence of CLS disease at Ardo-kola (63.40%) and Gassol (57.37%) as compared to susceptible Yandev 55 with the highest incidence (71.86% Ardo-kola and 71.39% Gassol), respectively (Table 2). There was also significant (P ≤ 0.05) difference between plant extracts and unsprayed control in 2012. Meanwhile, the lowest value (63 %) was obtained in plants treated with Chromolaena and Benomyl (standard check) in 2012. At Gassol location the result revealed that plant extracts (61.43%), which were significantly the same with Benomyl, gave the lowest incidence than unsprayed control (78.70%). The result of CLS incidence indicated insignificant effect due to location amongst varieties and plant extracts (Table 2). However, there were significant cultivar and plant extracts effects for the two locations' combined analysis (Table 2). Sesame variety E8, which was statistically the same with NCRIBEN-01M, gave the lowest combined analysis incidence of 60.39%, than Yandev 55 (71.63%) and NCRIBEN-03L (71.50%). Furthermore, the synthetic fungicide Benomyl, which was statistically similar to Chromolaena and Ocimum, produced the lowest combined analysis incidence (61.99%) than unsprayed control (78.90%).

Table 2: Incidence and infection rate of CLS on sesame at 12 WAS in Ardo-kola and Gassol during 2012 rainy season

Treatment	Incidence (%) at Ardo-kola	Incidence (%) at Gassol	Combined analysis of incidence (%)	[1]Infection rate at Ardo-kola	[1]Infection rate at Gassol	[1]Combined analysis of infection rate
Ardo-kola (L1)			67.37[a]			0.01[a]
Gassol (L2)			65.60[a]			0.0097[a]
Mean			66.49			0.0099
SE			2.55			0.00031
LSD			6.24			0.00076
Variety(V)						
Yandev 55	71.86[a]	71.39[a]	71.63[a]	0.014[a]	0.015[b]	0.015[a]
NCRIBEN-01M	65.64[bc]	59.22[b]	62.43[b]	0.0093[c]	0.0045[c]	0.0069[c]
E8	63.40[c]	57.37[b]	60.39[b]	0.007[d]	0.0027[d]	0.0049[d]
NCRIBEN-03L	68.58[ab]	74.41[a]	71.50[a]	0.011[b]	0.017[a]	0.014[b]
SE	2.32	2.78	2.55	0.00034	0.00027	0.00031
LSD(0.05)	5.06	6.06	5.56	0.00074	0.00059	0.00068
Plant Extract (F)						
Neem	69.88[b]	66.72[b]	68.3[b]	0.013[b]	0.01[b]	0.012[b]
Jatropha	68.30[b]	65.98[b]	67.14[b]	0.011[c]	0.0091[c]	0.010[c]
Garlic	65.41[bc]	62.34[b]	63.88[bc]	0.0087[d]	0.0076[d]	0.0082[d]
Ocimum	65.31[bc]	61.88[b]	63.60[bc]	0.0053[g]	0.0066[e]	0.0060[f]
Chromolaena	63.05[c]	62.14[b]	62.60[bc]	0.0066[f]	0.0073[d]	0.0070[e]
Benomyl	62.55[c]	61.43[b]	61.99[c]	0.0075[e]	0.0068[e]	0.0072[e]
Control	79.10[a]	78.70[a]	78.90[a]	0.019[a]	0.021[a]	0.02[a]
Mean	67.37	65.60	66.49	0.01	0.0097	0.0099
SE	2.32	2.78	2.55	0.00034	0.00027	0.00031
LSD(0.05)	4.65	5.57	5.11	0.00068	0.00054	0.00062
V x F	*	*	*	*	*	*
V x L	NS	NS	NS	NS	NS	NS
V x F x L	NS	NS	NS	NS	NS	NS

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD; [1]unit per day (calculated from incidence at 4 and 12 WAS)

Effects of varieties and plant extracts on CLS logistic infection rate

Logistic infection rate presented in Table 2 showed various levels of epiphytotic rate of progress in both locations with respect to varieties and plant extracts. The result indicated that sesame variety E8 had the lowest epiphytotic rate in Ardo-kola (0.007 unit per day), Gassol (0.0027 unit per day) and combined analysis (0.0049 unit per day) than Yandev 55 (0.014 units per day in Ardo-kola; 0.017 units per day in Gassol; 0.015 units per day for combined means of the two locations) respectively. The results of both locations indicated that the speed of the epiphytotic process was highly (P=0.01) slower in Ocimum extract than unsprayed plots. Combined analysis of two locations further confirmed the efficacy of Ocimum in slowing down rate of epiphytotic processes with lowest value of 0.0060 units per day (Table 2), compared with the unsprayed control plots having the highest logistic infection rate of 0.020 units per day. The result also revealed that infection rate did not show significant locational effect amongst varieties and plant extracts (Table 2).

Variety x plant extracts interaction on incidence

There was highly significant (P= 0.001) interaction between varieties and plant extracts on CLS incidence at 12 WAS at Ardo-kola field experiment (Table 3). The result revealed the lowest interaction value of 58.99 % in sesame variety E8 plants sprayed with Benomyl, which was statistically at par with combination of E8 x Chromolaena, E8 x Ocimum, and E8 x Garlic, NCRIBEN-01 M x Ocimum, NCRIBEN-01 M x Chromolaena and NCRIBEN-01 M x Benomyl. The highest incidence value of 84.98 % was obtained from unsprayed plants of Yandev 55. The trend was repeated in the Gassol location (Table 4) with E8 x Benomyl, which was statistically the same with E8 x Chromolaena, E8 x Ocimum, and E8 x Garlic, having lowest value (54.89 %), compared to the highest value obtained from unsprayed plants of NCRIBEN-03L (90.00 %) and Yandev 55 (88.42 %). The combined analysis interaction effect in Table 5 of the two locations indicated that plants of E8 (moderately resistant) sprayed with extract of Benomyl gave the lowest value of 56.94 %, which was at par with plants of the same variety treated with Ocimum andChromolaena. The highest combined analysis mean value of 87.43 % was observed on unsprayed susceptible Yandev 55.

Table 3: Interaction of plants extracts and varieties on incidence (%) of CLS at Ardo-kola in 2012 rainy season

Treatments	Incidence (%) of cercospora leaf spot at 12 weeks after sowing			
	NCRIBEN– 01M	E8	NCRIBEN-03L	Yandev 55
Neem	68.29^{ef}	64.52^{jk}	72.14^{d}	81.79^{a-c}
Jatropha	67.37^{ef}	64.56^{jk}	66.75^{f-h}	81.77^{bc}
Garlic	63.10^{k}	61.20^{l}	68.26^{ef}	79.06^{c-e}
Occimum	61.03^{l}	60.19^{l}	64.90^{h-k}	78.06^{de}
Chromoaena	61.35^{l}	59.99^{l}	64.69^{i-k}	77.59^{de}
Benomyl	60.65^{l}	58.99^{l}	64.03^{k}	77.78^{de}
Control	77.74^{bc}	74.34^{d}	79.33^{b}	86.43^{a}
LSD (0.05)	6.56			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 4: Interaction of plants extracts and varieties on incidence (%) of CLS at Gassol in 2012 rainy season

Treatments	Incidence (%) of cercospora leaf spot at 12 weeks after sowing			
	NCRIBEN–01M	E8	NCRIBEN-03L	Yandev 55
Neem	59.44^{j}	57.92^{j-l}	75.86^{b}	76.10^{bc}
Jatropha	58.84^{j}	58.17^{jk}	73.96^{bc}	75.75^{bc}
Garlic	56.14^{k-m}	55.78^{m}	70.43^{ef}	70.92^{de}
Occimum	56.16^{k-m}	54.85^{m}	70.39^{ef}	68.35^{ef}
Chromoaena	55.99^{lm}	55.30^{m}	70.66^{d-f}	69.46^{ef}
Benomyl	55.68^{m}	54.89^{m}	69.58^{fg}	67.04^{f}
Control	72.27^{c-f}	64.71^{i}	90.00^{a}	88.42^{a}
LSD (0.05)	12.01			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 5: Interaction of plants extracts and varieties on combined analysis of incidence (%) of CLS at Ardo-kola and Gassol in 2012 rainy season

Treatments	Incidence (%) of cercospora leaf spot at 12 weeks after sowing			
	NCRIBEN–01M	E8	NCRIBEN-03L	Yandev 55
Neem	63.87^{d-h}	61.22^{e-h}	74.00^{bc}	78.95^{ab}
Jatropha	63.10^{e-h}	61.37^{e-h}	70.36^{b-e}	78.76^{ab}
Garlic	59.62^{f-h}	58.50^{e-h}	69.35^{c-e}	74.99^{bc}
Occimum	58.60^{f-h}	57.52^{gh}	67.65^{c-f}	73.21^{bc}
Chromoaena	58.67^{f-h}	57.65^{gh}	67.68^{c-f}	73.53^{b}
Benomyl	58.17^{gh}	56.94g	66.81^{c-g}	72.41^{b-d}
Control	75.00^{bc}	69.53^{c-e}	84.67^{ab}	87.43^{a}
LSD (0.05)	9.28			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Variety x plant extracts interaction on infection rate

It was further observed that there was interaction between varieties and plant extracts on logistic infection rate of CLS infection on sesame at bothArdo-kola and Gassollocations (Tables 6 to 8). InTable 6 at Ardo-kola, the combinations of moderately resistant variety E8 xChromolaena (0.0033 units per day), which was similar statistically with E8 x Benomyl, E8 x Ocimum, E8 x Garlic and NCRIBEN-01M x Ocimum, gave the lowest logistic infection rate than unsprayed plants of Yandev 55 (0.025 units per day). Significant ($p \leq 0.05$) E8 x Ocimum extract application was observed on infection rate (0.0015 units per day) at Gassol, compared to the highest value (0.027 units per day) of unsprayed plants of Yandev 55 (Table 7). Thecombined analysis proved that the lowest infection rate (0.0028 units per day) was obtained from E8 x Chromolaena application, compared to 0.026 units per day from unsprayed plants of Yandev 55 (Table 8).

Table 6: Interaction of plants extracts and varieties on infection rate (unit per day) of CLS at Ardo-kola in 2012 rainy season

Treatments	Infection Rate (unit per day) of cercospora leaf spot at 4 and 12 weeks after sowing			
	NCRIBEN–01M	E8	NCRIBEN-03L	Yandev 55
Neem	0.011^{ef}	0.0089^{e-h}	0.015^{cd}	0.017^{b-e}
Jatropha	0.0080^{g-i}	0.0071^{h-j}	0.01^{e-g}	0.017^{b-e}
Garlic	0.0072^{h-j}	0.0048^{j-l}	0.012^{de}	0.011^{g-i}
Occimum	0.0035^{l}	0.0048^{j-l}	0.0063^{i-k}	0.015^{d-g}
Chromoaena	0.0069^{h-j}	0.0033^{l}	0.0083^{f-i}	0.015^{d-g}
Benomyl	0.0089^{e-h}	0.0041^{kl}	0.0089^{e-h}	0.014^{d-g}
Control	0.020^{ab}	0.016^{bc}	0.015^{cd}	0.025^{a}
LSD (0.05)	0.00068			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 7: Interaction of plants extracts and varieties on infection rate (unit per day) of CLS at Gassol in 2012 rainy season

Treatments	Infection rate (unit per day) of cercospora leaf spot at 4 and 12 weeks after sowing			
	NCRIBEN–01M	E8	NCRIBEN-03L	Yandev 55
Neem	0.0033^{hi}	0.0029^{hi}	0.018^{b}	0.018^{a}
Jatropha	0.002^{hi}	0.0024^{hi}	0.017^{b}	0.018^{a}
Garlic	0.0035^{gh}	0.0022^{hi}	0.013^{cd}	0.012^{bc}
Occimum	0.0022^{hi}	0.0015^{i}	0.013^{cd}	0.010^{cd}
Chromoaena	0.0033^{hi}	0.0022^{hi}	0.012^{de}	0.011^{c}
Benomyl	0.002^{hi}	0.0024^{hi}	0.013^{cd}	0.0067^{d-f}
Control	0.015^{bc}	0.0056^{g}	0.032^{a}	0.027^{a}
LSD (0.05)	0.00054			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 8: Interaction of plants extracts and varieties on combined analysis of infection rate (unit per day) of CLS at Ardo-kola and Gassol in 2012 rainy season

Treatments	Infection rate (unit per day) of cercospora leaf spot at 4 and 12 weeks after sowing			
	NCRIBEN – 01M	E8	NCRIBEN-03L	Yandev 55
Neem	0.0072^{j}	0.0059^{k}	0.017^{d}	0.018^{c}
Jatropha	0.005^{l}	0.0048^{l}	0.014^{e}	0.018^{c}
Garlic	0.0054^{k}	0.0035^{m}	0.013^{f}	0.012^{g}
Occimum	0.0029	0.0032^{mn}	0.0097^{f}	0.013^{f}
Chromoaena	0.0051^{l}	0.0028^{n}	0.0102^{i}	0.013^{f}
Benomyl	0.0055^{k}	0.0033^{mn}	0.011^{h}	0.0104
Control	0.018^{c}	0.011^{h}	0.024^{b}	0.026^{a}
LSD (0.05)	0.00061			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Plant height following effects of varieties and plant extracts on cls on sesame at Ardo-kola and Gassol

The results in Table 9 showed that E8 which was statistically at par with NCRIBEN-01M gave the highest plant height at Ardo-kola (147.68 cm) and Gassol (143.61 cm), compared with the lowest values of 118.72 cm and 111.94 cm from Yandev 55 respectively. Furthermore, combined analysis revealed that E8 continued to exhibit significantly highest plant height (145.65 cm), while Yandev 55 had the lowest value of 115.33 cm. The effect of Ocimumextracton plant height obtained at Ardo-kola, which was at par with that of Benomyl, showed significantly (P=0.05) tallest value of 142.81 cm, compared with unsprayed control having the shortest plant height (110.88 cm). The trend in Gassol proved the efficacy of Benomyl, which was statistically similar to Chromolaenaand Ocimum, in producing the tallest plant height (134.23 cm), than unsprayed control (109.30 cm). Combined analysis of the two locations indicated that Benomyl, which was satistically at par with extracts of Ocimum andChromolaena, produced highly significant plant height (138.46 cm), as compared to unsprayed control plots with the shortest height of 110.09 cm (Table 9).

Variety x plant extracts interaction on plant height

Table 10 showed significant interaction between varieties and plant extracts on plant height at Ardo-kola, which inferred that E8 x Benomyl, which was at par with E8 x Chromolaena and E8 x Ocimum, to control CLS significantly influenced the tallest plant height (160.33 cm), while the unsprayed plants of NCRIBEN-03L significantly produced the shortest plants height (108.88 cm).

Branches per plant following effects of varieties and plant extracts on CLS on sesame at Ardo-kola and Gassol

The results on branches per plant showed highly significant (P≤0.01) difference between varieties and plant extracts (Table 11). Highest values were observed on E8 at Ardo-kola (3.29), Gassol (3.34) and their combined analysis (3.32), while lowest values were observed on NCRIBEN-03L (2.89) at Ardo-kola, Yandev 55 (2.39) at Gassol and NCRIBEN-03L (2.65) for combined analysis of the two locations. Subsequently, plants treated with Chromolaena extract, which had statistical similarity with those of Ocimum, Garlic and Benomyl, produced more branches per plant (3.38) than the unsprayed control (2.39) in Ardo-kola. The trend in Gassol revealed the efficacy of the synthetic fungicide Benomyl (check), though at par with results of Ocimum, Chromolaenaand Garlicextracts, having the highest branches per plant (3.13) as against the unsprayed control (2.12). The results of the combined analysis confirmed the pattern obtained at Ardo-kola location with Chromolaena extract, which was statistically at par with Ocimum, Garlic and Benomyl, producing highest branches per plant (3.26), compared to the lowest branches per plant (2.26) from unsprayed control.

Variety x plant extracts interaction on branches per plant

Interaction result in Table 12 indicated that E8 seedlings treated with Ocimum extract significantly increased branches per plant of 4.04, though not different from results of E8 x Chomolaena, E8 x Benomyl and E8 x Garlic, compared to unsprayed control (1.96).

Table 9: Effect of CLS on plant height of sesame at 12 WAS in Ardo-kola and Gassol during 2012 rainy season

Treatment	Plant height (cm) at Ardo-kola	Plant height (cm) at Gassol	Combined analysis of plant height
Ardo-kola (L1)			133.57^{a}
Gassol (L2)			126.69^{a}
Mean			130.01
SE			4.43
LSD (0.05)			10.84
Variety(V)			
Yandev 55	118.72^{d}	111.94^{d}	115.33^{c}
NCRIBEN-01M	137.96^{b}	131.73^{b}	134.85^{b}
E8	147.68^{a}	143.61^{a}	145.65^{a}
NCRIBEN-03L	129.92^{c}	119.47^{c}	124.70^{c}
SE	4.28	4.57	4.43
LSD (0.05)	9.33	9.96	9.65
Plant Extract (F)			
Neem	128.83^{c}	120.84^{b}	124.84^{c}
Jatropha	129.18^{c}	123.73^{b}	126.46^{bc}
Garlic	138.91^{b}	131.37^{a}	135.14^{ab}
Ocimum	142.81^{a}	133.52^{a}	138.17^{a}
Chromolaena	141.69^{ab}	133.83^{a}	137.76^{a}
Benomyl	142.69^{a}	134.23^{a}	138.46^{a}
Control	110.88^{d}	109.30^{c}	110.09^{d}
Mean	133.57	126.69	130.13
SE	4.28	4.57	4.43
LSD (0.05)	8.58	9.16	8.88
V x F	*	NS	NS
V x L	NS	NS	NS
V x F x L	NS	NS	NS

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 10: Interaction of plants extracts and varieties on plant height (cm) of sesame at Ardo-kola in 2012 rainy season

Treatments	Plant height (cm) at 12 WAS			
	NCRIBEN–01M	E8	NCRIBEN -03L	Yandev 55
Neem	128.80^{i}	143.00^{fg}	127.93^{ij}	132.84^{k}
Jatropha	133.23^{h}	143.45^{fg}	124.75^{jk}	131.07^{k}
Garlic	145.13^{ef}	154.43^{b-d}	133.83^{h}	139.64^{ij}
Occimum	150.00^{c-e}	155.95^{ab}	139.83^{g}	141.10^{hi}
Chromoaena	151.23^{b-d}	155.43^{a-c}	134.98^{h}	141.68^{g-i}
Benomyl	148.48^{de}	160.33^{a}	134.30^{h}	140.37^{hi}
Control	108,88^{n}	121.18l	113.83^{m}	118.35^{m}
LSD (0.05)	8.58			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 11: Effect of CLS on branches per of sesame at 12 WAS in Ardo-kola and Gassol during 2012 rainy season

Treatment	Branches per plant at Ardo-kola	Branches per plant at Gassol	Combined analysis of Branches per plant
Ardo-kola (L1)			3.07^{a}
Gassol (L2)			2.77^{a}
Mean			2.92
SE			0.19
LSD (0.005)			0.46
Variety(V)			
Yandev 55	3.04^{b}	2.39^{c}	2.72^{b}
NCRIBEN-01M	3.09^{b}	2.97^{b}	3.03^{ab}
E8	3.29^{a}	3.34^{a}	3.32^{a}
NCRIBEN-03L	2.89^{c}	2.40^{c}	2.65^{b}
SE	0.62	0.82	0.19
LSD (0.005)			0.41
Plant Extract (F)			
Neem	2.88^{b}	2.47^{b}	2.68^{b}
Jatropha	2.94^{b}	2.59^{b}	2.77^{ab}
Garlic	3.26^{a}	2.97^{a}	3.12^{a}
Ocimum	3.25^{a}	3.08^{a}	3.17^{a}
Chromolaena	3.38^{a}	3.06^{a}	3.22^{a}
Benomyl	3.29^{a}	3.13^{a}	3.21^{a}
Control	2.39^{c}	2.12^{c}	2.26^{c}
Mean	3.07	2.77	2.92
SE	0.16	0.22	0.19
LSD (0.005)			0.38
V x F	NS	*	NS
V x L	NS	NS	NS
V x F x L	NS	NS	NS

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Table 12: Interaction of plants extracts and varieties on branches per plant at harvest of sesame at Gassol in 2012 rainy season

Treatments	Branches per plant at harvest			
	NCRIBEN–01M	E8	NCRIBEN-03L	Yandev 55
Neem	2.67^{f-h}	3.46^{b}	2.25^{l}	2.23^{l}
Jatropha	2.77^{f}	3.53^{b}	2.25^{l}	2.34^{kl}
Garlic	3.23^{cd}	3.87^{a}	2.52^{ij}	2.64^{f-i}
Occimum	3.15^{de}	4.04^{a}	2.61^{g-j}	2.71^{fg}
Chromoaena	3.25^{c}	4.01^{a}	2.56^{h-j}	2.69^{f-h}
Benomyl	3.43^{bc}	3.84^{a}	2.50^{j}	2.72^{fg}
Control	2.37^{k}	3.02^{e}	1.96^{m}	2.01^{m}
LSD (0.05)	0.44			

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD.

Weeks to 50 % flowering and weeks to harvest following effects of varieties and plant extracts on CLS

Effect of varieties on weeks to 50% flowering was highly significant. Varieties Yandev 55 and NCRIBEN -03L took more than 8 weeks to reach 50% flowering for both Ardo-kola and Gassol (Table 13). This was followed by E8 and NCRIBEN – 01M reaching 50% flowering at 6 to7 weeks. Results of the two locations and their combined analysis for weeks to 50% flowering showed that plant extracts and Benomyl were not statistically significant. Furthermore, there were highly significant (P=0.01) differences between varieties and weeks to harvest. NCRIBEN -03L and Yandev 55 stayed for 18 weeks to reach harvest (Tables 13). E8 and NCRIBEN -01M were early in maturity reaching up to 15 weeks before harvest at both locations. The results further inferred that plant extracts application had no significant effect on weeks to harvest.

Table 13: Effect of CLS on weeks to 50 % flowering and weeks to harvest of sesame at 12 WAS in Ardo-kola and Gassol

Treatment	Weeks to 50 % flowering at Ardo-kola	Weeks to 50 % flowering at Gassol	Combined analysis of weeks to 50 % flowering	Weeks to harvest at Ardo-kola	Weeks to harvest at Gassol	Combined analysis of weeks to harvest
Ardo-kola (L1)			7.56^{a}			16.71^{a}
Gassol (L2)			7.23^{a}			16.58^{a}
Mean			7.40			16.65
SE			0.78			1.19
LSD			1.91			2.91
Variety(V)						
Yandev 55	8.08^{b}	7.89^{b}	7.99^{a}	18.27^{b}	17.13^{b}	17.70^{ab}
NCRIBEN-01M	7.05^{c}	6.53^{c}	6.79^{a}	15.58^{c}	15.08^{c}	15.33^{bc}
E8	6.92^{d}	6.43^{d}	6.68^{a}	14.57^{d}	15.11^{c}	14.84^{c}
NCRIBEN-03L	8.20^{a}	8.06^{a}	8.13^{a}	18.43^{a}	18.22^{a}	18.33^{a}
SE	0.87	1.07	0.78	2.40	2.10	1.19
LSD(0.05)			1.70			2.59
Plant Extract (F)						
Neem	7.36^{b}	7.13^{c}	7.25^{a}	16.63^{c}	16.51^{bcd}	16.57^{a}
Jatropha	7.53^{b}	7.16^{c}	7.35^{a}	16.64^{bc}	16.53^{cd}	16.59^{a}
Garlic	7.80^{ab}	7.28^{ab}	7.54^{a}	16.73^{ab}	16.61^{abc}	16.67^{a}
Ocimum	7.07^{a}	7.20^{bc}	7.14^{a}	16.79^{a}	16.57^{bc}	16.68^{a}
Chromolaena	7.62^{a}	7.37^{a}	7.50^{a}	16.82^{a}	16.71^{ab}	16.77^{a}
Benomyl	7.43^{a}	7.49^{a}	7.46^{a}	16.83^{a}	16.33^{a}	16.58^{a}
Control	7.43^{c}	7.11^{c}	7.43^{a}	16.54^{c}	16.41^{d}	16.48^{a}
Mean	7.56	7.23	7.40	16.71	16.58	16.65
SE	0.63	0.92	0.78	0.97	1.40	1.19
LSD(0.05)			1.56			2.39
V x F	NS	NS	NS	NS	NS	NS
V x L	NS	NS	NS	NS	NS	NS
V x F x L	NS	NS	NS	NS	NS	NS

Means in the same column followed by the same superscript(s) are not significantly different (0.05) using LSD; NS = not significant; V = variety; F = plant extract; L = location.

Study on the effects of varieties and plant extracts on incidence and logistic infection rate of CLS disease infection on sesame showed that the disease progressed steadily from 4 – 12 WAS. Van der Plank's (1963) studied the rate of disease development and observed that *Cercospora* leaf spot is a compound interest disease, which completes many generations on the crop in a season. The results also proved the effectiveness of E8 in reducing incidence and infection rate, compared to the highest results from Yandev 55. The reduced rate of disease development in variety E8 observed may be attributed to the levels of resistance of the variety against *Cercospora* sp. This finding confirmed works by Kolte (1984) and Eman (2011) who reported that the resistant gene of genotypes was one of principal factors influencing *Cercospora inc*idence.

On the antimicrobial activities of plant extracts against incidence of CLS, a significant variation was observed on their effectiveness on the disease in both locations. In this study the Ocimum and Chromolaena extracts were found to significantly reduce disease incidence of Cercospora leaf spot (CLS) disease on sesame and slow down epiphytotic rate of progress, compared with the unsprayed control. The efficacy of the plant extracts in retarding the incidence of CLS over time in this study might be due to the presence of phenolic compound 4-Allyl-2-methoxyphenol-5-Allylguaiacol called eugenol (*Ocimumgratis simum*) and Geijerene and Pregeijerene (*Chromolaena odorata*) contained in them. This confirms the findings of (Terezinha*et al*., 2006; Prabhu*et al*., 2009) that eugenoland Geijerene and Pregeijerene inhibited the growth of *Alternaria* sp. and *P. chrysogenum*, in tomato plants. Different manifestations of CLS had been reported to individually or collectively influence the growth, development and yield of sesame (Khan *et al*., 2009). Investigation in this study revealed the presence of *Cercospora*sp.with varied reactions to sesame varieties and application of plant extracts. The study revealed that sesame varieties E8 had less prevalent of CLS disease which might have been responsible in increased plant height and branches per plant. This corroborated the works by Uwala (1998) which inferred that amongst the agronomic parameters measured, the total number of branches, plant height and capsule numbers were positively correlated with seed yield.

The application of Ocimumand Chromolaena extracts, which had statistical similarity with the synthetic fungicide Benomyl, influenced incidence and infection rate of CLS thereby inducing significantly better agronomic traits that contributed to increased plant height and branches per plant. Several workers have investigated the use of plant extracts as fungicides (Tewari, 1995; Qasem*et al*., 1995; Ogbor and Adekunle, 2008; Ogbebor *et al*., 2007). From this study it was also observed that synergistic effect of plant extracts and host resistance had strong capacity to reduce the spread of CLS on sesame plants compared to control treatment. Interactions of E8 x Ocimum extract, which is statistically the same with E8 x Chromolaena and E8 x Benlate, effectively reduced incidence and infection rate. This confirmed the work of (Enikuomehin, 2005) which revealed that Sesame cultivarPbtil No. 1 sprayed with plant extracts (*Aspiliaafricana, Chromoleana odorata* and *Tithoniadiversifalia*) and plots of sesame cv 530-6-1 sprayed with extracts (*A. Africana*, *C. odorata* and *T. diversifolia*) reduced the percentage of leaves infected and number of lesions per leaf. The application of plant extracts associated with host resistance of the four tested varieties considerably reduced the progression of CLS on sesame crops. Consequently, these two methods can be used in an integrated management approach to protect sesame against diseases.

Conclusion

Both Ardo – kola and Gassolfield experiments showed that sesame varieties E8 and NCRIBEN-01M had moderate resistance against *Cercospora* sp., while the extracts from Ocimum and Chomolaena contain substances that successfully suppressed or inhibited the growth of the pathogen. Furthermore, interactions in both fields revealed that combination of ocimum extract sprayed on plants of sesame varieties (E8 and NCRIBEN – 01M), and E8 sprayed with chromolaena extract were able to effectively control CLS disease.From this study it could be seen that the performance of the plant extracts is comparable to the synthetic fungicide Benomyl, and therefore this has given the farmers ample opportunities to try many alternatives that are user friendly. Therefore, plant extracts and crop varieties can be used as a potential tool in plant disease management, particularly Cercospora leaf spot of sesame, as sustainable and ecofriendly botanical fungicides that are economically and environmentally rewarding for sesame and other crop producers.

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