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Evaluation of plant extracts for the management of Cercospora leaf spot of groundnut (*Arachis hypogaea* L.)

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Groundnut (*Arachis hypogaea* L.) is a leguminous crop with high economic and nutritional value. However, increased production is hampered by Cercospora leaf spot (CLS) caused by *Cercospora arachidicola* and *Cercosporidium personatum*. Studies were conducted *in vitro* and *in vivo* to evaluate the efficacy of aqueous extracts of desert date seed (DDSE), neem seed (NSE), jatropha seed (JSE) and tobacco leaf (TLE) for the management of CLS. The antifungal activities of 25, 50, 75 and 100 g/l concentrations of each of the plant extracts was assessed *in vitro* on potato dextrose agar using the food poison technique. The field study was a factorial experiment consisting of 18 treatments laid in a Randomised Complete Block Design with four replications over two cropping seasons. The *in vitro* results revealed that all the botanicals at 100 g/l recorded the highest inhibition percentages. DDSE at 100 g/l significantly ($P < 0.001$) inhibited the highest mycelia growths compared to other levels of plant extracts used with inhibition percentages of 90.33 and 84.96% in *C. arachidicola* and *C. personatum*, respectively. Three out of the four aqueous extracts (DDSE, NSE and JSE) at 100 g/l significantly ($P < 0.05$) lowered disease incidence, severity and defoliation in the field and increased yield. Pod yield was significantly ($P < 0.05$) higher in plants treated with JSE, NSE, DDSE and Topsin-M, compared to those treated with TLE and the negative control plants. For most of the parameters, DDSE produced similar results as Topsin-M followed by NSE and JSE. Farmers can adopt DDSE, NSE and JSE as alternatives to fungicides leading to minimal effect on the environment since they are biodegradable.

Key words: Cercospora leaf spot, plant extracts, groundnut, incidence, severity, aqueous.

INTRODUCTION

Ghana is a major producer of groundnuts (*Arachis hypogaea* L.) in West Africa with nearly all production coming from northern Ghana (DAI and Nathan Associates, 2014). Despite its economic importance in the northern parts of Ghana, its current average yield of 0.8 t/ha is not up to its potential yield of 2.5 to 3.0 t/ha

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(Kombiok et al., 2012; Tanzubil et al., 2017). This large yield gap is attributable to diversity of production constraints, notably pests and diseases, low inherent yielding varieties, low and high temperatures at certain growth stages of the crop, non-irrigated cultures and increased cultivation on marginal lands among others (Ambang et al., 2011; Tshilenge-Lukanda et al., 2012). Nonetheless, Cercospora leaf spot (CLS) caused by *Cercospora arachidicola* and *Cercosporidium personatum* is the most destructive foliar disease in West Africa (Mohammed et al., 2019).

Control of CLS with fungicides is effective but it largely depends on inorganic fungicide applications which are too expensive for indigenous farmers in Northern Ghana (Nutsugah et al., 2007; Akinbode, 2010; Jordan et al., 2012). Aside from this, chemical control also raises environmental and health concerns (Jordan et al., 2012). In Ghana, Imoro et al. (2019) reported that mode of storage of pesticides by farmers have adverse effects on their health as well as the environment.

Although fungicides are effective for controlling the disease, awareness about environmental pollution caused by misuse of fungicide, tolerant pathogens strains, non-availability of both fungicides and their application technology to resource-limited farmers, have necessitated the use of more economical and ecologically-friendly alternatives. There are reports on the potential of some plants with fungicidal properties which can be used for controlling diseases. For instance, Sowley et al. (2017) reported that *Azadirachta indica* seed and *Cassia alata* leaf extracts controlled seed borne fungi of maize. The study sought to determine the efficacy of some botanicals for the management of Cercospora leaf spot of groundnut.

MATERIALS AND METHODS

Experimental site

Laboratory studies were carried out in the Spanish laboratory at the University for Development Studies, Nyankpala campus, during 2014 and 2015 cropping seasons whilst the field studies was conducted under rain-fed conditions in 2014 and repeated in 2015 on the experimental field of the Faculty of Agriculture, University for Development Studies, Nyankpala campus.

Sample collection

A. indica and *Jatropha curcas* seeds, as well as *Nicotiana tabacum* leaves, were collected from Fooshegu and Tamale whilst *Balanites aegyptiaca* seeds were obtained from Jantong-Dashee in the East Gonja district. The plant materials were obtained from healthy plants. The seed and leaf samples were stored in polyethene bags until required.

Optimization of plant extract concentrations

The various plant materials (that is, neem, *J. curcas*, desert date seeds and tobacco leaves) were collected, washed with several changes of sterile distilled water, and air-dried to constant weight for 10 days; tobacco leaves were cut into tiny pieces before washing and drying. For seeds, the coats were removed before pounding. The dried plant materials were pounded separately with sterile mortar and pestle and sieved with a fine sterile cheesecloth to obtain a fine powder. The powders obtained were sieved through a screen with a mesh size of 0.4 mm to obtain a fine powder. Cold aqueous extracts of the samples were prepared separately by adding 25, 50, 75 and 100 g of the powder samples into conical flasks. Each sample was wrapped in cheesecloth and soaked in 1 L of water for 24 h. The cloth was squeezed and the extract was filtered. 2 g of an emulsifier ('key soap') was added to each filtrate to facilitate sticking. Based on the results of the *in vitro* studies, 100 g/l was identified as the most effective concentration of the extract and used for the field study.

Phytochemicals screening of the plant extracts

Alkaloids, saponins, tannins, steroids and terpenoids were detected with the methods described by various workers.

Following the methods of Edeoga and Okwu (2005) and Kareru et al. (2008), the presence of alkaloids were detected in the plant extracts. The methods described by Wall et al. (1954) and Kareru et al. (2008) were used for testing for saponins. The methods described by Sabri et al. (2012) were also used for detecting tannins and phenolic compounds. Similarly, Salkowski test was also used for the detection of steroids and terpenoids.

Isolation and identification of *C. arachidicola* and *C. personatum*

Potato Dextrose Agar (PDA) was prepared based on the manufacturer's recommendation of 39 g/l. The media was autoclaved at a temperature of 121°C and a pressure of 1.02 kg/cm^3 for 15 min. It was then amended with 1 g of chloramphenicol before dispensing into sterile Petri dishes and allowed to cool. Pieces of infected groundnut leaves were sterilised with 4% sodium hypochlorite. The sterile pieces of leaf were placed on the PDA plates at equidistant points and kept in a freezer at a temperature of 28°C for 48 h. Following the procedure of Barnett and Hunter (1998), fungi were identified based on morphological and cultural features. Slides of pure cultures obtained were prepared and observed under a compound microscope (Celestron LCD Digital microscope, Model number 44340, UK).

Determination of the inhibitory effect of the aqueous plant extracts on mycelia growth of *C. arachidicola* and *C. personatum*

Food poison technique was used for the infected samples of the three groundnut cultivars ('Chinese,' Mani-pintar and 'Bugla'). Five millilitres of each extract concentration (that is, 25, 50, 75 and 100 g/l) of the supernatant of the test extracts were dispersed in 20 ml potato dextrose medium in 90 cm Petri dishes, swirled to blend and allowed to solidify. A 5 mm disc of five days old culture of the two test fungi each was inoculated separately at the centre of the PDA medium and incubated at 28 ± 2°C. The growth of each fungus diametrically was taken for 7 days on daily basis. For positive controls, 5 ml of Topsin-M prepared at the recommended rate (1 g/l) as well as 2 and 3 g/l were used for the amendment. The negative controls had only the PDA medium without the extracts. The colony diameter representing mycelia growth was measured using a transparent rule on a daily basis after inoculation for seven days.

The percentage inhibition of mycelial growth was calculated as follows (Begum et al., 2010):

I=(C-T/C) ×100

where I = Percentage inhibition, C = Radial growth in control, T =Radial growth in treatment.

Pathogenicity test of *C. arachidicola* and *C. personatum*

The seedlings of the 'Chinese' cultivar were raised on loamy soil contained in perforated black polythene bags (15 × 30 cm^2) in a plant house with an average temperature of 28°C. Twenty-one-day old plants were pinpricked and sprayed with a suspension containing mycelia of *C. arachidicola* and *C. personatum* [1 × 10^3 cfu mL^{-1}] prepared in sterile distilled water, except the control plants. Pathogenicity test of the fungal isolates was based on the method of Eman (2011).

Measurement of disease parameters

Disease incidence

Five plants were randomly selected and tagged for disease assessment in each plot per treatment during 2014 and 2015 cropping seasons. Disease incidence was recorded on these five plants in each plot for every treatment before treatment application. Mean % incidence was calculated with the formula (Chaube and Pundhir, 2009):

$$\text{Disease Incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Disease severity and disease severity index (%)

Five plants in each plot per treatment were randomly selected and tagged. These plants were used to assess the severity of CLS using the Florida scale system of 1 - 10, where 1 = no leaf spot and 10 = plants completely defoliated and killed by leaf spots (Chiteka et al., 1988). The descriptive keys were used to determine the severity of the disease.

Disease severity index (DSI) was then calculated using the equation proposed by Kobriger and Hagedorn (1983):

$$\text{DSI} = \sum \frac{(\text{severity} * \text{number of plants in the class}) * 100}{(\text{Total number of plants rated}) * (\text{Number of class} - 1)}$$

The evaluation of early and late symptoms of CLS was done after every 14 days starting from the 3rd WAP.

Yield and yield parameters

Yield characteristics such as the weights of 100 pods and 100 seeds from each plot per treatment were randomly picked and weighed using a Sartorious scale balance. The average weight of five counts was then taken as the weight of 100 pods and 100 seeds for each plot per treatment. Similarly, the total dry pod and seed yields of groundnut from the respective treatments were determined using the four median rows in each plot per treatment. The weights of groundnuts harvested from each plot were extrapolated to total pod yield per hectare basis.

Experimental design

The field experiment was a 6 × 3 factorial laid out in a Randomised Complete Block Design (RCBD) with four replications per treatment. Each replication consisted of 18 experimental plots measuring 4 × 5 m^2. The factor levels comprised three groundnut cultivars, namely: Chinese, Mani-Pinta and Bugla, and four plant extracts (desert date seed, neem seed, jatropha seed and tobacco leaf) with Topsin-M and water as positive and negative controls, respectively, producing 18 treatments. All groundnut cultivars (Chinese, Mani-pintar and Bugla) were obtained from the Seed Unit of the Savannah Agricultural Research Institute (SARI, 2014).

One seed each of the groundnut was sown per hole at a depth of about 5 cm in a planting distance of 50 cm × 20 cm. Each plot consisted of 10 rows and four median rows which were used for disease assessment and yield records. Treatments were applied every 2 weeks from 2 to 13 weeks after planting (WAP) using a 15-L knapsack sprayer.

The treatments used were as follows: Neem seed extract (NSE) + Chinese, Neem seed extract (NSE) + Mani-Pintar, Neem seed extract (NSE) + Bugla, Desert date seed extract (DDSE) + Chinese, Desert date seed extract (DDSE) + Mani-Pintar, Desert date seed extract (DDSE) + Bugla, Tobacco leaf extract (TLE) + Chinese, Tobacco leaf extract (TLE) + Mani-Pintar, Tobacco leaf extract (TLE) + Bugla, Jatropha seed extract (JSE) + Chinese, Jatropha seed extract (JSE) + Mani-Pintar, Jatropha seed extract (JSE) + Bugla, Topsin-M + Chinese, Topsin-M + Mani-Pintar, Topsin-M + Bugla, Water + Chinese, Water + Mani-Pintar and Water + Bugla.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using Genstat Discovery (12th Edition). Treatment means were separated using the Least Significance Difference (LSD) at 5% significant level.

RESULTS

Phytochemical composition of plant extracts

Neem seed and tobacco leaf extract treated plants had the highest number of phytochemicals while jatropha seed extract had the lowest (Table 1). All the extracts contained alkaloids, tannins and phenolic compounds. Only desert date seed, neem seed and tobacco leaf contained saponins. Steroids were present in only neem seed and terpenoids in only neem seed and tobacco leaf.

Isolation of causative organism

The fungal pathogens *C. arachidcola* and *C. personatum* were isolated from infected leaves of three groundnut cultivars Bugla, Mani-Pinta and Chinese and confirmed as the causative agents of Cercospora leaf spot diseases of groundnut. The conidium of *C. arachidicola* is sub hyaline or pale yellow, obclavate or cylindrical and septate with rounded base and sub-acute tip (Figure 1A). However, in the case of *C. personatum* conidium was obclavate or cylindrical and light coloured. The base is shortly tapered with a conscipicous hilum (Figure 1B).

Table 1. Phytochemical constituents of plant extracts.

Phytochemical constituent	Jatropha seed	Desert date seed	Neem seed	Tobacco leaf
Alkaloids	+	+	+	+
Saponins	-	+	+	+
Tannins and phenolic	+	+	+	+
Steroids	-	-	+	-
Terpenoids	-	-	+	+

+ = Present; - = Absent.

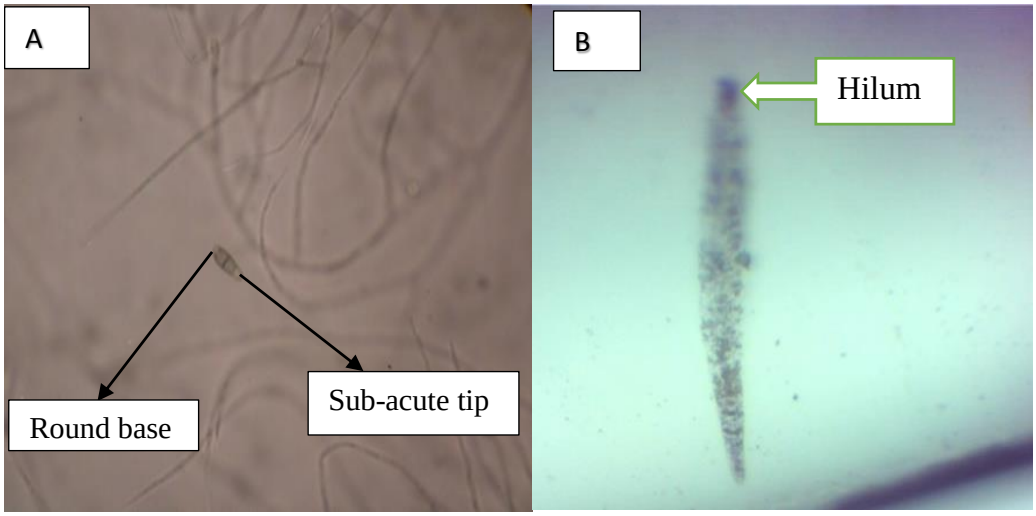

Figure 1. Conidium of *Cercospora arachidicola* (A) and broken conidium of *Cercosporidium personatum* (B) with distinct hilum at base.

Growth inhibition of fungal isolates

Topsin-M treated plants produces 100% mycelia growth inhibition (Table 2). All aqueous extract at 100 g/l recorded the highest inhibition percentages. Desert date seed extract (DDSE) at 100 g/l significantly ($P < 0.001$) inhibited the radial growths of both fungi compared to all levels of concentrations of plant extracts used with inhibition percentages of 90.33 and 84.96% in *C. arachidicola* and *C. personatum*, respectively. Even aqueous DDSE at 75 g/l was comparable to neem seed extract (NSE) at 100 g/l but was significantly higher ($P < 0.001$) than 100 g/l of jatropha seed extract (JSE) and tobacco leaf extract (TLE). Apart from DDSE at 100 and 75 g/l, NSE 100 g/l was the next best with percentage mycelia inhibition of 80.88 and 72.32% in both *C. arachidicola* and *C. personatum*, respectively. Different concentrations of tobacco leaf extract at 25, 50, 75 and 100 g/l reduced mycelial growth of both fungi. However, TLE was not as effective compared to DDSE, NSE and JSE in fungi-toxic activity against Cercospora leaf spot diseases (Table 2).

Disease incidence

In both 2014 and 2015 cropping seasons, plants treated with desert date extract (DDSE) recorded the lowest disease incidence with almost the same effect as Topsin-M the positive control from 3 to 7 weeks after planting (Figure 2). Tobacco leaf extract (TLE) recorded the highest. The disease incidence for all the plant extract treatments was generally lower in 2015 compared to 2014. For instance, by 7 WAP in 2014, Neem leaf seed extract (NSE) treated plants had recorded about 50% disease incidence compared to 20% disease incidence during the same period in 2015. By 7 WAP in both seasons, TLE treated plants and those which were treated with neither plant extracts nor fungicide, recorded 100% disease incidence.

Disease severity index

In the field experiment, both early leaf spot (ELS) and late leaf spot (LLS) were more severe in all treatments during 2015 cropping season (Table 3). In 2014 and 2015

Table 2. Effects of plant extracts on mycelia growth of the fungi.

Treatment	Growth inhibition (%)	
	C. arachidicola	*C. personatum*
Topsin-M (1 g/L)	100.00[a]	100.00[a]
Topsin-M (2 g/L)	100.00[a]	100.00[a]
Tops-M (3 g/L)	100.00[a]	100.00[a]
DDSE (25 g/L)	73.43[ef]	71.61[de]
DDSE (50 g/L)	77.94[de]	75.06[cd]
DDSE (75 g/L)	82.16[cd]	78.30[c]
DDSE (100 g/L)	90.33[b]	84.96[b]
JSE (25 g/L)	56.88[ij]	49.92[i]
JSE (50 g/L)	60.56[hi]	59.47[gh]
JSE (75 g/L)	68.71[fg]	62.91[g]
JSE (100 g/L)	75.66[ef]	67.28[ef]
NSE (25 g/L)	58.47[i]	60.20[g]
NSE (50 g/L)	64.35[gh]	64.63[fg]
NSE (75 g/L)	70.15[fg]	70.65[def]
NSE (100 g/L)	80.88[c]	73.32[cd]
TLE (25 g/L)	49.34[l]	54.01[hi]
TLE (50 g/L)	50.57[kl]	56.46[hi]
TLE (75 g/L)	51.53[kl]	57.59[h]
TLE (100 g/L)	54.50[jkl]	59.38[gh]
Control (Water)	0.00	0.00
Fr (*P*)	<0.001	<0.001
LSD (0.05)	6.461	6.583

Means with different letters within the same column are significantly different at 5%. Neem seed extract (NSE), Desert dates seed extract (DDSE), Jatropha seed extract (JSE) and Tobacco leaf extract (TLE).

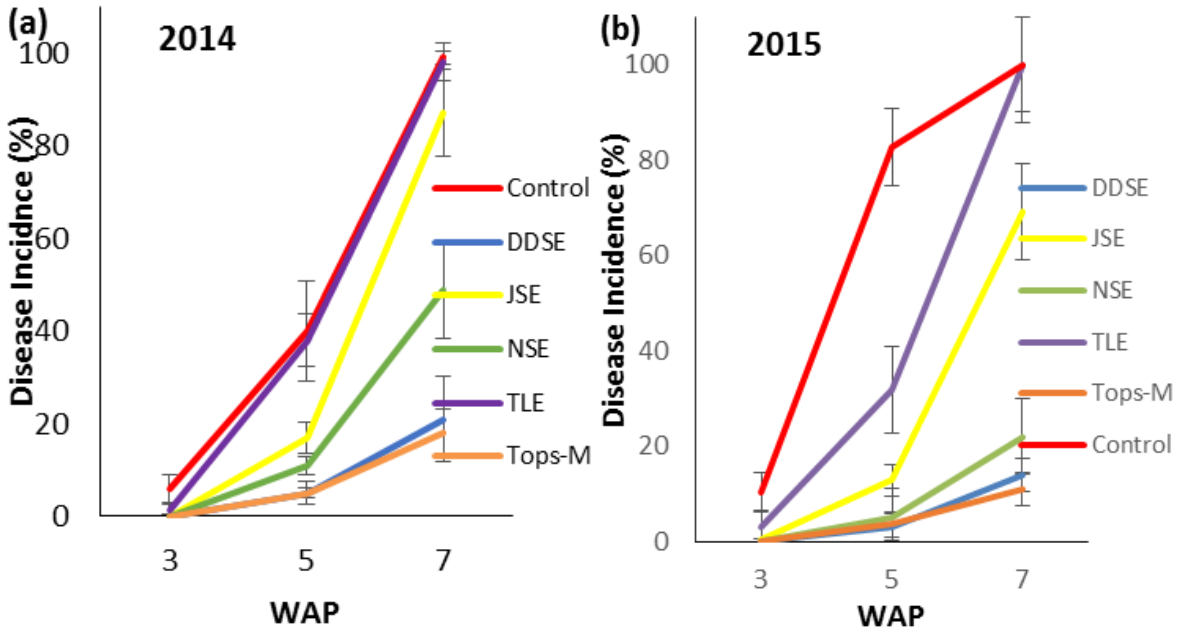

Figure 2. Influence of some botanicals on disease incidence of CLS of groundnut in 2014 and 2015 cropping seasons. Neem seed extract (NSE), Desert Date seed extract (DDSE), Jatropha seed extract (JSE), and Tobacco leaf extract (TLE).

Table 3. Effects of plant extracts on disease severity on three cultivars of groundnut in 2014 and 2015 cropping seasons.

Treatment		Disease severity index (%) cropping seasons			
		Early leaf spot (ELS)		Late leaf spot (LLS)	
Plant extract	**Cultivars**	**2014**	**2015**	**2014**	**2015**
DDSE	Mani-Pinta	22.00^{ab}	23.08^{a}	20.42^{a}	21.42^{ab}
	Bugla	21.42^{a}	22.75^{a}	21.08^{ab}	21.67^{ab}
	Chinese	21.75^{ab}	23.5^{a}	20.00^{a}	21.75^{ab}
JSE	Mani-Pinta	26.5^{abcd}	29.92^{abc}	26.08^{abc}	29.42^{abcd}
	Bugla	25.08^{abcd}	28.08^{ab}	27^{abcd}	29.75^{abcd}
	Chinese	28.5^{bcde}	32.33^{bcd}	26.50^{abc}	30.83^{bcde}
NSE	Mani-Pinta	23.42^{abc}	26.92^{ab}	24.17^{ab}	26.00^{abc}
	Bugla	23.08^{abc}	25.83^{ab}	24.42^{ab}	25.58^{abc}
	Chinese	25.42^{abcd}	29.17^{abc}	24.00^{ab}	27.00^{abc}
TLE	Mani-Pinta	29.58^{cde}	36.33^{cde}	28.17^{abcd}	35.25^{cde}
	Bugla	28.75^{bcde}	32.58^{bcd}	28.33^{abcd}	33.83^{cde}
	Chinese	36.08^{ef}	40.58^{ef}	30.58^{bcd}	38.75^{def}
Topsin-M (positive control)	Mani-Pinta	19.92^{a}	22.83^{a}	19.25^{a}	20.67^{a}
	Bugla	20.33^{a}	22.33^{a}	19.00^{a}	20.33^{a}
	Chinese	21.83^{ab}	24.00^{a}	19.67^{a}	21.00^{ab}
Water (negative control)	Mani-Pinta	30.50^{de}	39.17^{de}	35.08^{de}	39.83^{ef}
	Bugla	29.08^{cde}	35.92^{cde}	33.42^{cde}	37.17^{def}
	Chinese	39.83^{f}	47.28^{f}	42.58^{e}	47.92^{f}
Fr (*P*)		<0.001	<0.001	<0.001	<0.001
LSD (0.05)		7.001	7.754	9.920	10.379

cropping seasons, plants of the three cultivars (Bugla, Chinese and Mani-Pinta) treated with DDSE recorded a significantly lower ($P < 0.001$) severity similar to Topsin-M, whereas those treated with TLE recorded significantly higher ($P < 0.001$) severity comparable to the negative control. A similar trend was observed for the late leaf spot in both seasons

Yield and yield parameters

Plants treated with DDSE in both cropping seasons recorded significantly higher ($P < 0.001$) pod yield while those treated with TLE recorded the lowest (Table 4). However, the pod yield of DDSE treated plants in 2015 (1275 kg/ha) was higher than that in 2014 (931 kg/ha). Significant differences ($P < 0.001$) were observed among the treatments in both seasons except jatropha seed extract (JSE) and neem seed extract which yielded 931 and 1004 kg/ha, respectively but the differences were not significant.

Generally, plants treated with DDSE in both seasons produced heavier seeds than all the other treatments except Topsin-M the positive control (Table 4). Dry seed yield from all treatments in 2015 were higher than those produced in 2014. For instance, seed yield from DDSE treated plants in 2014 and 2015 were 992 and 751 kg/ha, respectively.

In both cropping seasons, DDSE treated plants produced a significantly higher 100 pod weight than all the other treatments except Topsin-M. Plants treated with TLE recorded the least 100 pod weight in both seasons (Table 4).

In 2014 cropping season plants treated with DDSE produced a higher 100 seed weight that all the other treatments but the differences were not significant at 5%. However, in 2015 DDSE treated plants recorded 100 seed weight of 49.82 g which was comparable to that of Topsin-M treated plants (50.72) but significantly higher ($P < 0.001$) than the other treatments (Table 4).

DISCUSSION

Alkaloids, tannins and phenolic compounds were found in all the botanicals used. This confirms the report that plant

Table 4. Effects of plant extracts on 100 pod weight, 100 seed weight, dry pod and seed yields in 2014 and 2015 cropping seasons.

Plant extract	Dry pod yield (kg/ha)		Dry seed yield (kg/ha)		100 pod weight (g)		100 seed weight (g)	
	2014	2015	2014	2015	2014	2015	2014	2015
Desert Date Seed Extracts	931.00^{b}	1275.00^{b}	751.00^{b}	992.00^{a}	87.90^{ab}	87.57^{a}	39.50^{b}	49.82^{a}
Jatropha seed extract	729.00^{c}	931.00^{c}	546.00^{c}	698.00^{b}	75.40^{cd}	56.39^{c}	36.70^{b}	32.86^{c}
Neem Seed Extract	875.00^{b}	1004.00^{c}	688.00^{b}	786.00^{b}	85.30^{bc}	67.07^{b}	37.50^{b}	37.31^{b}
Tobacco leaf Extract	626.00^{c}	692.00^{d}	504.00^{c}	570.00^{c}	74.50^{d}	49.86^{d}	37.20^{b}	30.19^{d}
Topsin-M (positive control)	1095.00^{a}	1322.00^{a}	922.00^{a}	1045.00^{a}	96.80^{a}	88.23^{a}	46.70^{a}	50.72^{a}
Water (negative control)	426.00^{d}	581.00^{d}	306.00^{d}	430.00^{d}	45.70^{e}	49.86^{d}	23.60^{c}	27.67^{d}
Fr (*P*)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	103.6	140.9	80.3	124.9	10.46	5.397	5.21	3.75

extracts contain phytochemicals such as phloretin, tannins, allicins, and azadirachtin which have antimicrobial properties (Gurjar et al., 2012). Desert date seeds, neem seeds and tobacco leaves contained saponins. Terpenoids were detected in neem seeds and tobacco leaves. Neem seeds also contained steroids. Kishore et al. (2001) observed the manifestation of these bioactive compounds in different plant materials. It has been noted that plant extracts with antimicrobial property can be either specific or broad spectrum in action against pathogens (Gurjar et al., 2012).

The fungal pathogens isolated and identified from infected groundnut leaves were *C. arachidcola* and *C. personatum* which are the causative agents of Cercospora leaf spot diseases of groundnut. The conidium of *C. arachidicola* was sub-hyaline or pale yellow, obclavate or cylindrical and septate with a rounded base and sub-acute tip. McDonald et al. (1985) observed related morphological characteristics. However, the conidium of *C. personatum* was obclavate or cylindrical, light coloured and the base was shortly tapered with a conspicuous hilum. This morphological description is similar to that reported by Ijaz (2011).

The *in vitro* studies showed significant differences ($P > 0.001$) among plants treated with various botanicals and the control treatment. The results also indicated that the efficacy of the different extracts is also dependent on the type of plant material. Therefore, the level of inhibitions of *C. arachidicola* and *C. personatum* were dependent on the type of plant extract and concentration level. This conforms to the works of Ibiam and Nwalobu (2016) who postulated that aqueous extract of *Asipilia africana* and *Vernonia amygdalina* decreased the vegetative growth of *Hendersonia celtifolia* as concentration increases. All extracts at 100 g/l especially desert date seed, neem seed and jatropha seed extract significantly inhibited the vegetative growth of the test fungi compared to tobacco leaf extract and control (negative). Again, this confirms the findings of Akinbode (2010) who observed that some botanicals at 100% concentration significantly inhibited the growth of *Curvularia lunata*. However, TLE was not as effective compared to DDSE, NSE and JSE in its fungi-toxic activity against Cercospora leaf spot diseases.

The results showed that plant extracts lowered the disease severity index with desert date seed extract at 100 g/l recording the least severity index percentage which was statistically similar to Topsin-M at 2 g/l. Plants treated with 100 g/l each of DDSE, NSE, JSE and TLE produced heavier pods. This can be attributed to the phytochemicals since some of them are known to induce growth. This supports the work of Ambang et al. (2011) that an increase in the concentration of *Thevetia peruviana* seed extract reduced the rate of spread of Cercospora leaf spot of groundnut.

Groundnut plants of all the three cultivars when sprayed with aqueous desert date seed extract had consistently lower disease incidence and severity in both 2014 and 2015 cropping seasons and the effect was comparable to the positive control (Topsin-M). This was followed by neem seed extract and then jatropha seed extract with tobacco leaf extract being the least. Therefore, the efficacy of the plant extracts could be attributed to the presence of the fungitoxic phytochemicals such as phenolic compounds, steroids and terpenoids. This confirms that phenols and saponins extracted from higher plants possess anti-fungal compounds against various microbes (Halama and Haluwin, 2004). However, the difference in efficacy of the four plant extracts could be attributed to the differences in the nature of their active ingredient (Ngegba et al., 2017). DDSE, NSE, JSE and TLE significantly increased yield parameters including 100 pod weight, 100 seed weight, dry pod and seed yields in both 2014 and 2015 cropping seasons compared to the negative control. This could be attributed to the antifungal properties which retarded or inhibited the activity of the fungi leading to a decrease in disease incidence and disease severity. This could have led to an increase in photosynthetic activity which enhanced vegetative growth, net assimilation and dry matter accumulation, resulting in more yield. The findings of this study support the report by Hossain and Hossain (2013) that plant extracts maximize yield of groundnut

comparative to the control (negative).

Conclusion

Desert date seed, neem seed, jatropha seed and tobacco leaf extracts suppressed the growth of *C. arachidicol*a and *C. personatum*. The studies showed that efficacy increases as concentrations of plants extracts increases and the level of efficacy also depends on the type of plant material used. All concentrations at 100 g/l extracts significantly inhibited the vegetative growth of the test fungi. The use of desert date seed extract (DDSE), neem seed extract (NSE) and jatropha seed extract (JSE) consistently reduced disease incidence and severity of both *C. arachidicola* and *C. personatum* than tobacco leaf extract (TLE) and negative control. However, the most effective plant extract was aqueous DDSE which was nearly as potent as the positive control, Topsin-M in 2014 and 2015 cropping seasons followed by NSE and JSE. Since DDSE was the most effective in both *in vitro* and field studies, it is recommended for the management of Cercospora disease of groundnut by farmers as an alternative to expensive inorganic fungicides.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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