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KOLA POD HUSK ASH SUPPRESSES THE DEVELOPMENT OF LEAF SPOT DISEASE IN FLUTED PUMPKIN (*Telfairia occidentalis* Hook f).

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ABSTRACT

Fluted pumpkin (*Telfairia occidentalis* Hookf) is a highly priced vegetable in Southern Nigeria where it is cultivated for its tender vines and leaves, and for its oil rich seeds. Leaf spot disease induced by a variety of fungi hinders the production of high quality crops. Whereas synthetic fungicide have been suggested for its control, scarcity, high cost and environmental and human health risks associated with injudicious use of conventional pesticides have hindered their use by resource poor farmers who are the major producers of the crop. In this study, ash from Kola pod husk - an agricultural by-product was evaluated for its disease suppressing potential against the development of two major leaf spot pathogens *Phomasorghina* and *Curvularia* species in *Telfairia* under Screen house and field conditions. Three ash concentrations (1.5, 3.0 and6.0gL^{-1}) were applied on artificially inoculated plants at 3, 6 and12 hours after pathogen inoculation in Screen house studies, and at first appearance of disease symptom in field experiment. The Screen house experiment was a 4 × 3 factorial laid out in a randomized complete block design with four replications whereas the field experiment was laid outin a randomized complete block design (RCBD) replicated five times. Disease incidence and severity were assessed weekly for three weeks from the time of ash application. Data were subjected to analysis of variance (ANOVA) and significant means compared by Fisher's Least Significant Difference (F-LSD) at $p \le 0.05$. Results showed that ash application suppressed leaf spot development with suppression being significantly ($p \ge 0.05$) highest in early application and least in late application. Similarly, disease suppression was concentration dependent being significantly ($p \le 0.05$) highest at 6.0 gL^{-1}. Leaf yield was also significantly ($p \le 0.05$) highest at 6.0gL^{-1} ash treatment. Ash treatment equally enhanced the acceptability index in treated plants.

Keywords: Kola pod ash, Leaf spot, Disease suppression, *and Telfairia occidentalis.*

1. INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis* Hook. F.) is an important vegetable widely cultivated in the forest zone of west and central Africa (Schippers 2002, Olaniyi and Oyerele, 2012). It is grown for its nutritive leaves and seeds and has nutritional, industrial and medicinal values (Okoli and Mgbeogwu, 1983; Fasuyi, 2006; Akanbi*et al*., 2006). In south eastern Nigeria, fluted pumpkin occupies an important position in the dietary and cropping systems of the Igbos (Olaniyi andOyerele2012) and play an important role in the economy of the producing areas where it is a high income earner for the farmers (Udo *et al*., 2013b).However, the production of this crop is hampered by poor soil fertility, pests and diseases.

Leaf spot disease caused by a variety of fungi pathogens is the most serious disease affecting the economic production of fluted pumpkin. It usually affects the leaves producing colour changes and shot holes which lead to low photosynthesis and hence reduced productivity and market value of the crop (Nwufo and Ihejerika,2008; Udo *et al*., 2013a). Reductions in nutrient elements and vitamins have also been associated with infection (Udo*et al*., 2013b). Besides synthetic fungicides (Nwufo, 1991).cultural methods such as intercropping and leaf removal (Nwufo and Ihejerika 2008; Godwin – Egein *et al*., 2015) and plant extracts and ashes (Ihejirika *et al*., 2010; Udo *et al*., 2013; Osai *et al*., 2013) have been reported to have varying effects on the control of leaf spot diseases. However, whereas synthetic fungicides are scarce, expensive, require expertise and sometimes accompanied with risks to human health and the environment; some of the plant materials so far reported effective in disease control are edible spices and medicinal plants whose economic exploitation for disease control may create demand pressure on them.In addition Eze and Maduewesi (1990) reported that thefungi toxic efficacy of plant ashes varied with the source plants. There is therefore the need to evaluate more plants and agricultural by –products for their potency and efficacy in disease control.

Kola (*Cola nitida* (vent) Schott &Endel) is a member of the family sterculiaceae cultivated for its alkaloid (caffeine and theobromine) rich cotyledons (nuts). At harvests, these cotyledons are exercised from the fruits and the pod husks and fleshy sugary testa are left as waste in the environment (Opeke, 1992). Against the background of a previous report that showed the fungi toxicity of ash obtained from kola pod husk against *Phoma sorghina* (Sacc) Boerenna, Dorenboschi & van Kest and *Curvularia* species causing leaf spot disease in fluted pumpkin, experiments were conducted to evaluate the ability of kola pod husk ash to suppress leaf spot development *in vivo* in both Screen house and field conditions.

2. MATERIALS AND METHODS

The disease suppressing potential of kola pod husk ash in fluted pumpkin was evaluated in both Screen house and field experiments.

2.1 Preparation of kola pod husk ash.

Pod husks of *C. nitida* were collected from local farmers in Ikom Local Government Area of Cross River State, Nigeria. The husks were cut into small pieces and sun dried for ten days and burnt to yield ash. The ash was sieved through 2mm seized mesh and stored in air tight containers until used.

2.2 Screen House Experiment

2.2.1 Preparation of pathogen inoculum

Two leaf spot pathogens – *Phoma sorghina* (Sacc) and C*urvularia* sp. previously isolated from infected fluted pumpkin leaves and maintained on Potato dextrose agar (PDA) slants were used for this study. Each fungus was grown on potato dextrose agar plates for ten days in the dark at 26±2°C and the spores harvested. Cultures of the fungal isolates were comminuted with 100 mL of sterile distilled water using porcelain Pestle and mortar, and filtered with 0.2×0.2mm nylon mesh. The sporeconcentration in the filtrate was estimated and adjusted with sterile distilled water to a final concentration of 4.0×10^8spores per L using a Haemocytometer (Neubauer-improved 0630010 model)

2.2.2 Establishment of fluted pumpkin plants

Fluted pumpkin plants used in this study were grown in heat pasteurized (160°C for three hours) garden soil contained in 20×12×0.04cm perforated black plastic bags. One seed of a local variety "Afia –Ubong" of fluted pumpkin was sown per bag.

2.2.3 Spore inoculation and ash application

Two hundred uniformly growing plants *Telfairia* were selected from a population of three week old plants (Maduewesi, 1977) and arranged factorially in a randomized complete block design within the Screen house. The two lower leaves of each plant were then removed and the others wounded by pricking with sterile inoculating needles. Wounded leaves were immediately sprayed with spore suspension(4.0×10^8 spores per L) of either *P. sorghina* or *Curvularia sp.* and covered with polyethylene sheets. At 3,6,and12 hours after spore inoculation, ash suspension was applied to inoculated plants at 1.5, 3.0 and 6gL^{-1} using a hand operated mist blower until run off with the polyethylene sheets replaced immediately thereafter and left for 24 hours. Five inoculated plants were sprayed in each spray time per concentration while unsprayed inoculated plants served as control.

2.3 Disease assessment

The effect of kola pod husk ash on disease development was measured at 7, 14 and 21 days after ash application. Disease control was measured in terms of reduction in disease incidence and disease severity index. Whereas disease incidence was expressed as counts of infected plants in the population inoculated, disease severity index was measured in terms of number of leaf spot lesions per leaf and the proportion of the infected leaf lamina following the 6 point (0-5) scale of Maduewesi (1977), and Onuegbu and Dimkpa (2010) but in which 1 was substituted for 0 thus 1=no symptom and 6= >75% of the leaf covered with lesions to completely dead leaves (very severe). Percentage Disease suppression was estimated thus:

$$\% DS = \frac{DIA - DIC}{DIC} \times 100$$

OR

$$\% DS = \frac{SIA - SIC}{SIC} \times 100$$

Where
DS=Disease suppression
SIA= Disease severity in ash treatment.
DIC= Disease incidence in control.
SIC= Disease severity in control.

2.4 Field experiment

Field experiments were conducted in the early planting season of 2013 and 2014 to evaluate the efficacy of kola pod husk ash in the control of leaf spot under natural infection. The experiments were carried out at the Crop Research Farm of the Department of Crop Science, University of Calabar, Calabar, Nigeria. The area lies between latitude 5° 32' and 4°27'' N, and between longitude 7°15' and 8° 18'E and 99m above sea level. It has a bi-modal rainfall pattern with total annual rainfall of 2500-3000mm, mean annual temperature of between 23°C and 33°C and relative humidity of 80 to 90 % (CRSNMANR, 1989). The soil is a sandy loam of the ultisol class (Esu 2010), acidic (pH (H_2O) 5.7) and contained 1.1% organic Carbon,0.11% total nitrogen, 6.6mgKg^{-1}available P, and exchangeable Na, K and Ca of 0.05,0.08 and 0.04cmolKg^{-1}respectively,as well as ECE of 77% before planting.

2.4.1Land preparation and planting

The experimental plot was cleared with Machete and tilled with a spade. Poultry manure (5 t ha^{-1}) was spread uniformly on the plots and incorporated into the soil two weeks before planting. Seeds of the local variety "Afia-Ubong" were purchased and cured for 24hrs before planting at 2-3cm depth and 1 m× 1m spacing in 5 m × 4m plots. Two seeds were planted per hole and later thinned to one plant per stand (10000 plants per hectare) in April of each year. Weeding was done every three weeks with a hand hoe

2.4.2 Treatment application

Kola pod husk ash was applied as water suspension at 0.0, 1.5, 3.0 and 6.0 gL^{-1} concentrations at the first appearance of disease symptom (3-4 weeks after planting). Carbendazim50 WP was applied at 3.0g a.i. L^{-1} as positive check. Treatments were applied with a hand sprayer. Data on disease incidence, disease severity index, acceptability indexand leaf yield were collected from the two central rows in each treatment. Data on disease incidence and severity index were collected at 21 days after ash application while yield data were collected at 10 weeks after planting. Acceptability index was based on the 6 point scale of Onuegbu and Bello (2011) where 1= Total loss of value, 2= Very high loss of value, 3= High loss of value, 4= Loss of value, 5= Valuable, 6=Very valuable

2.4.3 Experimental design, data collection and analysis

Screen house experiments were a two factor factorial arranged in a randomized complete block design (RCBD) with four replicates. The two factors were ash concentration (0.0, 1.5, 3.0, and 6.0 gL^{-1}) and time of application (3, 6 and 12 hours after pathogen inoculation (HAI)). There were fifty plants per replicate. Randomized complete block design (RCBD) was adopted for the field experiments with five replications. The treatment consisted of ash concentrations (0.0, 1.5, 3.0 and 6.0 gL^{-1}) and Carbendazim at 3.0 g a.i. L^{-1}. Data collected were subjected to analysis of variance (ANOVA). Before analysis, disease incidence data were transformed using logtransformation (log(x+1)) to account for zero values. Significant means were compared using Fisher's Least Significant Difference (F-LSD) at 5% probability level. All analysis followed GenSTAT,2014 software package

3. RESULTS

The effect of Kola pod husk ash on the development of *Curvularia* and *P. sorghina* leaf spot disease with artificial inoculation is shown in Tables1 – 5. The results show that ash at all tested concentrations significantly ($p \leq 0.05$) reduced leaf spot incidence and severity and suppressed the disease. Disease suppression was concentration dependent increasing with increase in concentration. Irrespective of the spray interval, 6.0 g L^{-1} completely suppressed *Curvularia* leaf spot throughout the study period (Tables 1 and 2).

Table 1. The effect of different concentrations and spray intervals of kola pod husk ash on the incidence of *Curvularia* induce leaf spot at 7, 14 and 21 DAI*

Ash Con ($mgmI^{-1}$)	7 DAI Spray intervals 3HAI**	6HAI**	12HAI**	Mean
0.00	12.0. (3.00)	16.0(3.77)	16.0(3.77)	14.7(3.51)
1.50	8.0 (2.24)	12.0(3.00)	12.0(3.00)	10.7(2.77)
3.00	4.0 (1.47)	4.0(1.47)	8.0(2.24)	5.3(1.73)
6.00	0.0 (0.71)	0.0(0.71)	0.0(0.71)	0.0(0.71)
Mean	6.0 (1.86)	8.0(2.24)	8.0(2.24)	
		14 DAI		
0.00	16.0(3.77)	16.0(3.77)	16.0(3.77)	16.0(3.77)
1.50	8.0(2.24)	12.0(3.00)	12.0(3.00)	10.7 (2.77)
3.00	4.0(1.47)	4.0(1.47)	8.0(2.24)	5.3 (1.73)
6.00	0.0(2.05)	0.0(0.71)	0.0(0.71)	0.0 (0.71)
Mean	7.0(2.05)	8.0(2.24)	8.0(2.24)	
		21 DAI		
0.00	16.0(3.77)	16.0(3.77)	20.0(4.53)	17.3 (4.02)
1.50	8.0(2.24)	12.0(3.00)	16.0(3.77)	12.0 (3.00)
3.00	4.0(1.47)	4.0(1.47)	8.0(2.24)	5.3 (1.73)
6.00	0.0(0.71)	0.0(0.71)	0.0(0.71)	0.0 (0.71)
Mean	7.0(2.05)	8.0(2.24)	11.0(2.81)	

		7DAI	14DAI	21DAI
LSD(.0.05) Comparing ash concentration means	=	0.72	0.50	0.49
LSD(0.05) Comparing spray intervals means	=	ns	0.15	0.12
LSD(0.05) Comparing ash con, and spray inter, means	=	ns	ns	0.18

Values in parenthesis are square root transformed data to which LSD (0.05) values apply
DAI* = Days After Inoculation
HAI** = Hours After Inoculation

Table 2. The effect of different concentrations and spray intervals of kola pod husk ash on the severity of *Curvularia* induce leaf spot at 7, 14 and 21 DAI*

Ash Con ($mgmI^{-1}$)	7 DAI Spray intervals 3HAI**	6HAI**	12HAI**	Mean
0.00	2.20	2.40	2.60	2.40
1.50	2.00	2.20	2.40	2.20
3.00	1.60	2.00	2.20	1.93
6.00	1.00	1.00	1.00	1.00
Mean	1.75	1.85	2.05	
		14 DAI		
0.00	2.40	2.60	2.80	2.60
1.50	2.00	2.20	2.40	2.30
3.00	1.60	2.00	2.20	1.93
6.00	1.00	1.00	1.00	1.00
Mean	1.90	1.95	2.10	
		21 DAI		
0.00	2.80	3.00	3.20	3.00
1.50	2.20	2.20	2.60	2.33
3.00	1.60	2.00	2.20	1.93
6.00	1.00	1.00	1.00	1.00
Mean	1.90	2.05	2.20	

		7DAI	14DAI	21DAI
LSD(.0.05) Comparing ash concentration means	=	0.31	0.31	0.24
LSD(0.05) Comparing sprat intervals means	=	ns	0.10	0.15
LSD(0.05) Comparing ash con, and spray inter, means	=	ns	0.54	0.41

Values in parenthesis are square root transformed data to which LSD (0.05) values apply
DAI* = Days After Inoculation

HAI** = Hours After Inoculation

Leaf spot incidence in 3.0 g L^{-1} sprayed plants was identical within each spray intervals being significantly ($P \leq 0.05$) highest (8 plants) at 12hrs throughout the study period (Table 1). Ash at 1.5g L^{-1}significantly ($p \geq 0.05$)produced the highest number of infected plants in all spray intervals. Ash application beyond 3 hrs after pathogen inoculation (3HAI) increased disease incidence. There was however no statistical ($p \geq 0.05$) difference in the number of infected plants between 6 hr and 12 hr application of 1.5 g L^{-1}, and between 3 hr and 6 hr application of 3.0 g L^{-1} ash within the first two weeks of inoculation (Table1). Interaction between ash concentration and spray interval had no significant ($p \geq 0.05$)effect on disease incidence at 7 and 14 DAI. Plants sprayed at 6 and 12 HAI had significantly ($p \leq 0.05$) higher disease severity index at 14 and 12 DAI (Table 2). Also, whereas the interaction between ash concentration and spray interval did not significantly ($p \geq 0.05$) affect disease severity at 7 DAI, it significantly reduced disease severity at 14 and 24 DAI.

Phoma sorghina-induced leaf spot disease was completely inhibited by 6.0 g L^{-1} treatment when applied at 3 and 6 HAI (Table 3). The application of 3.0 g L^{-1} at 3, 6 and 12 HAI produced same number of infected plants within the first two weeks of inoculation. However, application of 1.5 and 6.0 g L^{-1} ash at 12HAI had significantly ($P \leq 0.05$) higher number of diseased plants (Table 3).

Disease incidence was also highest with late application of 3.0 g L^{-1} at 21 DAI. Disease severity index was significantly ($P \leq 0.05$) lower with high ash concentrations (Table 4).

Table 3. The effect of different concentrations and spray intervals of kola pod husk ash on the incidence of *P.sorghina*- induced leaf spot at 7, 14 and 21 DAI*

Ash Con (mgmI^{-1})	7 DAI			
	Spray intervals			
	3HAI**	6HAI**	12HAI**	Mean
0.00	16.0(3.77)	16.0(3.77)	20.0 (4.53)	17.3 (4.02)
1.50	12.0(3.00)	12.0(3.00)	16.0(3.77)	13.3(3.25)
3.00	8.0(2.44)	8.0(2.44)	8.0(2.24)	8.0(2.24)
6.00	0.0(0.71)	0.0(0.71)	4.0(1.47)	1.3(0.96)
Mean	9.0(2.48)	9.0(2.48)	12.0(3.05)	
		14 DAI		
0.00	16.0(3.77)	20.0(4.53)	20.0(4.53)	18.7(4.28)
1.50	12.0(3.00)	12.0(3.00)	16.0(3.77)	13.3(3.25)
3.00	8.0(2.44)	8.0(2.24)	8.0(2.24)	8.0(2.24)
6.00	0.0(0.71)	0.0(0.71)	4.0(1.47)	1.3(0.96)
Mean	9.0(2.48)	10.0(2.62)	12.0(3.00)	
		21 DAI		
0.00	20.0(4.53)	20.0(4.35)	20.0(4.53)	20.0(4.53)
1.50	12.0(3.00)	12.0(3.00)	20.0(4.53)	14.67(3.51)
3.00	8.0(2.24)	12.0(3.00)	12.0(3.00)	10.67(2.75)
6.00	0.0(0.71)	0.0(00.71)	4.0(1.47)	1.3(0.96)
Mean	10.0(2.62)	11.0(2.81)	14.0(3.47)	

		7DAI	14DAI	21DAI
LSD(.0.05) Comparing ash concentration means	=	0.55	0.58	0.50
LSD(0.05) Comparing sprat intervals means	=	0.46	0.20	0.24
LSD(0.05) Comparing ash con, and spray inter, means	=	0.71	0.60	0.25

Values in parenthesis are square root transformed data to which LSD (0.05) values apply

DAI* = Days After Inoculation

HAI** = Hours After Inoculation

Table 4: The effect of different concentrations and spray intervals of kola pod husk ash on the severity of *P. sorghina*-induced leaf spot at 7,14 and 21 DAI*

Ash Con (mgmI-1)	7 DAI			
	Spray intervals			
	3HAI**	6HAI**	12HAI**	Mean
0.00	3.00	3.20	3.40	3.20
1.50	2.80	3.00	3.20	3.00
3.00	2.40	2.60	3.00	2.67
6.00	1.00	1.00	2.00	1.33
Mean	2.30	2.45	2.90	
		14 DAI		
0.00	3.40	3.40	3.80	3.53
1.50	2.80	3.20	3.60	3.20
3.00	2.40	2.60	3.20	2.73
6.00	1.00	1.00	2.00	1.33
Mean	2.40	2.55	3.15	
		21 DAI		
0.00	3.80	3.80	4.00	3.87
1.50	2.80	3.20	3.60	3.20
3.00	2.40	2.60	3.20	2.73
6.00	1.00	1.00	2.00	1.33
Mean	2.50	2.65	3.20	

		7DAI	14DAI	21DAI
LSD(.0.05) Comparing ash concentration means	=	0.31	0.26	0.27
LSD(0.05) Comparing sprat intervals means	=	0.27	0.25	0.20
LSD(0.05) Comparing ash con, and spray inter, means	=	ns	0.40	0.18

Values in parenthesis are square root transformed data to which LSD (0.05) values apply
DAI* = Days After Inoculation
HAI** = Hours After Inoculation

Similarly, ash application at 3 HAI produced the least disease severity index. This was however, not significantly ($P \geq 0.05$) different from the disease severity index at 6 HAI application. At 7 DAI, interaction between ash concentration and spray time had no effect statistically ($P \geq 0.05$) on disease severity index.

Results in Table 5 show the percentage disease suppression in *Curvularia* and *P. sorghina*-inoculated plants. *Curvularia* leaf spot disease incidence was suppressed by between 27.2 and 100.0% while *P. sorghina* leaf spot was suppressed between 23.3 and 93.4%. Disease severity index was equally reduced by between 8.2 and 74.4% in *Curvularia*- inoculated plants and between 6.3 and 62.5% in *P. sorghina*-infected plants among ash concentrations. Disease suppression due to application time was between 58.3 and 75.0% and 53.3 and 66.7% among *Curvularia* and *P. sorghina*-inoculated plants respectively (Table 5). Generally, disease suppression was highest with early (3 HAI) application and lowest with late (12 HAI) application. Severity index reduction also followed a similar trend at between 17.6 and 47.9% in *Curvularia*- infected plants. On the whole, the highest disease suppression was recorded at 21 DAI at all levels of concentrations and spray intervals. *Curvularia* leaf spot disease incidence was suppressed by between 36.6 and 100% among ash concentrations and between 60.0 and 75 % among spray intervals respectively on 21 DAI. Disease suppression due to ash application in *P. sorghina*- infected plants was in the range of 26.7 - 93.3% and 25.8 - 62.3% for disease incidence and severity respectively on 21 DAI.

Disease incidence and severity were significantly ($P \leq 0.05$) lower in ash and carbendazim- treated plants under natural infection. Suppression in disease incidence was 15.2 to 62.1 % in 2013 and 12.4 – 63.2 % in 2014 (Table 6). Similarly, reduction in disease severity index was 21.6 – 52.4 % and 26.1 – 56.4 % in 2013 and 2014 respectively. Among ash concentrations, disease incidence was statistically ($P \leq 0.5$) lower in 6.0 g L^{-1} than in other concentrations during both years of study. Differences in disease incidence and severity between 6.0 g L^{-1} and carbendazim were not significant ($P \geq 0.05$) in both years. There was significant ($P \leq 0.05$) increase in leaf yield with 3.0, 6.0 g L^{-1} and carbendazim treatments in both years of this study (Table 6). Acceptability index of infected leaves harvested from plots treated with 3.0, 6.0 gL^{1} ash and carbendazim was between 5.0 and 5.8 in both years as compared with 2.6 – 3.0 and 3.8 for leaves harvested from untreated and 1.5 g L^{-1} ash treated plots respectively (Table 6).

Table 5: Percentage disease suppression by different concentrations (gL^{-1}) of Kola pod ash and spray intervals (Hrs) after 7, 14 and 21 days of inoculation (DAI) with *curvularia*sp and *Phoma sorghina*.

Ash conc. (g L^{-1})	*Curvularia* sp						*P. sorghina*					
	Disease incidence			Disease severity index			Disease incidence			Disease severity index		
	Days After Inoculation			Days After Inoculation			Days After Inoculation			Days After Inoculation		
	7	14	21	7	14	21	7	14	21	7	14	21
1.5	27.2	33.1	31.6	8.3	13.3	22.3	23.3	28.9	26.7	6.3	9.4	25.8
3.0	63.9	66.8	69.3	19.4	25.8	55.0	53.3	56.19	47.7	18.8	22.7	29.3
6.0	100.0	100.0	100.0	58.3	74.4	61.2	93.4	93.3	93.3	92.5	62.3	62.3
Spray interval (hrs)												
3	66.7	75.0	75.0	31.3	39.2	47.9	58.3	58.3	66.7	30.3	36.1	42.8
6	66.7	66.7	66.7	21.5	33.3	40.3	58.3	66.7	60.0	27.8	33.2	42.2
12	58.3	58.3	60.0	17.6	21.1	35.0	53.3	53.3	40.0	28.2	33.3	39.6

Table 6: Effect of Kola pod husk ash and carbendazin spray on disease incidence, severity index, yield and acceptability index of *T.occidentalis* under field conditions in 2013 and 2014.

Ash conc. (g L^{-1})	2013				2014			
	Disease Incidence (%)	Severity index	Leaf yield [a] (t ha^{-1})	Acceptability index [b]	Disease incidence (%)	Severity index	Yield (t ha^{-1})	Acceptability index
0.0	62.6	4.2	2.11	3.0	65.4	4.5	2.80	2.6
1.5	53.7(15.2)	3.3(21.4)	2.78	3.8	57.2(12.4)	3.4(26.1	3.22	3.8
3.0	33.6(46.7)	3.1(26.1)	3.14	5.0	38.5(40.8)	2.8(34.8)	4.24	4.8
6.0	28.4(53.9)	2.2(48.2)	4.32	5.6	28.2(57.1)	2.4(47.8)	5.46	5.6
Carbendazin								
3.0	23.7(62.1)	2.0(52.4)	4.38	5.8	24.1(63.2)	2.0(56.4)	5.58	5.8
LSD (≤0.05)	5.6	0.60	0.86		6.2	0.76	1.1	

[a]Severity was scored on 1-6 point scale after Maduewesi (1977)
[b]Acceptability index was scored on 6 point scale after Onuegbu and Bello (2011)
[c]Values in brackets represent percentage disease reduction.

4. DISCUSSION

Kola pod husk ash suppressed the establishment of *Curvularia sp. and P. sorghina*- induced leaf spot disease under artificial inoculation. This is consistent with previous report of Osai *et al.* (2016b) on the *in vitro* toxicity of kola pod ash against these pathogens. Earlier workers (Eze and Maduewesi, 1990, Osai and Ikotun, 1996, Asuquo *et al.*, 2002, Osai *et al,* 2013, Nwagbara *et al.*, 2013) have reported similar fungitoxicity of ashes from other plants.

Ash efficacy was concentration dependent, being more potent with increasing concentrations in this study. This is in agreement with the results of previous workers (Asari-Bediako *et al., 2007*; and Osai, 2009) who reported similar concentration-dependent ash efficacy with *Senna seamea (L),* banana, oil palm and plantain ashes. Time of ash application equally affected the efficacy of kola pod husk ash. Early application at 3 HAI was more effective than other application times. This may be due to the ability of the ash to completely inhibit or significantly suppress spore germination efficiency of the pathogen.

Kola pod husk ash equally suppressed leaf spot disease, enhanced leaf yield and acceptability index of harvested infected leaves in field experiments. Osai and Ikotun (1996), Asari-

Bediako *et al.* (2007); Osai (2009) and Nwagbara *et al.* (2013) have reported rot suppression in yam minisetts treated with different plant ashes. Kola pod ash toxicity and disease suppression may be explained by its high alkaline nature. The pH value of the ash used in this study was 9.7-10.8 in water solution.Similar high pH value (11.73) was reported for *S. seamea* (Asari-Bediako *et al.*, 2007). Asuquo *et al.* (2002) attributed disease suppression by plant ash in their study to the presence of phenols, Na, K, P, in the ashes used. The presence of Na, K, P, Mg, and Ca previously reported (Osai *et al.*, 2016b) in the kola pod husk ash sample used in this study may therefore explain its disease suppressing efficacy in the present study.

Furthermore, interaction between ash concentration and spray interval showed that higher ash concentration applied early (3 HAI) suppressed disease incidence and severity to the lowest.This suggests that concentration and time of control are important in disease management with kola pod husk ash.

5. CONCLUSION

In conclusion, this study has shown the potential of kola pod husk ash for the control of leaf spot disease complex in fluted pumpkin. Application of 6 g L^{-1} ash at first appearance of disease symptom was more effective in disease control than 3.0 g L^{-1} and was comparable with carbendazim treatment and may therefore be used by resource- poor farmers to suppress leaf spot disease and increase yield in fluted pumpkin

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