Crop Protection xxx (2016) 1–8

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Cowpea scab disease (*Sphaceloma* sp.) in Uganda

Emmanuel Afutu [a, *], Eric E. Agoyi [a], Robert Amayo [b], Moses Biruma [b], Patrick R. Rubaihayo [a]

[a] *Department of Agricultural Production, School of Agriculture, College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda*
[b] *National Semi-Arid Resources Research Institute (NaSARRI), Serere, Uganda*

ARTICLE INFO

Article history:
Received 20 October 2015
Received in revised form
29 June 2016
Accepted 30 June 2016
Available online xxx

Keywords:
Vigna unguiculata
Sphaceloma sp.
Elsinoe
Incidence
Severity
Distribution

ABSTRACT

Cowpea (*Vigna unguiculata* L. Walp) is the third most important legume food crop in Uganda. It is the main legume food crop in the Eastern and Northern regions of the country, however, its mean yield is less than 400 kg ha^{-1}. Scab (*Sphaceloma* sp.) which is a seed-borne disease is one of the major constraints of cowpea production in the country, capable of causing yield losses of up to 100%. Cowpea scab is the anamorph of *Elsinoe phaseoli* in common bean (bean scab). The disease affects all the above ground parts of the cowpea plant. A study was conducted in the country to determine the incidence, severity and distribution of scab disease in 17 cowpea growing districts across three agro-ecological zones over a two year period. The results indicated that scab disease was widespread in all the districts with mean incidence ranging between 35 and 70% and mean severity 2–4. Tororo and Amuria districts had the highest incidence and severity, while Bukedea and Arua districts recorded the least disease incidence and severity. Cowpea fields located at altitudes above 1200 m.a.s.l had the highest mean disease incidence (82%) and severity (score = 3.4), while fields located on altitudes lying between 771 and 990 m.a.s.l registered the least disease incidence (64.7%) and severity (score = 2.7). The type of cultivar grown and cropping system practiced influenced the incidence and severity of the scab disease. The results of this study also showed that scab had high incidence and severity across districts and altitudes in Uganda suggesting the need to develop resistant cultivars. This indicates the need to establish the variability of the pathogen to inform the breeding programme for development of resistant varieties.

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is the most economically important indigenous African legume crop (Langyintuo et al., 2003). It is grown in more than 60 countries either as a food crop or cash crop (Davis et al., 1991) occupying parts of Asia and Oceania, the Middle East, Southern Europe, Africa, Southern USA, Central and South America (Singh et al., 2003). According to Ba et al. (2004), Africa is the main area of production, where the crop is very important for low input agriculture which is a characteristic of most parts of the continent.

In Uganda, cowpea is the third most important legume food crop after the common beans (*Phaseolus vulgaris* L.) and groundnuts (*Arachis hypogea* L.), however, it is the main legume food crop in the Eastern and Northern regions (Nabirye et al., 2003) where it accounts for most of the production in the country (FAO, 1997). The mean yield of the crop is less than 400 kg ha-1 (CCRP, 2012) with annual production estimated at 20,000 t/yr.

Cowpea farmers face several adverse factors in growing the crop (Asiwe et al., 2005) for example, in Nigeria (Singh et al., 2003) and Uganda (Rusoke and Rubaihayo, 1994) where diseases are a major production constraint. Insect pests have also been reported as a major production constraint in Uganda (Karungi et al., 2000) and Nigeria (Singh et al., 2003). According to Allen (1983), about 40 species of fungi are pathogens of cowpea. Mbong et al. (2012), described scab as one of the most destructive diseases of cowpea that was capable of causing yield losses of up to 100% in epidemic infections. Cowpea scab (*Sphaceloma* sp.) is the anamorph of *Elsinoe phaseoli* in common bean (bean scab). Allen (1983) suggested that scab of cowpea is widespread in Tropical Africa and is a major disease in Savannah areas, and is seed-borne. The disease affects all the above ground parts of cowpea (Plate 1). Symptoms of leaf infection include the appearance of spots on both leaf surfaces and

* Corresponding author. Permanent address: Department of Crop Science, School of Agriculture, College of Agriculture and Natural Sciences, University of Cape Coast, Cape Coast, Ghana.
E-mail address: mmanuelaf@yahoo.com (E. Afutu).

http://dx.doi.org/10.1016/j.cropro.2016.06.024
0261-2194/

cupped, small greyish scab lesions along the veins (Iceduna, 1993). The lesions coalesce and cause distortions or rugged appearance under severe infections. Infected stems show oval to elongated silver grey lesions surrounded by red or brown elliptical rings while infected pods show sunken spots with grey centres surrounded by brown borders, malformations, and dark coloured pycnidia formed in the brown spots (Singh and Allen, 1979). Conditions conducive for disease development have been described as moderate temperatures of about 23–28 °C, with three or more consecutive days of wet weather resulting in high relative humidity (Emechebe, 1980).

Though disease assessment is one of the most challenging tasks in working with plant diseases, it is the most important task in the study of plant diseases (Campbell and Neher, 1994). The incidence and severity of fungal diseases, as well as the prevalence rates have been found to be influenced by many factors. These factors have broadly been categorized into three which are, factors relating to the host plant, the pathogen and the environment (Agrios, 2005). The occurrence and the intensity of the disease are dependent on how these three factors interact. However, environmental factors have traditionally been considered to have the most impact on disease development (Keane and Kerr, 1997). According to Cooke and Whipps (1993), infection and disease occurrence on plants due to air-borne fungi are favoured by temperatures ranging between 15 and 40 °C. Atmospheric moisture is generally the single most important environmental factor influencing the incidence and severity of fungal diseases on plants (Talley et al., 2002).

Practices such as the planting density has also been found to affect the incidence and severity of fungal diseases. Gautam et al. (2013) indicated that an increase in biomass can modify the microclimate and affect the risk of infection. On the whole, an increase in plant density is said to increase the duration of leaf surface wetness and regulate temperature, thereby making infection by foliar pathogens more likely (Yáñez-López et al., 2012; Gautam et al., 2013). The recommended spacing for cowpea has been given as 50 × 20, 75 × 20 and 75 × 30–50 cm for erect, semi-erect and creeping types respectively (Dugje et al., 2009). The cultivar of cowpea grown, the source of seeds for planting and other husbandry practices may also influence disease incidence and severity (West et al., 2001). Studies on the scab disease in Uganda commenced in 1988 when the disease was reported to be rife in the Country in the preceding years (Takan, 1988). Successive studies on the disease were carried out by Iceduna et al. (1994), Nakawuka and Adipala (1997) and Tumwegamire et al. (1998) but since then, no other studies on the disease was considered until resurgence of the disease in the Country in 2010 necessitating further research on the disease by the National Semi-Arid Resources Research Institute (NaSARRI) and to develop resistant varieties to the disease as there is currently no improved cultivar resistant to the disease in the Country. There was therefore a need to conduct studies on the occurrence and distribution of the scab disease under different ecological zones in the major cowpea growing areas of Uganda to generate information that will serve as basis for the breeding programme.

2. Methodology

Field surveys were conducted in two years (2013 and 2014) within the major cowpea growing areas in Uganda. Fifteen districts were surveyed in 2013 (Fig. 1a.) while 14 districts were surveyed in 2014 (Fig. 1b). Twelve districts were common to both years of study while five districts (three for 2013 and two for 2014) had only one year data (two seasons combined). The dropping or adding of new districts in the 2014 study were based on new reports received on high occurrence of the disease on some farmers' fields within some Districts which were not covered in 2013. A total of 17 districts covering three (3) Agro-ecological Zones were surveyed. Districts under the Eastern Agro-ecological Zones (EAEZ) were surveyed in May 2013 and November 2014 while the districts within the North-Eastern Savanna Grasslands (NESG) and North-Western Savannah Grassland (NWSG) were surveyed in November 2013 and December of 2014 reflecting the differences in time of planting across the regions and the need to take observations at mid-podding stage. The average rainfall for the EAEZ, NESG and NWSG are 875 mm–1125 mm, 1250 mm–1500 mm and 875 mm–1250 mm respectively (NEMA, 2009). The number of districts surveyed under the various Agro-Ecological Zones were chosen in consultation with the Cowpea Breeding Programme at the National Semi-Arid Resources Research Institute (NaSARRI) on the basis of the size of the Agro-Ecological Zones and the areas where the cowpea crop is mostly grown in the districts. A total of 87 Sub-Counties (45 in 2013 and 42 in 2014) were selected across the districts and from each Sub-County, three cowpea farms were selected based on the purposive sampling technique of Gray et al. (2007). In all, a total of two hundred and sixty one (261) cowpea farms were surveyed. Data were collected on the incidence and severity of scab disease at three different sampling points on each of the farms. Other data collected were the cropping system employed, previous crop on the field, the variety cultivated, field planting distances and the type of crop/plants surrounding the field. Global Positioning System (GPS) readings of latitude, longitude and altitude were recorded for each location where data were collected.

2.1. Data analysis

Twenty (20) plants were observed for the presence of scab disease symptoms by taking a transact walk across the field and earmarking three sampling points which were 10 m apart along the transact (Ddamulira et al., 2014). Disease incidence was expressed as the percentage of infected plants over the 20 plants within the sampling point. Scab disease severity was scored using a scale of 1–5, where 1 = no symptoms, 2 = less than 10% infection, 3 = 10–20% infection, 4 = 20–50% infection, and 5 = more than 50% infection (Tumwegamire et al., 1998). Infected leaves and pods where available, were collected from each sampling point and wrapped in absorbent tissue and further wrapped in aluminium foil and kept on ice for pathogen isolation in the laboratory as shown in Plate 2A–D.

Scab disease incidence and severity maps were developed using GPS survey data points obtained from each sampling location and incidence and severity means generated from data analysis (Ddamulira et al., 2014). Correlation between incidence and severity means was done according to Payne et al. (2011) and data points were transformed into a point map using Ilwis 3.2 software (Toxopeus, 1997). The maps were exported and visualised in Arc View® GIS3.2 software (Rockware Inc). Disease incidence data was transformed using arcsine transformation of arcsine percentage (Gomez and Gomez, 1984) following a Kurtosis-Skewness test which showed a significant difference from the normal and the transformed data was analysed using Genstat edition 14 (Payne et al., 2011). Scab disease incidence and severity means were separated using Fisher's protected Least Significant Difference (LSD) test at $P < 0.05$. Chi-square test for independence or association of incidence and severity data with altitude was done in Genstat using the maximum likelihood method because it is more accurate (Payne et al., 2003). Cluster analysis was performed using R statistical package version 3.1.2 for windows. Clustering was done using Euclidean distances generated and the average method was used to generate hierarchical clusters.

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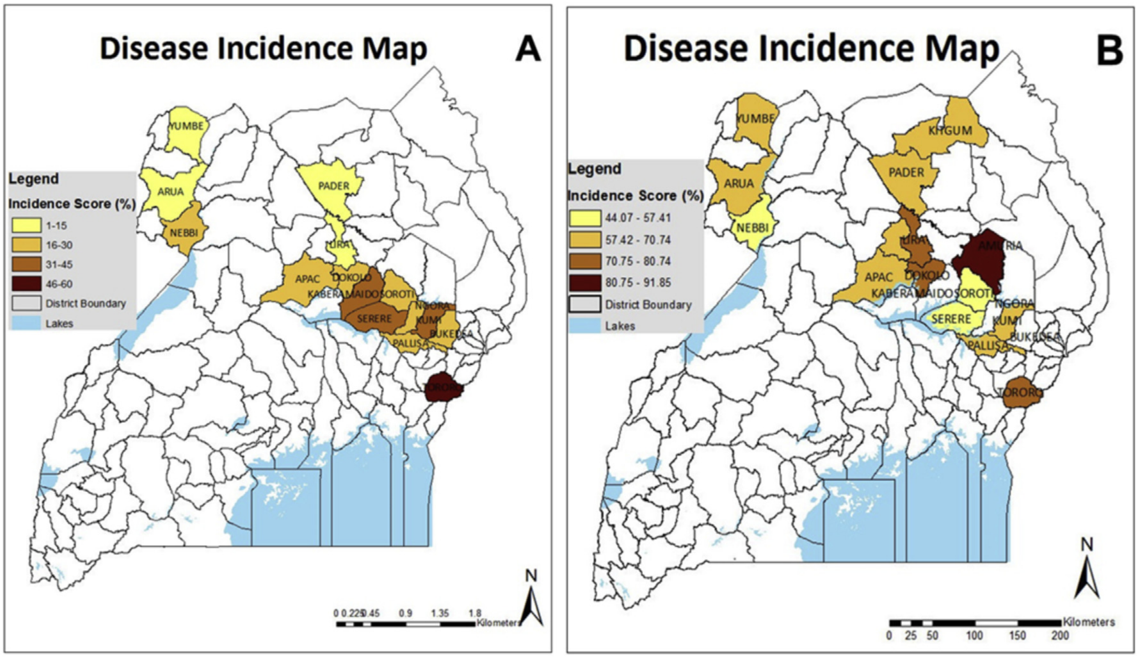

Fig. 1. A. Incidence of *Sphaceloma* sp in fifteen cowpea growing districts during 2013 cropping season (September–December), B. Incidence of *Sphaceloma* sp in fourteen cowpea growing districts during 2014 cropping season (September–December).

3. Results

The results of genotypes and cropping systems practiced in the various districts are presented in Table 1. The 17 districts surveyed lie on mean altitudes ranging between 894 and 1221 m.a.s.l. Amuria and Tororo districts predominantly cultivated cowpea genotypes such as Sunshine, WC 29 and WC36 which have been found to be susceptible. The remaining districts were found to have cultivated genotypes which are rated as moderately resistant to the scab disease (Table 1). The genotypes included two improved cultivars for high yield which were SECOW 2W and SECOW 3B, a local cultivar called Alegi, and the remaining genotypes were landraces. The percentage intercropping observed at the districts ranged between 47% and 88% with different crop combinations including cereals, other leguminous crops and root crops.

The results of scab disease incidence are presented in Fig. 1A for 2013 and 1B for 2014. There were differences in scab disease

Table 2
Mean incidence and severity of scab at four different altitudes in Uganda over 2 years.

Altitude (M) a.s.l	Incidence (%)	Severity (1–5)
551–875	23.60a	2.05a
876–1200	37.32a	2.63a
>1200	61.11b	3.60b
$LSD_{(0.01)}$	18.71	0.69
Correlation (r)	0.69	
P	<0.001	

Figures followed by the same letter indicate lack of significance while those with different letter indicate significant differences.

Table 1
Genotypes and cropping systems in districts.

District	Altitude (m.a.s.l.)	Genotype	Yield potential (t/ha)[a]	Resistance level[b]	% Inter- cropping	Crops grown
Amuria	1029	Sunshine, WC 29	0.72 and 0.89	Susceptible	56	Beans/ pigeon pea/ groundnuts/ Cassava
Bukedea	1103	SECOW 3B, Alegi	1.45 and 1.42	Moderate	71	Maize/ Cassava/ Groundnut
Kaberamaido	1094	SECOW 2W	1.55	Moderate	60	Sorghum/ Green gram
Kumi	1093	SECOW 2W, SECOW 3B	1.55 and 1.45	Moderate	48	Maize/ Cassava/ Sorghum
Ngora	1073	SECOW 2W, NE 50	1.55 and 1.45	Moderate	75	Maize/ Cassava/ Sorghum
Palisa	1089	SECOW 2W	1.55	Moderate	86	Maize/ Cassava/ Sorghum/ Millet
Serere	1077	SECOW 2W, SECOW 3B	1.55 and 1.45	Moderate	64	Maize/ Cassava/ Sorghum/ Green gram
Soroti	1085	SECOW 2W, SECOW 3B	1.55 and 1.45	Moderate	59	Maize/ Cassava/ Sorghum/ Green gram
Tororo	1221	WC 29, WC 36	0.89 and 1.21	Susceptible	50	Bean/ Maize/ Cassava/ Green gram
Apac	1061	Alegi	1.42	Moderate	48	Bean/ Maize/ Cassava/ Sorghum
Dokolo	1069	WC 10, NE 50	1.61 and 1.45	Moderate	47	Maize/ Sunflower/ Cassava
Kitgum	953	WC 10, NE 50	1.61 and 1.45	Moderate	56	Maize/ Green gram
Lira	1083	Alegi	1.42	Moderate	80	Bean/ Maize/ Cassava/ Millet
Pader	1031	Alegi	1.42	Moderate	69	Bean/ Maize/ Groundnuts/ Sorghum
Arua	926	Alegi, WC 10	1.42 and 1.61	Moderate	88	Maize/ Cassava/ Sorghum/ Pigeon Pea
Nebbi	894	Alegi, NE 48	1.42 and 1.43	Moderate	86	Maize/ Cassava
Yumbe	910	Alegi, NE 50	1.42 and 1.45	Moderate	69	Maize

[a] Where two genotypes occur, first yield written corresponds with first genotype and second yield indicated corresponds with second genotype within the districts.
[b] Resistance levels are based on results from NaSARRI following field screenings of germplasm.

incidences among the districts studied. There were also significant difference (P < 0.05) across different altitudes (Table 2). Mean scab disease incidence in 2013 ranged between 10 and 52%. The highest was recorded in Tororo (52%), followed by Kumi, Serere and Kaberamaido which recorded between 31 and 36% with the remaining districts recording incidences less than 30% (Fig. 1A).

The mean scab disease incidence in 2014 ranged between 44 and 92% (Fig. 1B). Amuria district recorded the highest incidence rate of 92%, followed by Lira, Tororo, Dokolo and Apac districts with mean incidence rates of 80%, 77%, 74% and 71% respectively. Kumi, Arua, Kitgum, Pader, Palisa and Yumbe districts recorded between 64 and 69%. The remaining three districts, viz., Nebbi, Soroti and Serere recorded incidence rates between 44 and 57% (Fig. 1B).The results of scab disease severity are presented in Fig. 2A for 2013 and 2B for 2014. Again, the results varied both among the surveyed districts and sub-counties across the two years of the study. The mean scab severity ranged from 2 to 4 (mild to severe) in both years. In 2013, Tororo district again recorded the highest mean severity score of 4 (severe) while Serere, Soroti, Palisa, Ngora and Bukedea districts recorded moderate severity scores of 3. All the remaining districts recorded mild infections with mean score of 2 (Fig. 2A). However, in 2014, Tororo, Amuria and Palisa districts recorded the highest scab disease severity score of 4. All the remaining districts recorded moderate scab severities (mean severity score = 3) except for Arua district which recorded a mean severity score of 2 (mild) (Fig. 2B).

The results of mean incidence and severity of scab at different altitudes over the 2 years are presented in Table 2. The mean incidence recorded at areas which lie above 1200 m.a.s.l. were higher and significantly different (P < 0.01) from mean incidence recorded in areas below 1200 m.a.s.l. However, there was no significant difference in mean disease incidence recorded for areas which lie at different altitudes below 1200 m.a.s.l.

The severity of scab also varied significantly (P < 0.01) across altitudes (Table 2). Thus, a mean scab severity of 3.60 was recorded at altitudes above 1200 m.a.s.l. which was significantly higher (P < 0.01) than severity values recorded at altitudes below 1200 m.a.s.l. There was a positive correlation (r = 0.69, P < 0.001) (Table 2) observed between disease incidence and severity across districts indicating that the two disease parameters were conditioned by same environment.

Results of chi-square test for independence to test the null hypothesis that high scab disease incidence is independent of altitude are presented in Table 3. The results gave the test statistic values ($\chi^2 = 23.54$, df = 6, and P < 0.001). The highly significant difference in scab incidence with altitude suggested a rejection of the null hypothesis thus indicating that high disease incidence is dependent on altitude. Out of the 15.858 margin contributed by altitude above 1200 m.a.s.l. to the chi-square statistic of 23.54, high incidence contributed 7.783 of the margin.

Also, chi-square test for independence of high scab disease severity from altitude, gave the test statistic values ($\chi^2 = 28.8$, df = 8, and P < 0.001). It thus showed a significant difference in scab severity with altitude indicating that high scab disease severity is dependent on altitude. Out of the 19.525 margin contributed by altitude above 1200 m.a.s.l. to the chi-square statistic of 28.8, 10.287 was contributed by severity level rated very severe.

The results of combined analysis of variance for scab disease incidence and severity at district and sub-county levels are presented in Table 4. The results for mean incidence of the disease showed highly significant differences (P < 0.001) among districts, sub-county and between seasons. There was no significant difference among the three agro-ecological zones in scab disease incidence. Also, there were highly significant differences (P < 0.001) in both mean severity scores among districts, sub-county, between seasons and among the three agro-ecological zones.

The results for cluster analysis of the 17 districts are presented in Fig. 3. The 17 districts were grouped into 3 statistically significant clusters. The clustering of the districts was based on the mean scab disease incidence and severity ratings recorded and the prevalence rate of the disease for the two years combined. Cluster 1 was the least weighted containing two districts followed by clusters 2 and 3

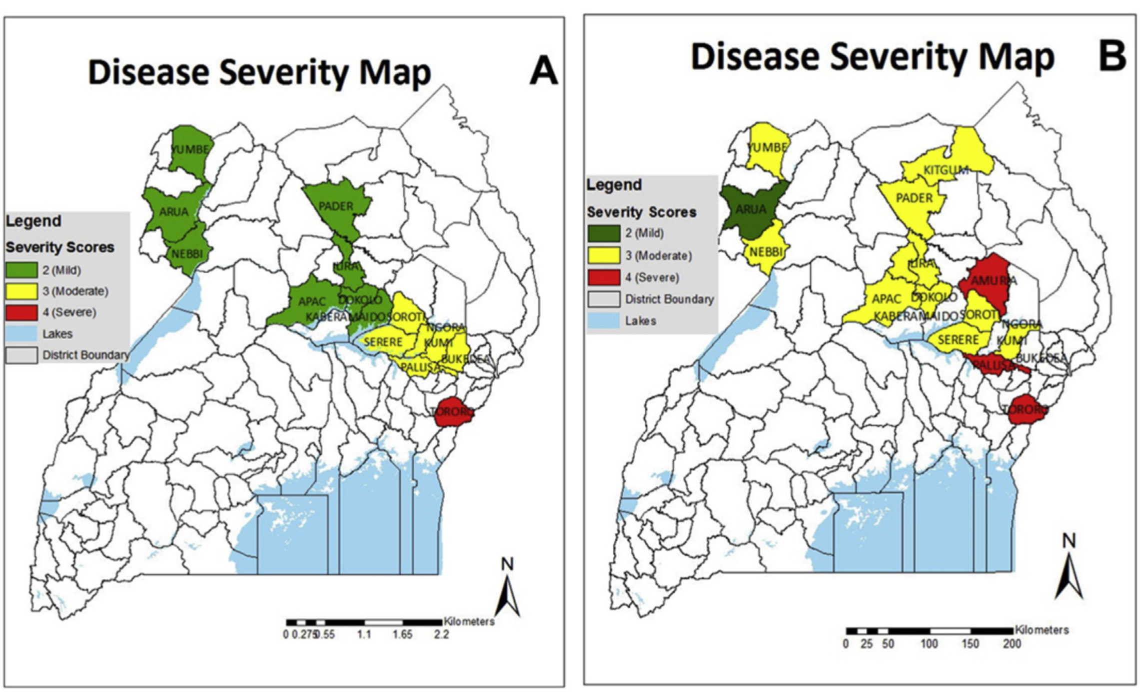

Fig. 2. A. Severity of *Sphaceloma* sp in fifteen cowpea growing districts during 2013 cropping season (September–December), B. Severity of *Sphaceloma* sp in fifteen cowpea growing districts during 2014 cropping season (September–December).

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Table 3
Combined chi-square test for both scab disease incidence and severity.

Altitude (M a.s.l.)	Incidence					Severity					
	Low	Med-ium	High	Very high	Mar-gin	Low	Mild	Mode-rate	Severe	Very severe	Mar-Gin
551–875	2.675	1.637	2.848	0.008	7.169	1.584	2.248	1.351	1.587	1.387	8.157
876–1200	0.011	0.207	0.236	0.057	0.511	0.021	0.017	0.040	0.015	1.019	1.113
>1200	6.299	0.821	7.783	0.955	15.858	7.562	1.368	0.031	0.276	10.287	19.525
Margin	8.986	2.665	10.867	1.019	23.537	9.168	3.633	1.422	1.879	12.693	28.795
χ^2			23.54						28.8		
Df			6						8		
P			<0.001						<0.001		

Table 4
Combined Analysis of variance for scab disease incidence and severity at district and sub-county levels.

Source of variation	df	Mean square		Pr > F
		Incidence	Severity	
District	16 (394)	4850.40 (650.60)***	7.12 (0.89)***	0.001
Sub-County	74 (336)	2440.10 (456.50)***	2.75 (0.78)***	0.001
Season	1 (409)	162786.10 (418.50)***	44.68 (1.03)***	0.001
AEZ	2 (408)	457.7 (816.30)	26.47 (1.01)***	0.571

Figures in parenthesis are error values; AEZ = Agro-ecological Zone.
*** = significant at $P < 0.001$.

with seven and eight districts respectively. Amuria and Tororo districts were put together in cluster 1. Both districts recorded mean prevalence rates of 100%, mean severity score of 4 and mean incidence between 65 and 70%. The seven districts in cluster 2 recorded mean disease incidence between 35% and 48%, mean severity scores of 2–2.5 and disease prevalence rates ranging from 64% to 76%. The districts in cluster 3 recorded mean incidence ranging from 39% to 52%, mean severity scores between 2.5 and 3.5 and a mean disease prevalence rate between 85% and 97%.

4. Discussion

The disease was found to occur at varying levels in all districts (Figs. 1A and 2B) and altitudes studied (Table 2). This clearly indicated the need for the use of scab resistant varieties for cultivation by the farmers. The results show that development of the disease was favoured by the prevailing conditions in all the cowpea growing areas (Table 1).

Among other factors that influence the incidence and severity of scab were environmental factors and husbandry practices. More specifically, the results in this study were explained by environmental factors such as temperature and relative humidity. Notwithstanding the differences in altitudes between Amuria and Tororo districts, they both recorded the highest occurrences and severities of the disease. Both districts record temperatures above the 25 °C threshold for the development of scab disease (Phillips, 1996). Optimum temperatures for development of the disease was reported as ranging between 23 and 28 °C (Bressani, 1985). Also, husbandry practices such as the continuous use of a susceptible cultivar overtime and choice of seed source lead to adaptation of pathogens in particular varieties for example, Sunshine and WC 29 (West et al., 2001) and locations such as Tororo and Amuria (Sartorato, 2004). It further explains why districts such as Arua, Yumbe and others recorded relatively lower incidences and severities consistently in both years. These districts were observed to cultivate mostly the local cultivar known as Alegi which has been found to be moderately resistant to the disease (Table 1).

Since incidence was found to be correlated with severity (Table 2), it was to be expected that areas which recorded high incidence rates would as well record high severity scores. Lawrence (2005) suggested that relative humidity increases as temperature decreases and since relatively higher altitudes are expected to have higher relative humidity due to lower temperatures (Harrison et al., 1997), this could in part explain the observation that areas lying above 1200 m.a.s.l. recorded both the highest occurrence and severity of the disease. These results were verified by the chi-

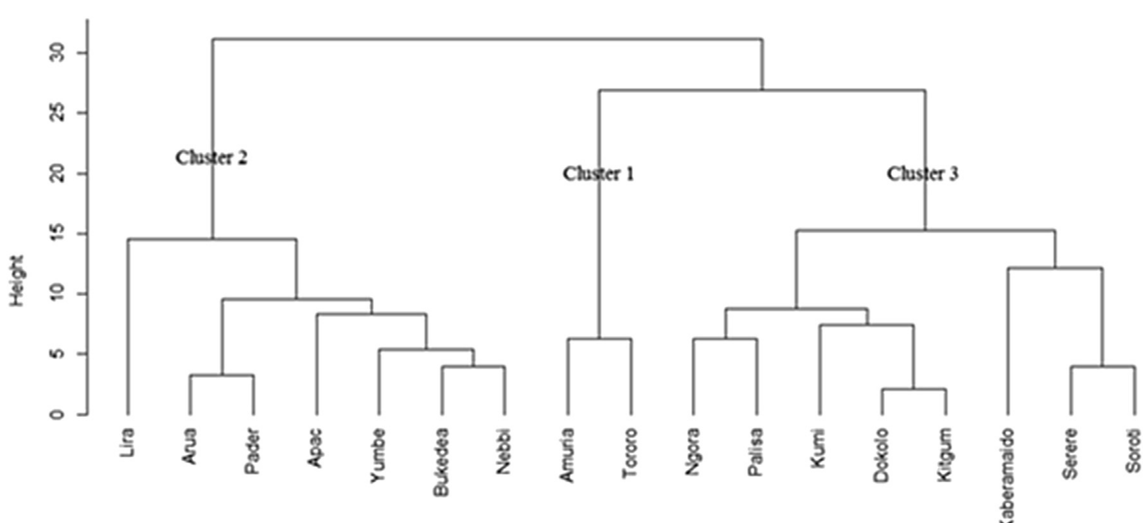

Fig. 3. Dendogram generated based on mean disease incidences, severity scores and disease prevalence rates across 17 districts over two years period.

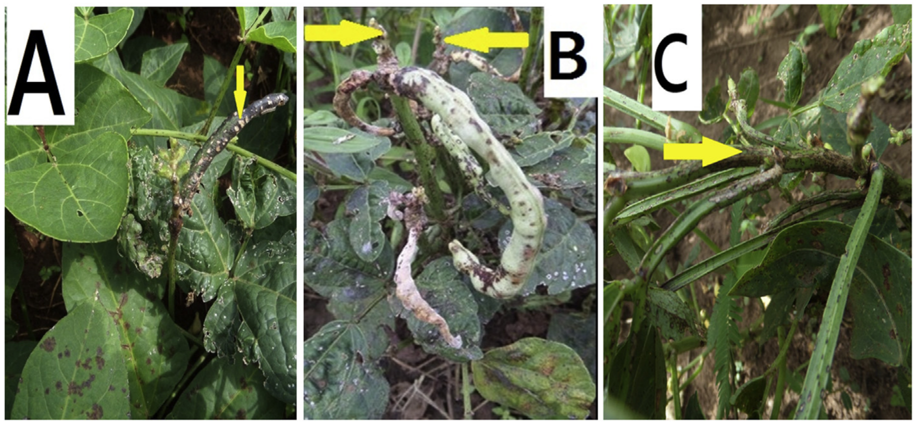

Plate 1. Scab disease symptoms on (A) infected leaves and pods, (B) flower cushions and (C) stem of cowpea. Plates show oval to elongated silver grey lesions surrounded by red or brown elliptical rings (1A and 1B) while infected pods show sunken spots with grey centres surrounded by brown borders (1A) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

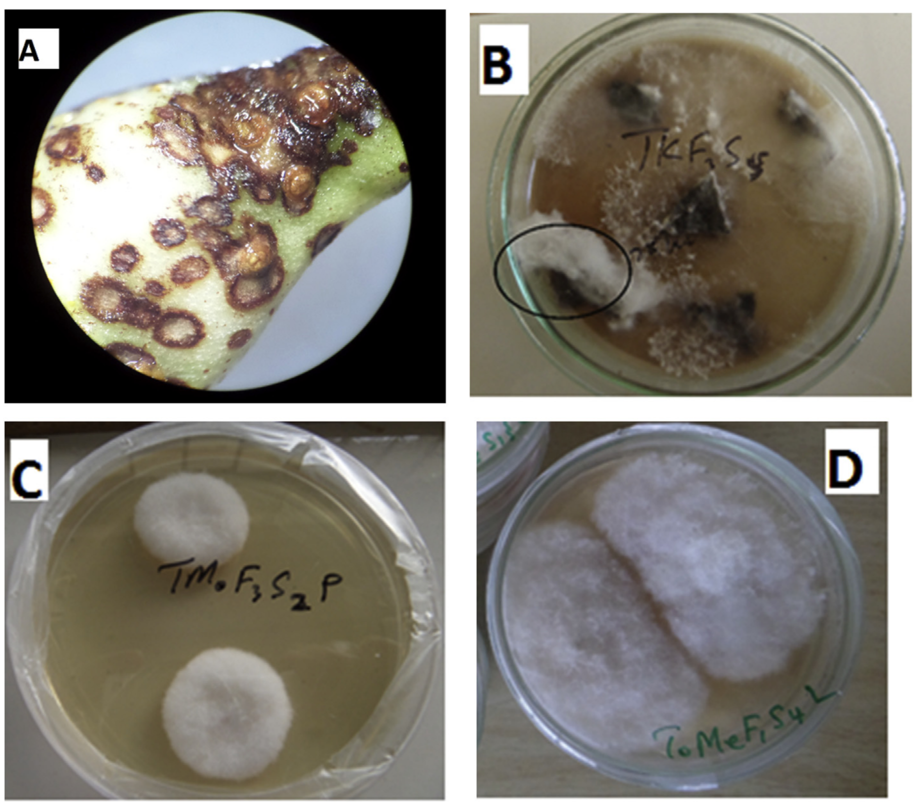

Plate 2. (A) Stereoscopic microscope view of scab-infected cowpea pod (magnification = 2X); (B) *Sphaceloma* sp growth on an infected pod (circled in black) on 7-day old PDA culture prior to isolation; (C) Single conidium isolate on PDA; (D) single conidia grown to cover entire petri dish. Note: Labels ending with P (Plate C) and L (Plate D) implies isolation from an infected pod and leaf respectively.

square test statistic results which showed highly significant differences ($P < 0.001$) both for occurrence and severity where data recorded at altitudes above 1200 m.a.s.l. for both disease parameters contributed more than half of the test statistic values. High relative humidity implied long periods of leaf surface wetness which was reported to favour the development and sporulation of fungal diseases (Gautam et al., 2013).

A district like Amuria lies at a relatively low altitude but it equally recorded higher incidence and severity than other low lying areas. This means that high relative humidity and lower temperatures might not be the only factors contributing to the high incidence and severity recorded at high altitudes. Other factors such as the cowpea cultivars grown, the source of seeds for planting, and husbandry practices may also influence disease incidence and severity (West et al., 2001). For example, it was observed that most sampled fields in Serere, Soroti and Kumi districts were growing SECOW 3B and SECOW 2W varieties (Table 1) which are improved cultivars for high yield released by NaSARRI and are moderately resistant to the disease.

The lack of significance in incidence across the different agroecologies may be attributable to the fact that there is not much difference in climatic conditions among these three ecological zones. Mugisha (2008) indicated that these zones in general record similar temperatures and relative humidity. The significant differences across districts and sub-counties could be due to the different cowpea varieties grown ranging from local to improved cultivars. Furthermore, different husbandry practices were observed across the locations. For example, moving from one sub-county to another, it was observed that different cropping systems were employed and even where similar cropping systems were carried out, different crop combinations were involved (Table 1). Similar results were reported by Hemannavar (2008) who observed that the occurrence of a disease in a location may greatly be due to provenance effects.

The 17 districts were categorized into 3 statistically significant groups by the cluster analysis (Fig. 3). These groups were obtained on the basis of the incidence levels, severity scores and the prevalence of the disease in the districts for two years. Tororo and Amuria districts were categorized as being similar and the two districts were found to be the worst hit by the scab disease during the study. The high occurrence and severity of the disease in Tororo could partly be due to its altitude (mean altitude = 1221 m.a.s.l.) as compared to districts such as Palisa and Kumi which lie between mean altitudes of 1089 and 1093 m.a.s.l. Therefore, Tororo district recorded a relatively high relative humidity (>70%) coupled with high temperatures which were favourable for the development of the disease. According to Yáñez-López et al. (2012), this condition causes prolonged periods of leaf surface wetness and therefore favours the development of disease. Secondly, it is partly due to the varieties found to be cultivated in the district (WC 29 and WC 36). Within the whole of the district, no field was found to be cultivated with any improved variety, and this was the same for Amuria district (Sunshine and WC 39). Amuria also recorded high occurrence of the disease because most of the fields in the district were found to be intercropped with other leguminous crops such as common beans which have been reported to be greatly affected by scab (*Elsinoe phaseoli*) (Phillips, 1994). Also, the intercropping of cowpeas with cassava could partly account for the high incidence and severity of the disease in these districts as the scab fungus has also been reported in cassava (*Sphaceloma manihoticola*) and scab fungus isolates obtained from the weed *Euphorbia heterophylla* has been reported to be pathogenic on cassava (Alvarez et al., 2003), therefore, suggesting possibilities of cross infections from both common beans and cassava to the cowpea crop.

On the other hand, Apac, Arua, Bukedea, Lira, Nebbi, Pader, and Yumbe districts were found to have clustered together because all these 7 districts recorded incidence rates less than 50% and had mean severity scores between 2 and 2.5 which was rated as mild infection. The results were partly accounted for by the particular varieties being cultivated and the planting densities observed in these districts (Table 1). Most of the fields in these districts were observed to have planted the local cultivar known as “Alegi” which has moderate resistance to the disease. Also, the planting distance observed during the study in most of the fields especially for between rows were between 30 and 45 cm which is less than the standard 50–70 cm for the erect and semi-erect varieties (Dugje et al., 2009). Districts such as Serere, Soroti and Bukedea recorded low occurrence of the disease because most of the fields within these districts were found to be cultivating the SECOW 3B and SECOW 2W varieties (Table 1) which are moderately resistant to the disease. Although, districts such as Apac, Arua, Lira, Nebbi and Yumbe were found to be predominantly growing unimproved varieties it was observed that the between row distance in most of the fields in these districts ranged between 60 and 70 cm which is the recommended planting distance (Dugje et al., 2009). Gautam et al. (2013) reported that an increase in biomass modifies the microclimate by increasing the duration of leaf surface wetness and regulating temperature, thereby making infection by foliar pathogens more likely.

5. Conclusion

The study revealed a wide occurrence of cowpea scab disease in the major cowpea growing areas of Uganda at different altitudes. Altitude, the type of cultivar grown and cropping system practiced influenced the occurrence of the scab disease. Amuria and Tororo districts were found to be hot spots of cowpea scab disease in the country. Future work is needed to establish the variability of the pathogen to better inform breeders working to develop resistant varieties as a management strategy to control the disease.

Acknowledgements

This study was funded by Carnegie Corporation of New York and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) (RU/2012/DRS/01). Appreciation also goes to the team of the cowpea scab project in the National Semi Arid Resources Research institute (NaSARRI-Uganda) for their assistance during the survey of the districts.

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Please cite this article in press as: Afutu, E., et al., Cowpea scab disease (*Sphaceloma* sp.) in Uganda, Crop Protection (2016), http://dx.doi.org/10.1016/j.cropro.2016.06.024