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Severity of angular leaf spot and rust diseases on common beans in Central Uganda

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Abstract

Angular leaf spot (ALS) and rust are important diseases of common beans (*Phaseolus vulgaris* L.) in the tropics, causing yield losses of up to 100%. ALS and rust have occurred in farmers' fields in the tropics for years, but the significance of the two diseases in Uganda is still unknown. In 2010, the incidence and severity of ALS in five bean agro-ecologies within Uganda was between 40-99 and 21-80%, respectively; and that of rust was between 37-69 and 24-44%, respectively. To determine the impact of ALS and rust diseases on the yield of common beans, yield loss trials were established in farmers' fields in Wakiso and Mpigi districts in central Uganda. Bush bean varieties K132 and 'Kanyebwa' were used. Two treatments were applied to each variety; namely: (i) where ALS and rust diseases were controlled through the application the fungicide Orius® (Tebuconazole 250 g L^{-1}), and (ii) control treatment with no disease control. Fungicide treated 'Kanyebwa' plants showed the lowest ALS and rust severities in Mpigi district and this was significantly different from all the other treatments. In Wakiso, ALS and rust severities for all fungicide treated plots of both 'Kanyebwa' and K132 were significantly lower than that for untreated plots for both varieties. In both districts, the highest disease severities were observed for untreated K132. Marketable yield was significantly influenced by disease severity, with up to 54% yield losses observed in non-treated plots of K132 in the 2012B season where ALS and rust disease severities were 6.9 and 5.3, respectively.

Key words: Common beans, disease management, *Phaseolus vulgaris*, *Pseudocercospora griseola, Uromyces appendiculatus*

Introduction

Common bean (*Phaseolus vulgaris* L.) is an important crop worldwide, comprising of both dry beans and snap (green) beans. It is widely grown in the temperate and sub-tropical Africa and on other continents (FAO, 2007). According to Broughton *et al.* (2003), the common bean is the most important legume consumed by man and 30% of the crop is produced by small-scale farmers in Latin America and Africa. The crop offers the second most important source of dietary fiber for humans and the third most important source of calories among all agricultural products in Eastern and Southern Africa (Pachico, 1993). Despite its significance, common bean production is greatly affected by diseases such as Angular leaf spot (ALS) and rust.

Angular leaf spot (ALS) disease caused by *Pseudocercospora griseola* (Sacc.) is a major disease of common beans in the tropics and sub-tropics (Stenglein *et al.*, 2003). The disease is of great economic importance in Eastern and Central African countries of Uganda, Kenya, Tanzania, Ethiopia, Rwanda, Burundi and Kivu Province of the Democratic Republic of Congo (Sengooba and Mukiibi, 1986; Pastor-Corrales *et al.*, 1998). According to Stenglein *et al.* (2003), every 10% increase in ALS severity results in 7.9% yield loss. ALS disease is spread within and among fields by wind-blown particles of infested soil, and wind-blown and rain-splashed spores. However, the primary source of infection is considered to be infested seed (Cardona-Alvarez and Walker, 1956). Other important sources of *P. griseola* inoculum include crop debris, volunteer crops and off season bean crops.

Rust of common beans is caused by *Uromyces appendiculatus* (Pers:Pers.) Unger, and occurs worldwide, reaching high severities in cool (17 - 22 ^{o}C) and humid (>95% humidity) environments (Pastor-Corrales and Liebenberg, 2010). Common bean rust occurs widely in Africa, causing an estimated yield loss of 191,400 metric tonnes per *annum* (Wortmann *et al.*, 1998). Long distance dissemination of rust inoculum is mainly by wind (Aylor, 1990). However, short distance dissemination may occur through contaminated farm implements, clothing and insects. Unlike ALS, rust is not seed borne.

Angular leaf spot and rust of common beans can be controlled using fungicides, resistant varieties, biological control and cultural practices such as intercropping, crop rotation, optimum plant spacing and use of soil amendments that promote soil health and plant nutrition. In Uganda, the use of fungicide is limited to common bean variables such as snap beans, because they are mostly grown by commercial farmers. Fungicide use in dry common bean production is extremely rare. However, in southern Africa, various fungicides are routinely used to control rust (Liebenberg and Pretorius, 2010; Miles *et al.*, 2007). For example, use of the triazole Tebuconazole triples yields under conditions of high disease pressure (Liebenberg and Pretorius, 2010). The use of fungicides to control ALS disease is relatively uncommon in eastern and central Africa. But in bean producing regions outside Africa, fungicides such as Tebuconazole, Mancozeb and Benomyl are regularly used to control ALS (Johnson *et al.*, 1986, Picinini and Fernandez, 2000).

Resistant varieties are widely used to control ALS and rust diseases of common beans (Stenglein *et al.*, 2003). However, their use is often limited because of high pathogen variability in the field. Intercropping with non-host plants such as maize is common in bean cropping systems (Sengooba, 1990). Despite being unpredictable, intercropping with non-host plants has been shown to reduce pest and disease damage (Trenbath, 1993). Boudreau and Mundt (1992) and Fininsa (1996) reported reduced rust severities for beans intercropped with maize. Fungal disease control in intercrops is believed to result from effects such as host dilution (reduced numbers of susceptible hosts) and barrier effect (barrier to spore dispersal) (Trenbath, 1993). Improving plant nutrition through organic soil amendments such as composts and farm yard manure is reported to induce disease resistance in plants, resulting in reduced disease damage. For example, Stone *et al.* (2003) reported suppression of ALS of cucumber and anthracnose of snap beans following application of paper mill residuals.

In recent on-farm trials, Paparu *et al.* (2014) observed simultaneous infection of snap beans by ALS and rust pathogens, where severity of both diseases exceeded 50%. The occurrence of more than one pathogen on a single crop is well known in the tropics (Waller and Bridge, 1984). Often in such cases, the effect of a disease complex on yield is estimated by assuming that each disease acts independently. However, simultaneous occurrences of diseases can lead to combined effects on crop yield and on population dynamics of infecting pathogens (de Jesus Junior, 2001); thus causing difficulties in disease management and partitioning of primary cause of loss.

The target of any disease management programme is to reduce crop losses, but not increase yields. Therefore, knowledge of the relationship between disease management, disease and yield is critical in decision making for plant disease management (Savary *et al.*, 2006). Whereas there is information on the occurrence and current severity of ALS and rust diseases in Ugandan bean agro-ecologies, there is limited information on losses caused by the two diseases. Yet a reliable estimate of losses caused by diseases is a prerequisite for the development of interventions in a crop protection programme. The objective of this study was to determine the combined effect of ALS and rust on disease severity and yield loss of common beans in Uganda.

Materials and methods

Trials were conducted in central Uganda; in Wakiso district, at Lukwanga and Gimbo villages in Wakiso sub-county during October 2012-Jan 2013 (2012B) and March-July 2013 (2013A); and in Mpigi district in Kataba and Kanyike villages in Kamengo sub-county, during October 2013-January 2014 (2013B). Two bean varieties, K132 (released variety) and 'Kanyebwa' (local variety) were used in all trials. In each season, trials were established in 3 farmers' fields per district. Experimental units consisted of 3 m x 3 m plots, with inter- and intra-row spacing of 30 cm and 10 cm, respectively. There was 2 m spacing between plots to avoid inter-plot interference. In each farmer's garden, each bean variety was planted in 6 plots, giving a total of 12 plots. For each variety, half of these plots (3 plots, corresponding to replications 1, 2 and 3) were treated with the fungicide Orius® (Tebuconazole 250 g L^{-1}; IRVITA Plant Protection N.V, CURACAO, Netherlands) at a rate of 20 ml per 15 L of spray water and the other half acted as untreated controls. The fungicide was applied thrice in the season, at 2-trifoliate leaf stage, 50% flowering and pod initiation. All treatments were laid out in a completely randomised block design.

ALS and rust disease severities were assessed at R7 (podding), using the CIAT scales of 1-9 (van Schoonhoven and Pastor-Corrales, 1991). For ALS, a rating of 1 = no visible disease symptom, 3 = plants with 5-10% leaf area having lesions, 5 = plants with 20% leaf area having lesions and sporulation, 7 = plants with up to 60% leaf area having lesions associated with chlorosis and necrotic tissue, and 9 = plants with 90% leaf area having lesions, associated with early leaf fall and death. For rust, 1 = Highly resistant: no visible rust pustules, 3 = Resistant: few and generally small pustules on most leaves, covering 2% of the foliar area, 5 = Intermediate: intermediate pustules that cover about 5% of the foliar area, 7 =

Susceptible: presence of mostly large pustules surrounded by chlorotic halos, covering approximately 10% of the foliar area, and 9 = Highly susceptible: presence of large and very large pustules surrounded by chlorotic halos, covering 25% or more of the foliar area, sometimes with defoliation. Twenty plants chosen randomly from five inner rows of each plot were used for disease severity assessment.

Marketable yields were measured as weight of clean dry seed per plot. For each plot, the weight of 100 healthy seeds was also determined. Yield loss was determined using the formula:

$$\% \text{ Yield Loss} = \frac{\text{Yield of treated plots} - \text{Yield of untreated plots}}{\text{Yield of treated plots}} \times 100$$

Disease severity and yield data were subjected to a normality test to ensure homogeneity of variance prior to statistical analysis. Data with uneven variance were transformed prior to analysis of variance. Multiple mean comparisons between treatments were performed using Tukey's studentised range test, where $\alpha = 0.05$ (SAS Institute, 1989). Pearson product-moment correlation coefficients were calculated using SAS to determine the relationship between yield and disease severity.

Results

Angular leaf spot and rust severities

In 2012B, both ALS and rust diseases were observed in farmers' fields in Wakiso; however, ALS disease was more severe than rust (Table 1). Between the two varieties, K132 was more susceptible to both rust and ALS. Angular leaf spot severities were significantly different among fungicide treated and non-treated plants of the two varieties ($F = 455.92$, df = 3, $P \leq .0001$), with the highest ALS severity score (6.9) observed for non-treated plants of K132 (Table 1). In both varieties, ALS disease was significantly reduced by fungicide treatment, and this reduction was significantly higher for fungicide treated plants of 'Kanyebwa'. Similarly, rust severities were significantly different among fungicide treated and non-treated plants of the two varieties ($F = 226.92$, df = 3, $P \leq .0001$), with the highest rust severity score (5.3) observed for non-treated plants of K132. In both varieties, rust disease was significantly reduced by fungicide treatment (Table 1).

In 2013A, both ALS and rust diseases were observed in farmers' fields in Wakiso. Just as in 2012B, ALS disease was more severe than rust (Table 1). Between the two varieties, K132 was still more susceptible to both rust and ALS. Rust severity was significantly low for fungicide treated plants of Kanyebwa, compared to the other treatments ($F = 29.52$, df = 3, $P \leq .0001$). Whereas rust severities were not statistically different between control plants of 'Kanyebwa', and fungicide treated plants of K132, severity for non-treated K132 plants was significantly higher compared to all other treatments (Table 1). The highest ALS severity score (4.3) was observed for non-treated plants of K132, and this was significantly different from that for all other treatments ($F = 54.70$, df = 3, $P \leq .0001$) (Table 1).

In Mpigi (2013B season), both ALS and rust diseases were observed in farmers' fields (Table 1). The reactions of the varieties to treatments applied were noted to be similar to those observed in Wakiso. For example, the highest rust severity score (3.3) was observed for non-treated plants of K132, and this was

Table 1. Severities of common bean rust and angular leaf spot (ALS) for fungicide treated and untreated plots of varieties K132 and 'Kanyebwa' in central Uganda

Location	Season	Variety	Treatment	Mean disease scores (means ± SE)[1,2]	
				ALS	Rust
Wakiso	2012B	K132	Fungicide	3.9 ± 0.07 c	3.2 ± 0.05 c
Wakiso	2012B	K132	No fungicide	6.9 ± 0.77 a	5.3 ± 0.07 a
Wakiso	2012B	'Kanyebwa'	Fungicide	3.6 ± 0.07 d	3.1 ± 0.03 c
Wakiso	2012B	'Kanyebwa'	No fungicide	4.5 ± 0.07 b	3.8 ± 0.07 b
Wakiso	2013A	K132	Fungicide	3.3 ± 0.06 b	2.8 ± 0.06 b
Wakiso	2013A	K132	No fungicide	4.3 ± 0.07 a	3.2 ± 0.05 a
Wakiso	2013A	'Kanyebwa'	Fungicide	3.3 ± 0.07 b	2.4 ± 0.08 c
Wakiso	2013A	'Kanyebwa'	No fungicide	3.4 ± 0.06 b	2.7 ± 0.05 b
Mpigi	2013B	K132	Fungicide	3.3 ± 0.06 b	3.1 ± 0.05 b
Mpigi	2013B	K132	No fungicide	3.5 ± 0.06 a	3.3 ± 0.06 a
Mpigi	2013B	'Kanyebwa'	Fungicide	2.9 ± 0.03 c	2.1 ± 0.03 c
Mpigi	2013B	'Kanyebwa'	No fungicide	3.3 ± 0.06 b	2.9 ± 0.04 b

[1]Mean angular leaf spot and rust severities measured on a scale of 1-9 (van Schoonhoven and Pastor-Corrales, 1991)
[2] For each season, means within a column followed by different letters are significantly different (P≤0.05, Tukeys Studentized range test)

significantly higher than that for all the other treatments (F = 97.20, df = 3, P ≤ .0001). The lowest rust severity score (2.1) was observed for fungicide treated plants of 'Kanyebwa', and this was significantly different from severity scores for fungicide treated plants of K132 and non-treated plants of 'Kanyebwa' (Table 1). In Mpigi, the ALS severity pattern was similar to that for rust (Table 1).

Marketable grain yield

In season 2012B, marketable bean yields ranged between 262and 537 kg ha^{-1}, with highest yields obtained for plots from variety K132 treated with the fungicide (Table 2). Ironically, the lowest marketable bean yields were obtained for non-treated plots of K132. Marketable yields were significantly (F = 6.55, P = 0.0014) higher for fungicide treated than the untreated plots for both varieties. During the same season, no significant (F = 2.43, P>0.05) differences were observed between treatments in 100-seed weight (Table 2). However, numerically higher seed weights were observed for fungicide treated plots of both varieties. Yield losses due to ALS and rust diseases were 54.7% in K132 and 46.6% in 'Kanyebwa' (Table 2).

In 2013A, yields were generally higher than those in 2012B. Marketable yields ranged between 611 and 882 kg ha^{-1}, with the highest yields obtained for fungicide treated plots of 'Kanyebwa' (Table 2). Marketable yield for untreated plots of

Table 2. Effect of disease control using the fungicide Orius on marketable yield and 100-seed weight for common bean varieties K132 and 'Kanyebwa' in central Uganda (Wakiso and Mpigi districts)

Location	Season	Variety	Treatment	Marketable Yield (kg ha^{-1})[1]	100-seed weight (g)[2]	% Yield loss[3]
Wakiso	2012B	K132	Fungicide	537.1 a	49.3 a	-
Wakiso	2012B	K132	No fungicide	243.1 b	40.2 a	54.7
Wakiso	2012B	'Kanyebwa'	Fungicide	491.0 a	52.1 a	-
Wakiso	2012B	'Kanyebwa'	No fungicide	262.2 b	44.0 a	46.6
Wakiso	2013A	K132	Fungicide	771.6 ab	39.8 a	-
Wakiso	2013A	K132	No fungicide	611.1 b	36.1 ab	20.8
Wakiso	2013A	'Kanyebwa'	Fungicide	882.7 a	39.8 a	-
Wakiso	2013A	'Kanyebwa'	No fungicide	784.0 ab	35.1 b	11.2
Mpigi	2013B	K132	Fungicide	802.4 a	38.4 a	-
Mpigi	2013B	K132	No fungicide	648.1 b	33.7 b	19.2
Mpigi	2013B	'Kanyebwa'	Fungicide	807.7 a	39.1 a	-
Mpigi	2013B	'Kanyebwa'	No fungicide	648.1 b	34.7 ab	19.9

[1]Mean marketable yield (weight of clean seeds) per ha obtained after extrapolation using the mean yield per plot

[2]For each season, means within a column followed by different letters are significantly different (P≤0.05, Tukeys Studentized range test)

[3]Percentage of yield lost for each variety when Rust and ALS diseases are not controlled

K132 were significantly lower than that for the other treatments. The 100-seed weights for fungicide treated plots of K132 and 'Kanyebwa' were significantly (F = 4.15, P = 0.014) higher than that for untreated plots of 'Kanyebwa' (Table 2). Lower yield losses of 20.8 and 11.2 % were obtained for untreated plots of K132 and 'Kanyebwa', respectively (Table 2).

In 2013B, the amount of marketable yields obtained were close to that for 2013A, ranging from 648 to 807 kg ha^{-1}. The highest yields were still obtained for fungicide treated plots of 'Kanyebwa'. Significant (F = 3.35, P = 0.031) differences were observed in yield among treatments, with marketable yields being significantly lower in non-treated plots of both varieties. Similarly, 100-seed weights were significantly (F = 5.32, P = 0.0044) higher for fungicide treated plots, compared to untreated plots of K132 (Table 2). Yield losses due to rust and ALS diseases were 19.2% in K132 and 19.9% in 'Kanyebwa' (Table 2).

For both diseases, common bean yields were negatively correlated to disease severity (r = -0.8492, P = 0.0005 for rust; and r = -0.8019, P = 0.0017 for ALS).

Discussion

Both ALS and rust diseases were present in farmers' fields in all seasons of experimentation (Table 1). Disease severities for both rust and ALS did not vary greatly between seasons, and districts. This may be because the two districts fall within the same bean agro-ecology (Lake Victoria Crescent and Mbale Farmlands) and differences in temperature, humidity and altitude are minimal. According to Mwang'ombe *et al.* (2007), ALS severity in Kenya was significantly influenced by agro-ecology, altitude and humidity. However, ALS and rust severities were highly positively correlated and similar in extent. Similar observations were made by Mmbaga (1984) for ALS and rust joint infection of common beans in Tanzania. Just as in our study, the individual effect of the two diseases was not determined.

Angular leaf spot and rust diseases were effectively reduced by the application of Orius® at a rate of 20 ml per 15 L of spray water thrice during the season. In most instances, fungicide application resulted in significant yield increments compared to non-treated plots. The findings of the current study agree with an earlier study in snap beans, where the use of Orius® to control ALS and rust resulted in significant yield increments (Paparu *et al.*, 2014).

For both diseases, severity was significantly and negatively associated with yield. Similar findings have been reported for diseases of beans and several crop plants. For example Anthracnose disease of common beans (Nkalubo *et a.l*, 2007), Sclerotinia stem rot of Canola (del Rio *et al.*, 2007), Northern leaf blight of sweet corn (Pataky *et al*, 1998), and Verticillium wilt of cotton (Paplomatas *et al.*, 1992). Contradictory to the above findings, Bergamin Filho *et al.* (1997) found no relationship between among of angular leaf spot disease and yield of common beans. However, this was attributed to agro-ecological conditions among locations.

Losses caused by rust and ALS were between 11 and 54%. The highest yield losses were observed when Rust and ALS disease severities were highest. This agrees with the above observation that disease severity is directly correlated with yield. In tropical South American countries of Brazil and Columbia, common bean yield losses due to rust infection can reach 45 and 22%, respectively (Schwartz *et al.*, 1981). Angular leaf spot disease causes higher yield losses i.e 70 and 80%, respectively, for Brazil and Columbia.

Conclusion

Our findings show that ALS and rust diseases are important diseases in central Uganda. We recommend that similar studies be conducted in other bean producing districts where the two diseases are wide spread. According to unpublished data (Legumes Programme-NARO), the severities of ALS and rust are 80 and 39%, respectively in Mbale; 54 and 44%, respectively in Kabale; and 58 and 40%, respectively in Sironko. If the two diseases are found to cause high yield losses in the above locations, we recommend the development and implementation of an integrated disease management package to curb losses.

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