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Determinants of groundnut rosette virus disease occurrence in Uganda

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ABSTRACT

Groundnut rosette virus disease (GRVD) is the major constraint to groundnut (*Arachis hypogaea*) production in Uganda. It is principally transmitted by the groundnut aphid (*Aphis craccivora* Koch). The disease is known to cause total crop failure in cases where susceptible varieties are used. During any particular season, GRVD displays variations in incidence and severity in different agro-ecologies within the country, but the reasons for the varying disease patterns remain unclear. This study was aimed at establishing the factors influencing the occurrence of GRVD in Uganda. Trials were established for three seasons in four groundnut growing locations situated in different agro-ecologies in Uganda. Four groundnut genotypes were used as treatments in a randomized complete block design with four replications. Disease progress and aphid populations were assessed at 4, 8 and 12 weeks after planting. Data on environmental factors; particularly rainfall, temperature and wind speed were obtained from standard meteorological stations located at/near the study sites. Soil samples and yield data were also obtained in each season. The study revealed that disease incidence; severity and groundnut yields were significantly affected by season, location and genotype. The same applied to their three way interactions. Levels of disease infection were found to be majorly influenced by rainfall and wind speed. Disease incidence and severity were generally higher in conditions with less rainfall and low wind speeds. The Pearson's two tailed correlation between total rainfall and disease incidence for all trial sites was negative and highly significant ($r = -0.280$, $P \leq 0.01$). The same was true for wind speed and disease incidence ($r = -0.476$, $P \leq 0.01$). However, there was no conclusive trend between temperature and disease incidence with the Pearson's two tailed correlation showing significantly positive and negative trends depending on location.

1. Introduction

The groundnut (*Arachis hypogea* L.), also known as peanut, is the second most highly produced food legume in Uganda after phaseolus beans (UBOS, 2013). The crop has gained popularity, especially in the eastern and northern regions of the country, where it has become part of the peoples' culture (Mahmoud et al., 1991). However, its production is constrained by numerous factors including pests and diseases, unreliable rains with recurrent droughts, poor agronomic practices, lack of high yielding cultivars, shortage of good planting seed and low levels of input use (Mahmoud et al., 1991; Adipala et al., 1998). This situation has led to extremely low yields at farmer level averaging 0.8 tons per hectare of dried pods. This is in contrast to yields as high as 2.5–3.0 tons per hectare reported at research stations within Uganda and other countries with developed agriculture (ICRISAT, 1986; Busolo-Bulafu, 2004). Pests and diseases have been found to cause the greatest economic damage to groundnut production in Uganda. Major pests include: aphids (*Aphis craccivora* Koch), thrips (*Thrips* spp) and termites (*Hodotermes mossambicus*); whereas important diseases include: groundnut rosette virus disease (GRVD), cercospora leaf spots, rusts, and aflatoxin (Okello et al., 2010). Of these diseases, GRVD has been identified as the major constraint to increased groundnut production, causing total crop failure when

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susceptible varieties are used (Okello et al., 2010). Groundnut rosette virus disease is transmitted by the groundnut aphid (*A. craccivora* Koch) and is characterized by unpredictable epidemics that are known to cause devastating losses in some years while others are relatively unaffected (Naidu et al., 1998). This poses a great threat to groundnut production in the country.

Uganda has three known GRVD hotspots where total crop loss has been observed on unsprayed susceptible varieties. These include; the National Semi Arid Resources Research Institute (NaSARRI) in Serere district, Nakabango in Jinja district and Iki–Iki in Pallisa district (Okello et al., 2010). It has also been observed that different regions in the country have varying levels of GRVD pressure. However, the reasons for the disparity in occurrence remain unclear. Naidu et al. (1998) highlighted the importance of detailed studies on the pattern of GRVD spread at a representative range of sites in different agro-ecologies and cropping systems. A better understanding of the agro-ecological factors affecting GRVD incidence and severity is critical for the successful development of sustainable disease management strategies. This study was conducted in different agro-ecological zones within Uganda with the aim of establishing how selected agro-ecological factors affect GRVD occurrence and severity.

2. Materials and methods

2.1. Study area

Field trials were conducted for three seasons: first rainy season 2011 (2011A), second rainy season 2011 (2011B) and second rainy season 2012 (2012B) at four research stations located in major groundnut producing areas, each representing a different agro-ecological zone within Uganda. These areas fell in the districts of Sironko (01°13′46″N, 34°4′53″ E), Lira (2°14′50″N, 32°54′00″E), Jinja (00°23′00″N, 32°33′00″ E) and Mbarara (00°36′48S, 30°39′30E) districts. Sironko lies within the Highland ranges of Eastern Uganda with average rainfall of 1456 mm/yr. Average temperatures are 22.9 °C and wind speed ranges from 4 to 19 km/h. Lira is found in the North Eastern Savannah Grasslands that is comprised of generally flat isolated hills with average rainfall of 1,465 mm/year. Temperature ranges from 18 to 32.5 °C and wind speed from 7 to 185 km/h. Jinja is located in the Lake Victoria Crescent where there are flat-topped areas and long gentle slopes. Rain fall is bimodal with an average of 1200 mm/year. Temperatures range between 15 and 29 °C and average wind speed is 11 km/h. Mbarara is in the South Western farmlands with average rainfall of about 896 mm/year. Temperature ranges from 13 to 27 °C and average wind speed is 0 km/h (MAAIF, 2010; Climatevo, 2015).

2.2. Experimental design

The locations and groundnut genotypes were considered as factors in the study. There were four locations as described above. Four genotypes commonly grown in the country were assessed namely:- Serenut 1R and Acholi white (susceptible to GRVD) and Serenut 6T and Serenut 3R (resistant to GRVD). All genotypes were obtained from the Groundnut Improvement Program at NaSARRI. In each location, the trial was established as a randomized complete block design (RCBD) with 4 replications. Each experimental unit measured 3 m × 3 m, and groundnut seeds were direct seeded at a spacing of 45 cm × 15 cm, with one seed per hill. No fertilizers, pesticides or herbicides were applied in the fields. Hand-weeding was done thrice during each growing season.

2.3. Data collection

Disease status was recorded in terms of incidence and severity. Groundnut rosette virus disease incidence was assessed at 4, 8 and 12 weeks (NaSARRI, unpublished). Incidence was expressed as the percentage of plants infected with GRVD over the total number of plants in the plot. Disease severity was scored at 12 weeks after planting using a scale of 1–9 based on the intensity of disease attack (Okello et al., 2014), where; 1–3 = Low GRVD severity, 4–6 = Moderate severity, 7–9 = High GRVD severity. For aphid populations, 10 plants were randomly selected per plot and the numbers of adult aphids on each plant were counted. However, this information was obtained from only two districts, Mbarara and Sironko during two planting seasons (2011A and 2011B). Results for aphid population dynamics for Jinja and Lira were not included because no aphids were found at the time of data collection. Data on the environmental factors of rainfall, temperature and wind speed were obtained from meteorological stations located at or near the trial sites. Information on rainfall and temperature was obtained from all the trial sites whereas wind speed data was obtained from only two sites, Jinja and Lira during 2011A and 2011B. Yield data was obtained for each planting season by weighing the dried pods taken from 5 plants that were randomly selected from each experimental unit. Soil samples were also taken from each trial site and analyzed at the National Agricultural Research Laboratories (NaRL) Kawanda, using Mehlich 3 and Walkley Black procedures (Walkley and Black, 1934; Mehlich, 1984) in order to determine their characteristics.

2.4. Data analysis

Incidence data was used to compute the area the under disease progress curve (AUDPC) as described by Campbell and Madden (1990) as;

$$\mathrm{AUDPC} = \sum_{i=1}^{n} [(X_{i+1} + X_i)/2][t_{i+1} - t_i]$$

Where: X_i = disease incidence at the ith observation
t_i = time (days) at the ith observation
n = total number of observations

Data on disease incidence, severity, AUDPC's, yield and aphid occurrence were analyzed using a GenStat computer package (Genstat, 2010) to generate analyses of variance (ANOVA). For the treatments showing significant 'F' statistics, the means were separated using SED (the standard error of the difference between two sample means, SED x 1.96 = $LSD_{5\%}$). The Pearson's two tailed correlation analysis was used to assess the strength of association between weather variables and GRVD incidence (Cohen et al., 2003).

3. Results

3.1. Incidence and severity of GRVD

Significant differences in GRVD incidence, severity and AUDPC were recorded across season, genotype and site ($P < 0.05$) (Table 1). The two-way interactions of season x site; and site x genotype and the three-way interaction of season x site x genotype significantly ($P < 0.05$) affected GRVD incidence and AUDPC. The only interaction that significantly affected disease severity was the season x site.