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Alectra vogelii, a Threat to Bambara Groundnut Production in Singida and Dodoma Regions, Tanzania

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Authors' contributions

This work was carried out in collaboration with all authors. Author ERM conducted the field assessment, designed the study and wrote the manuscript. Author CRM conducted the field assessment and reviewed the manuscript and author AMM also conducted the field assessment reviewed the manuscript and was also the project leader. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: To document the occurrence and effect of *Alectra vogelii* on bambara groundnut yield in Tanzania.
Place and Duration of Study: Singida and Dodoma regions, Tanzania between 4th to 20th April 2014.
Methodology: The number of *A. vogelii* and of bambara groundnut plants per 2 m x 2 m quadrant in triplicates was counted per farm from nine different villages. The *A. vogelii* infestation was scored as 0 = no infestation, 1 = 1-5 (less severe), 2 = 6 – 10 (severe) and 3 = > 10 (very severe). The bambara groundnut yield loss was determined as (C-A)/ C x 100% or (C-B)/C X 100%, where C =

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Number of pegs in a non-infested plant, A =Number of pegs in a wilted *A. vogelii*- infested plants and B = Number of pegs in yellowing or stunted- *A. vogelii* infested plants

Results: The average number of *A. vogelii* was 55 plants infesting about 26 plants per quadrant. This number scored 3 (very severe) in a 0-3 scale. The highest number of pegs (90, 75 and 68) per plant was recorded in the non- infected bambara groundnut plants in Iramba, Dodoma urban and Ikungi Districts, respectively, while smaller number or no pegs was recorded in yellowing-*A. vogelii* infected or wilted-*A. vogelii* infected plants translating to a yield loss of 97.3–100%.

Conclusion: *A. vogelii* is a threat to bambara ground nut production in Tanzania. Yield losses of up to 100% have been recorded and this can affect growers who depend on the crop for their protein source. As no report from the literature showing the occurrence of *A. vogelii* in bambara groundnut in the country, we document its first report and effect on the yield of the crop in Tanzania. Future studies to determine distribution of *A. vogelii* in other bambara groundnut-growing areas are needed.

Keywords: Alectrol; pegs; quadrant; infestation.

1. INTRODUCTION

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is an important leguminous crop of African origin grown mainly by subsistence farmers under low input agricultural system in semi-arid areas [1-3]. The crop ranks as the third most important food legume crop in semi-arid Africa in terms of production and consumption after groundnut (*Arachis hypogaea* L.) and cowpea (*Vigna unguiculata* L. Walp) [3,4]. Bambara groundnut is highly nutritious,

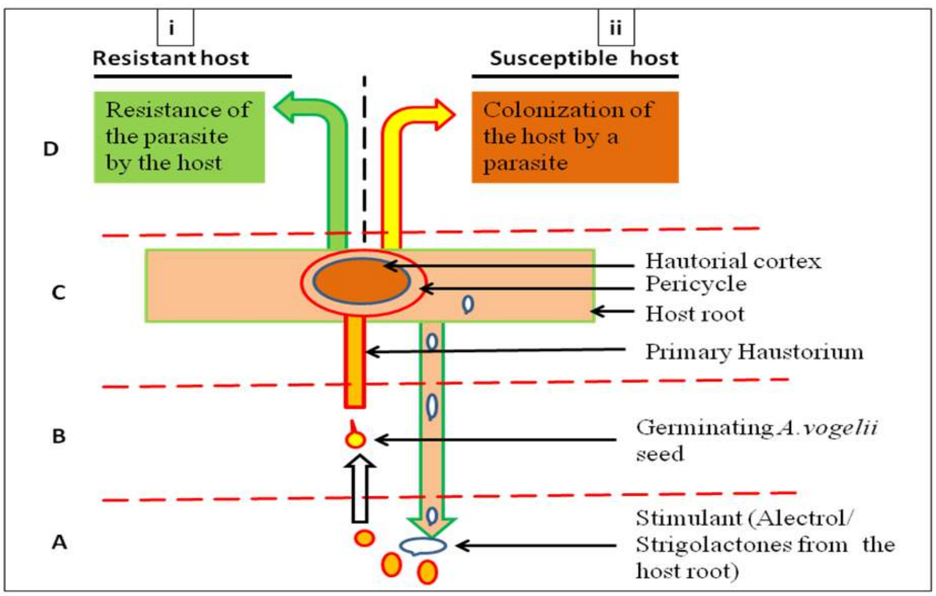

Fig. 1. A model describes four stages (A-D) of *A. vogelii* infection on its host plant: A) Stimulation and Germination, B) Rhizotropism, C) Attachment and establishment and D) Development on host. In stage A, the host root releases a stimulant namely Alectrol/strigolactones (SLs) that stimulates germination of *A. vogelli* seed. In stage B the same stimulants acts like a signal of attracting the developing germ-tube towards the host root. In stage C the parasite attaches itself onto the host root and develops a morphological/ physiological bridge called haustorium within the host root which taps nutrients from the host. In stage D, the developed haustorium stimulates aggressive growth of both the host pericycle around the parasite and the parasite's haustorial cortex tissues forming complex tuberous organ with roots called haustorial roots. Infection to a resistant host may not affect the host (direction i) while infestation to a susceptible host leads to colonization of the host by the parasite (direction ii)

and has been termed a complete food because of its nutritional value, which can ensure regular availability under harsh climatic conditions, providing protein, carbohydrates, fats, fibres and minerals [1-3]. In Tanzania, bambara groundnut is an important food grain legume in the tradition farming system providing food to the resource poor farmers, feed to pigs and chickens, fodder to domestic ruminants and improving soil fertility status through its ability to fix nitrogen [5]. Bambara groundnut can grow well under stressful conditions of drought where other crops cannot grow well [3]. Despite its importance in these drier parts of the country, bambara groundnut can seriously be infested by *Alectra vogelii* (L.) Benth, resulting in a reduced or total yield loss. *A. vogelii* commonly known as yellow witch-weed is a vascular hemi-parasite weed in the family Scrophulariaceae that parasites a wide range of legumes in the West, East and Southern Africa [6-8]. This parasitic plant spends most of its life cycle underground and incapable of completing its life cycles without connecting to and residing within its host roots where it taps nutrients from it [9]. Other main hosts of *A. vogelii* include cowpea (*Vigna unguiculata*), peanut (*Arachis hypogaea*), common bean (*Phaseolus vulgaris*), soybean (*Glycine max*), and mung bean (*Vigna radiata*). *A. vogelii* causes a substantial damage as it draws nutrients and water from the host plant leading to reduced dry matter accumulations in the host in favor of its shoot growth [7,10]. The interaction between the host and the parasite involves four major stages (Fig. 1). The initial stage involves chemical communication between the host and the parasite. The seed of *A. vogelii* and other related parasites cannot germinate unless they are exposed to chemical /germination stimulants namely Alectrol or Strigolactones (SLs) which is produced by and released from host roots [9,11-14]. The second stage involves growth of the parasite towards the host root where it attaches itself to the host root and develops a morphological/ physiological bridge called haustorium within the host root which taps nutrients from the host. The developed haustorium (as it grows in the host) stimulates aggressive growth of both the host pericycle around the parasite and the parasite's haustorial cortex tissues forming a complex tuberous organ with roots called haustorial roots [13,15]. Infestation to a resistant host has no damage on the host (direction i) while infestation to a susceptible host leads to colonization of the host by the parasite (direction ii). In this study, we document the first report on occurrence, severe infestation and effects of *A. vogelii* on the yield of bambara groundnut in Tanzania.

2. MATERIALS AND METHODS

2.1 Survey and Assessment of *A. vogelii* Infestation Symptoms on Bambara Groundnuts

Field surveys were conducted in early April 2014 in bambara groundnut fields at Kaselya, Msungua and Mpunguzi villages in Iramba, Ikungi and Dodoma urban Districts, respectively. Three farms per village were assessed for infestation by *A. vogelii* based on symptoms described by Subrahmanyam [7]. The *A. vogelii* plants were 0.2 to 0.45 m tall with multiple stems branching at the base and had a deep orange color subsoil parts, lemon yellow flowers with horseshoe-shaped stigmata and light green leaves. The infested plants were stunted, yellowing and permanently wilted.

2.2 Infestation Level of *A. vogelii* Plants on Bambara Groundnuts

In each visited field, the number of *A. vogelii* and of bambara groundnut plants per randomly thrown 2 m x 2 m quadrant in triplicate were counted. The infestation was scored as 0 = no *A. vogelii* infestation, 1 = 1-5 *A. vogelii* plants per quadrant (less severe), 2 = 6 – 10 *A. vogelii* plants per quadrant (severe) and 3 = > 10 *A. vogelii* plants per quadrant (very severe). The average number of *A. vogelii* infestation per bambara groundnut plant was calculated by dividing the total number of *A. vogelii* by total number of bambara groundnut plants per quadrant.

2.3 Yield Loss Assessment

Assessment of the yield loss was conducted in randomly selected farmer's fields in each District. From the selected farms, three plants (one wilted due to infestation by *A. vogelii*, the second yellowing and stunted due to infestation and the third non-infested) in triplicates were uprooted and the number of pegs were counted per each plant. To assess the yield loss, equations 1 and 2 were created and used as follows:

$$\zeta_W = (C-A)/C \times 100 \quad (1)$$

$$\zeta_Y = (C-B)/C \times 100 \quad (2)$$

where ζ_W = yield loss (%) in wilted *A. vogelii*-infested plants, ζ_Y = yield loss (%) in yellowing or stunted- *A. vogelii* infested plants, C = Number of pegs in a non-infested plant, A = Number of pegs in a wilted *A. vogelii*- infested plants and B = Number of pegs in yellowing or stunted- *A. vogelii* infested plants.

2.4 Data Analysis

Data were summarized and plotting was aid by Pivot Table and Pivot Chart Report of the spreadsheet program of Microsoft Excel Office 2007.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 The level of Alectra infestation in the surveyed bambara groundnut fields

Results show that all nine surveyed bambara groundnut fields in Singida and Dodoma regions (Map 1) were infested by *A. vogelii* (Table 1). The highest number (137 and 126) of *A. vogelii* count were recorded at Kaselya village, Iramba District and the lowest number (4 and 6) was recorded at Mpunguzi in Dodoma urban and Msungua in Ikungi Districts, respectively (Table 1). In average, the number of *A. vogelii* per quadrant was 54.90 (approximately 55 plants) infesting about 26 plants per 2 m x 2 m quadrant. The average number of *A. vogelii* per bambara groundnut plant was higher (4.28) at field number one in Kaselya village and lower (0.18) at Mpunguzi village Dodoma urban District. The results also show that six out of nine visited fields were very severely infested (score = 3) and only one bambara groundnut field located at Mpunguzi village Dodoma rural District was found less severely infested (Table 1).

3.1.2 The effect of *A. vogelii* infestation on number of pegs per plant and yield

The results show that non- infested bambara groundnut crop had the highest number of pegs per plant compared with yellowing-*A. vogelii* infected or wilted-*A. vogelii* infected bambara groundnut plant (Fig. 2, Plate 1). For instance, the highest number of pegs (90, 75 and 68) per plant was recorded in non- infected bambara groundnut plants in Iramba, Dodoma rural and Ikungi Districts, respectively, while yellowing-*A. vogelii* infected or wilted-*A. vogelii* infected plants had smaller number or no pegs (Fig. 2).

The results obtained by comparing the yield from non-infected bambara groundnut plants to that from infested plants show that the yield loss was 100, 98.5 and 97.3% in wilted-*A. vogelii* infested plants followed by 83.3, 88.2 and 77.3% in yellowing-*A. vogelii* infested bambara groundnut plants in Iramba, Ikungi and Dodoma rural Districts, respectively (Fig. 3).

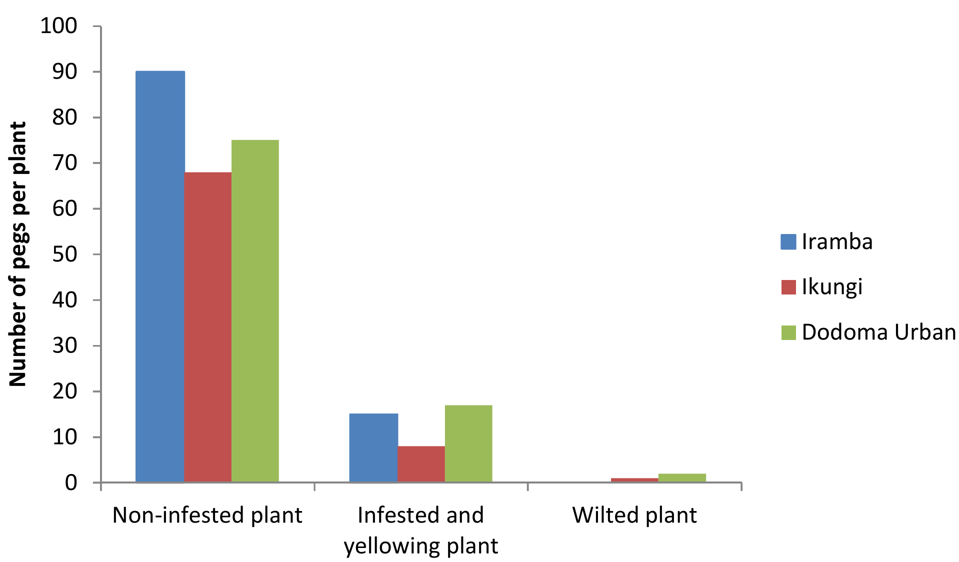

Fig. 2. Effects of *A. vogelii* on number of pegs per plant. Each value is the mean of three plants per bambara groundnut farm x three locations

Map 1. Map of Tanzania showing the location (area shaded green i.e. Dodoma and Singida regions) of the study

Table 1. Bambara groundnut farms covered during the current survey

Farm number	Village	District	Number of *A. vogelii* per quadrant[a]	Number of plants per quadrant[b]	Number of *A. vogelii* infestation per plant[c]	Score[d]
1	Kaselya	Iramba	137	32	4.28	3
2	Kaselya	Iramba	85	33	2.58	3
3	Kaselya	Iramba	126	38	3.32	3
4	Msungua	Ikungi	71	28	2.54	3
5	Msungua	Ikungi	6	22	0.27	2
6	Msungua	Ikungi	37	19	1.95	3
7	Mpunguzi	Dodoma urban	18	19	0.95	3
8	Mpunguzi	Dodoma urban	10	22	0.45	2
9	Mpunguzi	Dodoma urban	4	22	0.18	1
Mean			54.90	26.11	1.84	2.56

[a]*Each value is an average of A. vogelii counts of three randomly thrown quadrants*
[b]*Each value is an average of cowpea plants of three randomly thrown quadrants*
[c]*Each value is an average ratio of number of A. vogelii counts per number of plants from three randomly thrown quadrants*
[d]*The score was based on a 0-3 scale where 0 = no A. vogelii infestation, 1 = 1- 5 A. vogelii plants per quadrant(less severe), 2 = 6 – 10 A. vogelii plants per quadrant(severe) and 3 = > 10 A. vogelii plants per quadrant (very severe)*

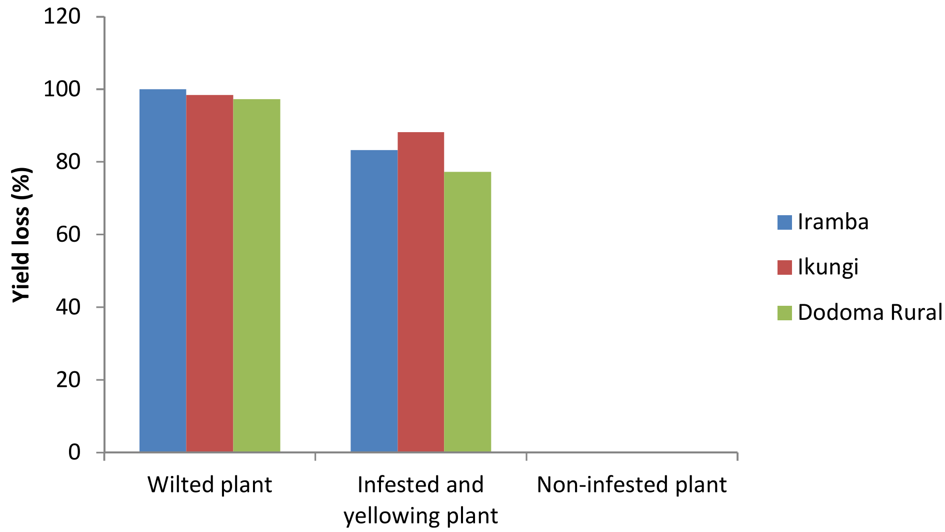

Fig. 3. Yield loss of bambara groundnuts caused by infestation by *A. vogelii*. Each value is the mean of pegs counted from three plants per bambara groundut farm x three locations

Plate 1. Uprooted bambara infested by *Alectra vogelii* (a) and non-infested bambara plant (b)

3.2 Discussion

In this study, bambara groundnut plants growing in Iramba, Ikungi and Dodoma rural Districts were found highly infested by *A. vogelii*. Such observations were not surprising as previously reported that bambara groundunt is one of an important host of *A. vogelii* [4,6,7,16-19]. Infestation by *A. vogelii* has been reported to significantly reduce the dry matter accumulation on host crop and gain of dry matter in the parasitic weed [20]. In the present study, most of the visited bambara groundnut fields were severely infested by *A. vogelii*. The infestation by this parasitic weed pose a threat to the production of bambara groundnut, alarming a possibility of affecting the resource poor farmers in the semi arid and drought prone areas of the country who solemnly depend on the crop for their protein source. Bambara groundnut is highly nutritious [3], and as a legume, it provides the least expensive, easily stored and transported non-processed protein source for rural households in the drier areas. In fact, though the crop is among the orphan crops in the country, its importance in the tradition food system cannot be substituted by any other leguminous crop due to its ability to grow in harsh conditions encompassed with low soil fertility and drought.

4. CONCLUSION

Conclusively, *A. vogelii* is a threat to bambara groundnut production in the semi-arid areas of Tanzania including Singida and Dodoma regions. In this study bambara groundnut plants growing in Singida and Dodoma regions were found severely infested by *A. vogelii* causing a significant loss of up to 100%, thus alarming a threat to growers of the crop in Tanzania. As no report from the literature showing the occurrence of *A. vogelii* in bambara groundnut in the country, we document its first report and effect on the yield of the crop in Tanzania. Future studies are needed to determine the distribution of this parasitic weed in other bambara groundnut-growing areas, screen different bambara groundnut genotypes for their resistance/susceptibility to the parasitic weed and to study whether the *A. vogelii* strains infesting bambara groundnut are the same or different from those affecting other leguminous crops in the country.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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