Distribution And Host Range Of Mistletoe (Tapinanthusglobiferus) (A. Rich.) Van Tieghan) Along The Blue Nile Banks In Central Sudan

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Abstract: Mistletoe of the genus Tapinanthus(Loranthaceae) is a stem hemiparasite causing damage on citruses and guava trees in central Sudan. The objectives of this study were: to evaluate the distribution, incidence, , severity and host range of the parasite. Surveys were conducted in 2010\2013 in four States along the Blue Nile banks in an area extended about 492 km. Results indicated that the parasite is widely distributed along the Blue Nile banks from Al-Rusayris (12° 21' 4" N and 34° 22' 14" E) to Hisahisa (14 44' 47" N and 33° 17' 43" E). The highest incidence of the parasite (69%) occurred in Blue Nile State, followed by Sinar state (66.3%) with highest incidence (100%) reported in Singa Province. While Kamlin province (Northern Gezira state) and Khartoum state were seemed to be free from the parasite. The highest percentage of mistletoe infection was found on lime (Citrus aurantifoliaSwingle) and guava (Psidiumguajava M.) in Western and Eastern Sinar, respectively, with disease severity index range between 74.2%-90.6% in both localities. The parasitic weed appears to have a wide host range, attacking 22 species belonging to 14 families. The most affected trees were citruses, guava and Ziziphusspina-chriti. In conclusion the results reflects the epidemic situation of mistletoe along the Blue Nile banks, despite the lack of quantitative data concerning losses in fruit production of infected plants. It also revealed that mistletoe could parasitize a variety of host plants, with special preference of potential suitable hosts.

Key words: Mistletoes, guava, lime, incidence, severity index, host range,.

1. Introduction

Mistletoe of the genus *Tapinanthus* (Loranthaceae) is a stem hemiparasite of about 250 species in East and West Africa having straight pentamerous colorful red flowers, causing damage on coffee, citrus, guava, other fruits and ornamental trees (Viccer, 1991). The nature of sticky seeds enhances the distribution by birds and other animals (DelRio*et al*., 1996; Aukema, 2004). This parasite attacks citrus plants as early as three years after planting and causes severe damage to citrus trees by retarding growth, causing yield loss and mortality (Asare-Bediako*et al.,* 2013). *Tapinanthus*speciesinfection causes a noticeable decrease in vigor of the branches above the point of attachment of the parasite, followed by galls, branch bending and sometimes death may occur. Damage from mistletoes, involves the death of branches distal to the infection site. More serious damage occurs in poorly-managed orchards and/or under drought stress conditions, situations that often lead to the death of the host (Boussim, *et al*., 2004).Mistletoes infection on orchard trees has rapidly increased in Sudan. These were found to cause drastic growth retardation, yield losses and subsequent death of citrus and guava trees (Sidahmed, 1984). High incidence of mistletoe infection was reported in Gezira (60%), and Sinar states (84%) along the Blue Nile, Sudan (Osman *et al*., 2007; Zaroug*etal*., 2009). The parasite entirely depend on their host for water and mineral salts and for most of their carbohydrates because of the inefficiency of their photosynthetic apparatus (Marshall and Ehleringer, 1990). The high transpiration rate exhibited by the parasite may result in the host plant becoming water stressed.

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Host range varies widely among species of parasitic plants (Norton and De Lange, 1999). Many parasitic plants can simultaneously parasitize many host species. Since different host species may supply a parasite with different resources, a mixture of host species may be superior to a single host alone (Govier*et al*., 1967). Bossium*et al.,* 2004 reported that mistletoe (*T. globiferus*) parasitized 126 species, and believed that it is less specific compared to other mistletoe species. Despite the large host range of the majority of parasitic plants, many also show high levels of host preference. In mistletoe plants, host choice can be considerably influenced with relatively abundant hosts (Norton and Carpenter, 1998, Norton and De Lange, 1999), host characteristics such as branch size, age and height (Martinez del Rio *et al*., 1995), and the duration of association between the host and the parasite (Didier *et al*., 2009). Recently it was observed that the mistletoes infection on orchard trees rapidly increases in Sudan. However, there is no enough information about the geographical distribution, incidence and host range of mistletoe in Sudan. Therefore, the main objectives of this research were to determine the geographic distribution of mistletoes along the blue Nile banks from Al-Rusayris of the Blue Nile province in the south to Khartoum in the north, the assessment of severity of infection and host range of the parasite.

2. Materials and Methods:

2.1. Study area:

The study area extends in 492 kilometers along the east and west Blue Nile banks from Al-Rusayris (12°21'4"N 34°22' 16" E) in the Blue Nile State, through Wad-Madani (14° 24' 30.20" N 33° 31' 47.88"E) in the Gezira state to Khartoum (Fig. 1). A survey was conducted in 2010-2013**.** The area surveyed lies in fertile soils most of it is cultivated in fruit trees.

2.2. Field survey:

This study investigated the incidence of mistletoe infection on orchards along the Blue Nile banks. The surveyed area falls in four States, from north to south: Khartoum, Gezira, Sinar and Blue Nile States, andthe provinces within the study area were surveyed. At least 10 locations within inhabited villages were visited, they were spaced 5-8 km. The mere presence or absence of the parasite in 2-3 orchards each was determined. Moreover, questions were asked to farmers concerning the local names, the spread, and the hosts of mistletoe in their orchards and the surroundings. Thereafter, orchards were inspected for the presence of the parasite. Percent incidence of mistletoe in each State was calculated.

2.3. Degree of infection:

Severity of infection of mistletoe parasitizing lime (*Citrus aurantifolia*Swingle) and guava (*Psidiumguajava* M.) trees was evaluated in eleven different locations in the eastern and western banks of the Blue Nile in the Gezira State (4 provinces); Sinar State (5 provinces); and Blue Nile State (2 provinces). In each province at least 5 orchards, infected with the parasite were examined for the degree of infection. Three samples each consisted of 20 trees in different orchards for both lime and guava were evaluated. Two methods were adopted to evaluate the degree of infection these were: percentage of infected trees and disease index. Infection percentage (IP) was calculated using the formula:

IP= {Q / M} x 100

Where Q = number of infected plants; M = total number of plants observed. For the second method severity of infection was rated on the scale 0-4 (0= no infection, 1= low infection with 1-5 haustoria/tree, 2= moderate infection with 6-10 haustoria/tree, 3= severe infection with 11-15 haustoria/tree and 4= very severe infection with ≤16 haustorium/tree. A severity index for each sample was then calculated using the formula:

$$\frac{(0xa)+(1xb)+(2xc)+(3xd)+(4xd)}{(a+b+c+d+e)}\,\frac{x100}{4}$$

Theincidencepercent of mistletoe, percent infection and severity index was calculated for each province and State.

2.4. Host Range:

The tree species parasitized by mistletoe during the field survey were identified and recorded. The abundance of mistletoe on the different hosts was evaluated by counting the number of shoots/ host plant. The degree of infection was noted according to the following scale:

\+ = low infection (1-5 shoots of the parasite/tree)

++ = moderate infection (6-10 shoots/tree)

+++ = high infection (more than 10 shoots/tree)

Data generated was subjected to statistical analysis, using Statistical Product for Service Solutions software version 14.0 (SPSS V14.0). Data were presented as frequency distributions and percentages.

3. Results and discussion:

3.1. Distribution and incidence of the parasite:

Results of the surveys indicated that the parasite is widely distributed along the Blue Nile banks in an area extended about 360 kilometers from Al- Rusayris in the south to Hisahisa in the north (Figure 1). The highest incidence of the parasite (86.5%) occurred in Sinar State, followed by Blue Nile State (78.5%), and Gezira State (54.8%)(table 1).

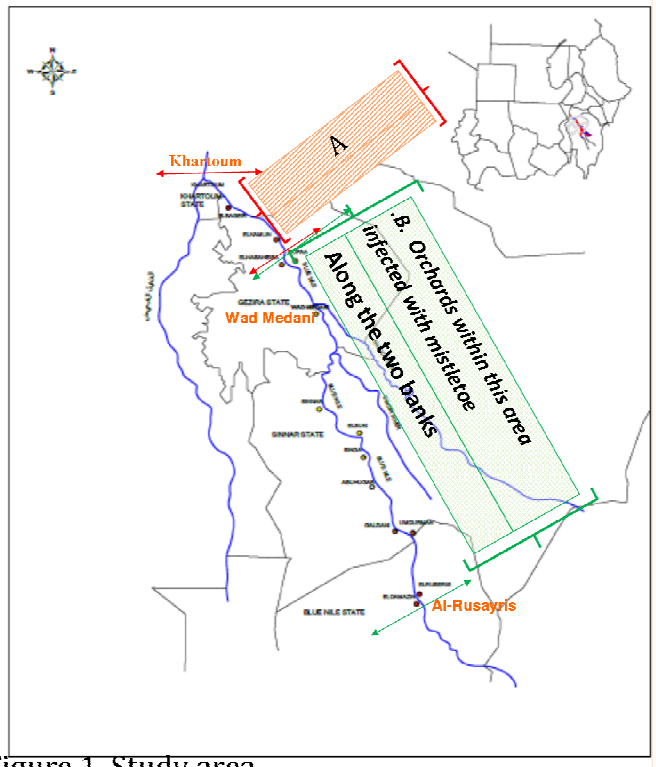

Figure 1. Study area

A mistletoe free ; B mistletoe infected

These results are in agreement with the reports of over 60% incidence of mistletoe in citrus orchards in Gezira State (Osman *et al*., 2007) and 84% In Sinar State (Zarou*et al.*,2009). While Kamlin province (Northern Gezira state) and Khartoum State were seemed to be free from the parasite. Occurrence and spread of mistletoe believed to be determined by host specificity, environmental conditions, host plant characteristics (Martinez del Rio *et al*., 1995) and the movement patterns of dispersal agents (Aukemaand Martinez del Rio, 2002).

Table 1. Incidence of mistletoe along the Blue Nile banks from Khartoum in the north to Al-Rusayris in the south of the study area.

State	Locality (Provinces)	Incidence %	
Khartoum	Khartoum	0	
	Kamlin	0	
	El Hisahisa	23.3	
Gezira	Eastern Gezira	81.0	54.8
	Wad Medani	72.8	
	Southern Gezira	75.0	
	Sinar	55.6	
	Eastern Sinar	50.0	
Sinar	Singa	100.0	66.3*
	Abu Hogar	40.0	
	Elsuki	85.7	
Blue Nile	Al Rusayris	74.0	
	El Damazin	64.0	69.0*

significant at 5%

The wide spread of the parasite in the study area could be attributed to the prevailing environmental conditions where forests dominated by aged tall Acacia trees favoring the mistletoe dispersing birds to perch and feed. The continuous movement of birds visiting mistletoe attracted by the showy flowers and fruits, gradually accumulate infections in their nesting sites and build up a continuous source of inoculum. The spread of mistletoe along the Blue Nile banks seems to be enhanced by the gradual built up of the parasite on its host and poor control methods used. The built up of the parasite in orchards is due to the fact that the seeds of the parasite are surrounded by a persistent and very adhesive pulp, these were either fall and adhere naturally from higher to lower branches of the same host tree to ensure continuous infestation, or they were eaten by certain birds and are largely disseminated by them as the adhesive pulp stick to their feet and beaks, thus the seeds were carried about and lodged on the twigs of another tree in the same or neighboring orchard (DelRio*et al.*,1996). The seeds were also spread in the excrement of birds to ensure distant spread (Mathiasen*et al.*, 2008). The second factor is that the only available method of control in Sudan is preventive using irregular pruning. Unfortunately the method applied is not done properly; the farmers used to remove the haustorium of the parasite which lead to resprouting of the parasite vigoursly (Zaroug*et al.*,2013). The accurate method is to cut the infected branch at least 20 -30 cm behind the haustorium (Parker and Riches, 1993). Therefore, the infected branches should be removed regularly at short intervals with continuous inspection of the orchard to stop the spread of mistletoe.

3.2. Severity of mistletoe in fruit tree crops

Disease index has the advantage of rating incidence on the basis of severity while percentage of infection measures the mere presence of the parasite among the trees evaluated. Disease index is therefore more relevant to an epidemic situation and application of control measures than percentage of infection. The lime trees in all locations surveyed had manifested relatively high percent infection of mistletoe. The highest magnitude of infection was found in orchards in Sinar state (80%-92.5%), followed by Blue Nile (76.4%-89.3%), and Gezira states (20%-72.2%). Likewise, was the severity index, the highest was recoded in Sinar (44.06%-90.6%), and the lowest in Gezira state (5%-32.4%) (table 2).

Table 2: Incidence of mistletoe along the Blue Nile Banks with reference to infection percentage and severity index on lime and guava

	Lime		Guava	
Locality (Provinces)	% infected trees	severity index	% infected trees	severity index
El Hisahisa	53.3	16.0	75.0	28.1
Eastern Gezira	72.2	32.4	85.7	42.7
Wad Medani	61.7	43.3	69.2	40.7
Southern Gezira	20.0	5.0	40.0	12.5
Sinar	92.5	90.6	62.5	25.9
Eastern Sinar	80.0	44.1	91.7	74.2
Singa	80.0	50.0	85.0	51.8
Abu Hogar	90.9	65.9	70.0	47.2
Elsuki	76.2	46.0	91.1	62.7
Al Rusayris	76.4	50.1	50.0	37.5
El Damazin	89.3	52.5	25.0	17.2

These indicate that lime is severely infected by mistletoe causing drastic damage. These results are in agreement with Asare-Bediako*et al.*, (2013) who reported high level of infestation and very high severity indices ranging between 20% and 90% in citrus trees, in orchards in Ghana. Whereas in Sudan it was reported to cause severe damage to fruit tree crops, which include growth loss, mortality and reduced yields (Sidahmed, 1984). Similarly guava trees grown in the same study area with lime were severely infected by mistletoe. The highest percent infection was reported in Sinar (62.5%-91.7%), and the lowest was recorded in the Blue Nile states (25.0%-50.0%); with severity index of (25.9%-74.2%) in Sinar, (12.5%-42.7%) in Gezira, and (17.2%-37.5%) in Blue Nile states. It is clear from the study that there is a high infection and severity of mistletoe infestation in fruit trees in orchards along the Blue Nile banks. These results reflects the epidemic situation of mistletoe along the east and west banks of the Blue Nile, despite the lack of quantitative data concerning losses in fruit production of infected plants. It is generally recognized by specialists (Parker and Riches, 1993; Didier *et al.,* 2008) and by farmers that significant losses result from mistletoe parasitism. Therefore these results justify the necessity of an effective control measures to be developed. This suggest that the mistletoe will pose a threat to citruses and guava tree crops grown in an area extending for 360 km along the east and west banks of the Blue Nile.

3.3. Host range:

The results presented in table 3 indicated that mistletoe (*Tapinanthusglobiferus*) parasitized 22 plant species belong to 14 families. Some of the hosts are fruit tree crops, others are useful hedges around orchards in the same habitat. The severely infected host plants include citruses, guava,

Zizphus sp. and *Moringa* sp. were the most prevalent in the study area. These findings are in agreement with Didier *et al*.,(2008) who reported the same species of mistletoe infecting different fruit trees including citruses and guava. Mistletoe was reported to parasitize 126 taxa and believed to be less specific (Boussim*et al*., 2004). However, the results suggested that the relatively abundant citruses and guava in the study area influenced the host choice of mistletoe. Besides the relative abundance of host species (Norton and Carpenter, 1998), characteristics such as branch size, age and height can have a strong effect on mistletoe attachment resulting in size-related mistletoe infection patterns (Overton, 1994). The occurrence of mistletoe in orchard trees was observed on citruses and guava 30 years ago in Sinar state (Zarou*et al*., 2009) which indicates a long period of association between the parasite and its hosts. These are in agreement with Didier *et al*.,(2009) who reported that the degree of specialization of the African mistletoe, *Tapinanthusogowensis*parasitizing *Dacryodesedulis*is influenced by its abundance and the duration of association between the two.

Table 3: Host range of mistletoe (*Tapinanthusglobiferus*) in central Sudan

Host	Family	Severity
*Annonasquamosa*L.	Annonaceae	+
Calotropisprocera (Ait.) Ait.f.	Asclepiadaceae	+
Balanitesaegyptiaca Del.	Balanitaceae	+
*Adansoniadigitata*L.	Bombacaceae	+
Tamarindusindica L.	Caesalpinaceae	+
Lawsoniainermis (L.) Koehne	Lythraceae	+
Albizialebbeck (L.) Benth.	Mimosaceae	+
Leucaenaleucocephala (Lam.) De. Wit	Mimosaceae	+
Acacia albida Del.	Mimosaceae	++
Acacia meliferae (Vahl) Benth.	Mimosaceae	+
Acacia nilotica(L.) Willd. Ex Del.	Mimosaceae	++
*Ficus*sp	Moraceae	+
*Morus*sp	Moraceae	+
*Moringa*sp. Adans.	Moringaceae	+++
Psidiumguajava M.	Myrtaceae	+++
Punicagranatum L.	Punicaceae	+
Ziziphusspina-chrsti (L) Desf.	Rhamnaceae	+++
*Citrus ariantum*L.	Rutaceae	+++
Citrus sinensis L.	Rutaceae	+++
*Citrus aurantifolia*Swingle	Rutaceae	+++
*Citrus paradisii*Macf.	Rutaceae	+
Tamarixnilotica (Ehrenb.) Burge	Tamaricaceae	+

+ = low infection 1-5 shoots of mistletoe/tree
++ = moderate infection 6-10 shoots of mistletoe/tree
+++ = high infection ≥ 10 shoots of mistletoe/tree

Observations during surveys revealed that almost all citruses, and guava the widely grown tree crops were severely damaged. However, mango trees were not infected despite the presence of mistletoe seeds deposited on its branches. This suggested the tolerance of mango to mistletoe *T. globiferus* parasitism. This agreed with Musselman, (1984) who reported that *T.globiferus* spreading in Sudan was damaging to citruses and guava trees but conspicuously absent from mangos. It was also reported that mango was totally resistant to Loranthaceae parasitism in Burkina Faso and Cameron (Boussim*et al*., 2004, Didier *et al*., 2008). These findings revealed that mistletoe could parasitize a variety of host plants, with special preference of potential suitable hosts. Factors influenced the host choice include, the abundance of potential host species, host characteristics and the duration of the host-parasite association. In addition to the presence of suitable seed dispersers.

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