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A STUDY OF THE CONSERVATION STATUS OF *CITRUS SINENSIS* AS AFFECTED BY THE AFRICAN MISTLETOE, *TAPINANTHUS BANGWENSIS* IN MOOR PLANTATION, IBADAN, SOUTH-WEST, NIGERIA

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ABSTRACT

An investigation was conducted into host-parasite interaction between the trees of *Citrus sinensis* and their parasitic associate, the African Mistletoe, *Tapinanthus bangwensis* on how much of the products of metabolic processes and structural components of the host are affected by the relationship. The rate of parasitism was observed to vary with differences in age and location and as well as by the peculiar nature of susceptible hosts. Susceptibility to infestation was aided by senescence and loss of vigour, large bole and fissured bark, open vegetation and wide canopy base. Impact of the mistletoe infestation on its *Citrus* host in this study was negligible but unfettered growth of the parasite if allowed to continue could become a serious threat to the survival of the host trees in no distant future.

INTRODUCTION

Citrus is a very wide genus of fruit-bearing tree crops in the family *Rutaceae*, originating in tropical and sub-tropical south-east regions of the world. The taxonomy and systematics of the genus is complex, and the precise number of natural species is unclear (Ezejiofor *et al.*, 2011). Citrus though have a botanically large family, the dominant members include sweet orange (*Citrus sinensis*), tangerine orange (*Citrus reticulata*), grape fruit (*Citrus paradisi*), lemon orange (*Citrus limonum*) and lime orange (*Citrus aurantifolia*). The fruits are classified as berries and could be termed as a hesperidium. Citrus fruits have a rough, robust and bright (green to yellow) coloured skin. They are usually 4 to 30 cm long and 4 to 20 cm in diameter, with a leathery surrounding rind or skin known as epicarp (or flavedo) that covers the fruits and protects it from damages. Citrus fruits are notable for their fragrance, partly due to flavonoids and limonoids contained in the rind (Manthey, 2004). The endocarp is rich in soluble sugars and contains significant amounts of vitamin C, pectin, fibers, different organic acids and potassium salt which give the fruits its characteristics citrus flavor (Roger, 2002). Citrus juice also contains a high quantity of organic acids such as citric, malic, acetic and formic acids (Rogers, 2002). Citrus contain the largest number of carotenoids found in any fruit and an extensive array of secondary compounds with pivotal nutritional properties such as vitamin E, provitamin A, flavonoids, limonoids, polysaccharides, lignin, fiber, phenolic compounds, essential oils among others. These substances greatly contribute to the supply of anticancer agents and other nutraceutical compounds with anti-oxidant, inflammatory, cholesterol and allergic activities, all of them essential to prevent cardiovascular and degenerative diseases, thrombosis, cancer, atherosclerosis and obesity (Iglesias *et al*., 2007; Okwu and Emenike, 2006; Rapisararda *et al.*, 1999). *Citrus sinensis* is a small, shallow-rooted evergreen shrub or tree about 6- 13 m high with enclosed conical top and mostly spiny branches. Twigs angled when young, often with thick spines (Orwa *et al*., 2009).

Sweet orange (*Citrus sinensis*) is mainly cultivated in the subtropical and tropical regions of the world in 137 countries and on six continents (Ismail and Zhang, 2004). Its production in Nigeria is significant, with heavy direct consumption due primarily to few and small capacity processing industries to convert the fruit to juice concentrate and canned fruit (Oluremi *et al.,* 2006). Nigeria produces 3% of fresh citrus in the world and thus contributes 3,488,400 tonnes to the world output (FAOSTAT, 2010). Trees aged 3-4 years produce 2.5-5 t/ha of fruit and 8-12 year old trees produce 20-40 t/ha of fruit. Citrus single trees may live up to 100 years, but the economic life of an orchard seldom exceeds 30 years (Orwa *et al*., 2009).

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The Loranthacean mistletoe (*Tapinanthus spp.* and related species) are widely distributed in Nigeria. They grow as woody shoot parasites on a diverse range of trees and shrubs, which have ethnobotanical and economic importance (Wahab *et al*., 2010). They grow attached to branches and stems of host trees by means of specialized absorbing organ called the haustorium, which penetrates into host's living tissues and functions for translocation of various materials (water and mineral nutrients) from the host into the parasite. It thus deprives the host of essential nutrients that may be utilized for photosynthetic and other metabolic activities. Each haustorium consists of mostly parenchymatous tissues, sclerenchyma and xylem but with little phloem tissues (Benzing 1990; Polhill and Wiens, 1998). When established on a host tree therefore, mistletoes grow into bushy evergreen masses producing berries in which seeds immersed in viscous fluid, is contained. The fluid helps the seeds to adhere to the host branch when released. Hence, this mistletoe causes general decrease in the vegetative vigour, value and viability of the affected host plants (Kwon-Ndung and Ismaila, 2009).

Mistletoes affect host viability by withdrawing essential resources. The parasite competes with its host for water, inorganic nutrients and organic compounds. The extent to which the host is affected depends not only on how much of the resource is diverted by the parasite, but also on the overall supply available to the host. Some leafy mistletoe may live for decades in association with their host trees and result in little apparent damage, while others inflict severe damage. Mistletoes affect hosts in many ways, including reduced growth, diminished vigor, premature mortality, impaired quality and quantity of wood, reduced fruit set, and heightened susceptibility to attack by other agents such as insects or fungi. When one part of the host is intensively attacked by mistletoe, the reproductive and photosynthetic potential of the part distal to the infestation declines leading to death of the part. But the extent of damage caused to the host depends on size of the parasite, the growth rate and metabolic activity of the parasite, the degree of dependency on the host for resources, and the stage of development of the host (Aliero and Ismaila, 2002; Davcota, 2005; Kwon-Ndung and Ismaila, 2009). The Loranthacean mistletoe (including *Tapinanthus bangwensis* (Engl. and K. Krause) Danser and other species which are known to be of widespread occurrence even in Nigeria have been reported attacking a number of many wild and domesticated tree and shrub species such as *Azadirachta indica, Vitellaria paradoxa, Nerium Oleander, Albizia lebbeck, Morinda lucida, Theobroma cacao, Cola nitida, Jatropha curcas, Ficus exasperata, Parkia biglobosa, and Citrus sinensis* (Bright and Okusanya, 1998; Ayuba, 2000; Bako *et al.*, 2001; Wahab *et al*., 2010). This study was initiated to investigate the impact of the infestation of the mistletoe species (*Tapinanthus bangwensis*) on the population of *Citrus sinensis* and elicit the probable factors which are in favour of the parasitic infestation and proffer the necessary steps that should be taken to reverse any negative trend and maintain balance.

MATERIALS AND METHODS

The study was carried out in the *Citrus* orchards of the Nat. Cereals Research institute (NCRI) and the National Centre for Genetic Resources and Biotechnology (NACGRAB) within the Moor Plantation complex, Ibadan, South-west, Nigeria between November 2011 and June 2012. The collected parasitic plant samples of the *Tapinanthus* species of mistletoe were identified at the herbarium of NACGRAB with the assistance of Mr. Daramola. The *Citrus* orchards were mapped and 3 randomly selected plots were studied.

Girth size of all the *Citrus* was determined by measuring the diameter at height of primary branches using a measuring tape. The number of host trees infested and those uninfested in each girth size range was determined; and percentage infestation was calculated. The severity of infestation was estimated according to the amount of plant crown area infested by mistletoes on a visual scale of 1 to 4, by standing at a distance of 3 to 6m to the host tree from four different directions.

Total number of fruits on the infested and uninfested *Citrus* were determined by plucking and counting of the fruits. The extent of impact/loss in the tree productivity was evaluated by random sampling of three infested and three uninfested trees from each girth size range and counting the number of fruits produced by each at maturity with the mean productivity calculated for each group.

RESULTS AND DISCUSSION

The infestation rate of *Citrus* in the three study locations (Table I) vary sharply from 0% in the uninfested stand to 83.9% in the infested stands. However, among the infested *Citrus* stands, infestation ranged from 42.2% to 83.9%.

In table II, the severity scaling of the mistletoe infestation on the *Citrus* orchards romped toward a gradual build up in the intensity of the parasitism. In orchard 1, the aggregate population of host trees suffering minimal and tolerable infestation (low + fairly high) was about 18 while the population subjected to critical and more damaging effect (high + very high) was spread among 20 stands of the total infestation.

Table 1 Rate of infestation of *Tapinanthus bangwensis on Citrus sinensis* at the three studied locations.

Location	Total No. of Trees Surveyed	Total No. of Trees Infested	Percentage (%) Infestation
Citrus orchard 1 (adjacent borehole water supply station)	90	38	42.2
Citrus orchard 2 (by staff quarters N-E of orch.1)	31	26	83.9
Citrus orchard 3 (close to BCGA axis)	10	0	0

For orchard 2, similar demarcation reflected 6 and 20 aggregate population for the less devastating and critical zone respectively. In the third location of orchard 3, there was no infestation.

Table 2 Severity of infestation of the infested *Citrus* stands across the three studied locations

Location	Total No. of Trees Infested	Effect on Crown Area Among Infested Population			
		Low (1)	Fairly high (2)	High (3)	Very high (4)
Citrus orchard 1 (adjacent borehole water supply station)	38	12	6	16	14
Citrus orchard 2 (by staff quarters N-E of orch.1)	26	3	3	14	6
Citrus orchard 3 (close to BCGA axis)	0	N/A	N/A	N/A	N/A

N/A, Not Applicable

The rate of parasitism by *T. bangwensis* on *C. sinensis* based on stem girth was presented in Table III. The result revealed that the percentage infestation was on a 0% level at the least stem girth range (0-33cm) and 100% in girth ranges 68-101cm and 102-135cm while it was at the level of 44.4% and 57.1% in girth ranges 34-67cm and 136-169 respectively (Table III).

Table 3 Classification of *C. sinensis* based on the girth size and rate of *Tapinanthus* infestation

Girth size (cm)	No of trees surveyed	No. of trees infested	Percentage (%) infestation
0-33	36	0	0
34-67	18	8	44.4
68-101	19	19	100
102-135	12	12	100
136-169	7	4	57.1

The mean numbers of fruits produced by *C. sinensis* based on the girth size and on whether a stand was infested or uninfested (Table IV) depicted a scenario wherein the smaller girth size range had lower output in situations where there was representation. So that at 0-33cm, an average of 84 fruits was produced by uninfested trees while there was no sample population of infested trees at that girth range. Uninfested *Citrus* stands at 34-67cm range had 87 fruits while infested stand yielded 100 fruits. However, for the 68-101cm and 102-135cm girth ranges, there were no extant sample population representation for the uninfested trees but the infested *Citrus* stands had 114 and 128 fruits respectively (Table IV). One hundred and ninety-eight (198) fruits were produced by uninfested *Citrus* stands that fell within the 136-169cm girth range while the infested stand of that range had 94 fruits.

The parasitism of the African Mistletoe, *Tapinanthus bangwensis* vary among the different locations of the *Citrus* orchard, depending on the prevailing circumstances subsisting in the environment of particular stands and orchards of the host plant. The sharp differences in the rate of infestation were partly as a result of the age of the susceptible host plants. This was such that while the average age of the plants in some locations (orchards 1 & 2) was about 45yrs, the age of the plants in one of the sample location (orchard 3) was less than 20yrs. And since younger plants are more active and possess greater resistance to parasitic attack (Oteng – Yeboah and Garba, 1983); it therefore follows that such noticeable difference would come to bare. Other features which go along with the advancement in the years of the *Citrus*, as is noticeable in related trees are large bole, fissured bark and large canopy which all encouraged the attachment and germination of mistletoe seeds for infestation. Again, it should be mentioned that topography and vegetation cover over each orchard were other determining factors in the host-parasite interactions. While the younger aged orchard was positioned in steeply lower terrain, enveloped by the aggregation of some massive and bigger shade trees such as *Delonix regia*, *Polyathia longifolia*, *Eugenia vitiflora* and *Hura crepitans*, the others were on plain terrain without vegetation cover. Going by the two situations so described, it should be noted that the former shielded the *Citrus* stands from exposure to frequent visitation of the major dispersal agent of *Tapinanthus spp*, the tinker birds (*Pogoniulus* spp.) and hence less exposure to infestation.

Severity of the parasitic infestation on the *Citrus* orchards depicted an overall scaling up in the population and activities of *Tapinanthus bangwensis* which is bound to grow in intensity and lead to rapid decline in the economic value of the host plants should the mistletoe parasites be left to thrive unchecked. In view of the prevailing ecological conditions in which the host-parasite association was observed; it is obvious that without external interference/control, there is likelihood that the mistletoes will grow in size and numbers (increase severity rate) and

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The graduation of the percentage infestation of the *Citrus* by the mistletoe from an abysmally low level at a correspondingly low girth size through a correlated oscillatory rise to a peak, and a later subsequent decline conforms to the assertion by Kwon-Ndung and Ismaila, (2009) that parasitic infestation increase with increase in girth size of host plants. In this vein, as susceptible host trees mature and add up in girth size, their morphological and physiological structure are more liable to favour and support increased parasitic habitation and are therefore rarely free of infestation. Thus, this *Citrus*-mistletoe association is congruent with the observation by Kwon-Ndung and Ismaila, (2009) that trees of large girth size generally have wider crowns and as such provide more surface area for bird's activities and hence more mistletoe seeds deposition on them, resulting in more severe infestations.

The data on the productivity mean of the *Citrus* which represent the uninfested and infested stands with a consideration along the different girth size range did not reflect a uniform output pattern. Unlike the observation by Kwon-Ndung and Ismaila, (2009) where there was loss in reproduction (fruit yields) which increased with increase in the girth size of host plant (i.e *Parkia biglobosa*), the *Citrus* in this case produced some more fruits at the infested state while there were marginal increases in the number of fruits produced as the girth size increase. This means the effect of the mistletoe on most of the *Citrus s*tands were negligible considering the level of infestation. It was noted however that loss in productivity appeared to be a function of the canopy area covered by the mistletoe as inferred by Kwon-Ndung and Ismaila, (2009) and Aliero and Ismaila (2002). This was corroborated on the strength that the few stands seen to have suffered serious crown degradation manifested sharp loss in productivity.

CONCLUSION

The study realized the implication of *Tapinanthus* species infestation on the yields of *Citrus sinensis* and the threat to genetic diversity of this germplasm in the eco-habitat under study if the host-parasite association is not effectively monitored. It is noteworthy however, that while the mistletoe appears to be of some threat to the survival of its host population; it bore some value as important component of the natural ecosystem especially as an asset of keystone species of biodiversity and phytomedicinal resource. As an advocate of conservation and sustainable utilization of genetic resources; a position of regulated pruning vis-a-vis optimum productivity of the host plant while as well guarding against a drive for extinction of its parasite associate is therefore encouraged.

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