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Cicadulina mbila (Naudé)

(Maize Leafhopper)

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Background Information

Common Names:

Maize leafhopper

Scientific Name:

Cicadulina mbila

Synonyms:

Balclutha mbila

Taxonomy:

Kingdom: Animalia; Phylum: Arthropoda;

Class: Insecta; Order: Hemiptera;

Family: Cicadellidae

Crop Hosts:

Grasses and cereals: oats, millet, barley, rice, sugarcane, sorghum, wheat



Figure 1. Adult leafhopper, *Cicadulina mbila* (left, lateral view) and maize streak geminivirus (MSV) symptoms (right). <http://pbt.padil.gov.au/pbt/index.php?q=node/15&pbtID=129>, Accessed 31 July 2014.

Introduction

Cicadulina spp. (Hemiptera: Cicadellidae) are leafhoppers that are primarily associated with grass and cereals in Africa and parts of Asia. Their importance as pests relies on their ability to transmit the maize streak geminivirus (MSV) (Rose 1978; Page et al. 1999; Magenya et al. 2008). MSV has a broad distribution in Africa and apart from maize has as many as 80 hosts in the Poaceae family (Shepherd et al. 2010). The virus is exclusively transmitted by *Cicadulina* species (Rose 1978; Asanzi et al. 1994). There are 22 species in the genus, 18 of them occur in Africa, 9 of which are known to be vectors of MSV (Webb 1987; Oluwafemi et al. 2007). Of these, *C. mbila* is considered the most important in the epidemiology of the virus (Storey 1938; Asanzi et al. 1994; Oluwafemi et al. 2007).

Known Distribution

Cicadulina mbila (Naudé) (Figure 1) is currently known to occur in sub Saharan Africa, parts of India, and there are two single reports from Yemen and Tadzhikistan (Zakhvatkin 1946; Ruppel 1965; CABI 1986). However, the Yemen report (Zakhvatkin 1946) is for an interception at Hodeida Port, so does not in fact indicate persistence of *C. mbila* here. In Africa, *C. mbila* is found in most central and southern sub-Saharan countries, including Angola, Botswana, Congo, Ethiopia, Kenya, Mauritius, Mozambique, Namibia, Nigeria, South Africa, Swaziland, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe, and adjacent islands Cape Verde and Reunion (CABI 1986; Reynaud et al. 2009; Webb 1987). *Cicadulina mbila* also occurs in Burundi (Gelaw 1985), Zaire and probably also in Rwanda, as MSV is a major constraint to maize production here (Mpabanzi and Ntawuyirusha 1985). Its abundance is considered to be highly influenced by rainfalls and availability of host plants (Rose 1973b; Asanzi et al. 1994). *Cicadulina mbila* is characterised by its ability to fly for long distances when hosts become unattractive. Two different body sized forms have been observed: short-body and long-body, with the former being more frequently associated with long distance flying (Rose 1972).

Description and Biology

The life cycle of *C. mbila* includes three developmental stages: egg, nymph and adult. The nymphal stage has five instars (Rose 1973a). *C. mbila* will complete 5-8 generations in Zimbabwe depending on location, rain and host availability (Rose 1973b). It is not known to diapause or have any other form of dormancy. It develops throughout the year, with periods of prolonged development (Rose 1973b).

Females lay their eggs in the leaf tissue, usually near the main vein. Eggs are creamy-white, elliptical and narrow, and their size range is 0.3 to 0.5 mm long by 0.1 mm in diameter. Eggs hatch within 7 to 35 days depending on temperature, and young nymphs take 14 to 20 days to become adults at 25 °C (Rose 1973a; Okoth et al. 1987). Adults have a relatively long preoviposition period, ranging from 2 to 20 days depending on temperature and population characteristics (Rose 1973a; Okoth et al. 1987). Adult lifespan and fecundity is influenced by host plant and population origin. Females have an average lifespan of 33 days on millet but just 18 days on sorghum. Females have an average fecundity of 129 eggs/female at 28 °C (Bosque-Pérez and Alam 1992; Rose 1973a).

Both nymphs and adults feed by piercing into the plant tissues but feeding activity per se by leafhoppers causes insignificant damage. It is their ability to transmit MSV that makes them important pests. Uninfective active *C. mbila* can acquire MSV from chlorotic regions of infested plants within 15 s of feeding (Storey 1938). Symptoms of MSV (Figure 1) include small, spherical, chlorotic spots on the younger leaves of the maize plant which later coalesce into longitudinal chlorotic streaks (Bosque-Pérez et al. 1998). In highly sensitive maize varieties, MSV is likely to result in chlorosis of the entire leaf lamina and result in plant death. The significance of the damage is strongly correlated with the time of the infestation and plant development. There is 100% yield loss in plants infested within the first three weeks after seedling emergence. Later infestations cause small and poor ear formation; however, plants infested 8 weeks after seedling emergence produce their full yield. Symptoms only appear on leaves formed after infestation. The incidence of virus infection has been reported to range from 5% to 100% within the same year and between first and second growing season in Nigeria (Rose 1978; Asanzi et al. 1994). The infestation patterns of MSV in maize fields have been shown to follow the seasonal abundance and distribution of *Cicadulina* species (Rose 1978).

Host Crops and Other Plants

Cicadulina species are generally considered to be grassland species. Maize, barley, finger millet, oats, rye, sugar-cane, and alfalfa are all crop hosts of *C. mbila*. Star grass, Sudan grass, kikuyu grass, nappier fodder, vasey grass, and a number of annual grasses (*Digitaria* spp., *Eleusine* spp., *Setaria* spp.) are also known as hosts of *C. mbila* (Rose 1973b).

Potential Distribution

A CLIMEX (Sutherst et al. 2007) model for *C. mbila* (Table 1) was developed using published records of current distribution in Africa. Available literature on biology and seasonal phenology was used to adjust model parameters (Rose 1973a; 1973b; Okoth and Dabrowski 1987; Asanzi et al. 1995).

Table 1. CLIMEX Parameter Values for *Cicadulina mbila*

Parameter	Description	Value
Moisture		
SM0	lower soil moisture threshold	0.1
SM1	lower optimum soil moisture	0.5
SM2	upper optimum soil moisture	1.5
SM3	upper soil moisture threshold	2.5
Temperature		
DV0	lower threshold	15 °C
DV1	lower optimum temperature	25 °C
DV2	upper optimum temperature	30 °C
DV3	upper threshold	33 °C
Cold Stress		
TTCS	cold stress temperature threshold	0 °C
THCS	temperature threshold stress accumulation rate	-0.03 week ⁻¹
Heat Stress		
DTHS	degree-day threshold (stress accumulates if the number of degree-days above DV3 is above this value)	10 °C days
DHHS	degree-day stress accumulation rate	0.01 week ⁻¹
Dry Stress		
SMDS	soil moisture dry stress threshold	0.1
HDS	stress accumulation rate	-0.01 week ⁻¹
Wet Stress		
SMWS	soil moisture wet stress threshold	2.5
HWS	stress accumulation rate	0.01 week ⁻¹
Threshold Annual Heat Sum		
PDD	number of degree-days above DV0 needed to complete one generation	300 °C days
Irrigation Scenario		
2.5 mm day ⁻¹ as top-up throughout the year		

There are no real data with which to set the moisture parameters, but *C. mbila* occurs in the more humid areas of Ethiopia (Mesfin et al. 1991) and throughout sub-Saharan Africa (CABI 1986; Reynaud et al. 2009). The lower threshold was set to approximate the permanent wilting point for plants (Kriticos et al. 2003); the upper threshold makes relatively wet areas suitable.

Temperature parameters were derived from the literature. The minimum threshold of 15 °C was derived from Rose (1973a), van Rensburg (1982), Damsteegt (1984), Mesfin et al. (1991) and Bosque-Pérez & Alam (1992). Optimal temperatures range from 25 °C to 30 °C (van Rensburg 1982; Rose 1973a; Bosque-Pérez & Alam

1992), and the maximum threshold for development is above 30 °C (Rose 1973a; van Rensburg 1982; and Bosque-Pérez & Alam 1992). A PDD value (the number of degree-days greater than the developmental threshold (DV0 = 15°C) necessary to complete a generation) was set at 300 to allow 4-5 generations to occur in the Harare region of Zimbabwe (Rose 1973a; 1978).

Damsteegt (1984) indicates that as temperatures approach freezing, mortality of adults increases, and there is no physiological mechanism to allow overwintering of *C. mbila* in cold climates. This implies that low temperatures per se (around 0°C) will induce mortality. The Cold Stress temperature threshold of 0 °C precludes persistence in high altitude areas of South Africa and Lesotho. With no evidence to support the choice of parameter values, the degree-day Cold Stress mechanism was not used.

Percentage mortality is higher at 31 °C than at 25 °C and 28 °C, and no nymphs reach the adult stage at 31 °C (van Rensburg 1982). Bosque-Pérez & Alam (1992) indicate that 35 °C is detrimental to *C. mbila*, but provide no further information than a statement to this effect. With a degree-day model of Heat Stress, the only mainland African site to accumulate any Heat Stress (HS = 2) is Gambella in Ethiopia (Mesfin et al. 1991). The Yemen site accumulates lethal Heat Stress (HS = 115), but it would be possible for *C. mbila* to go through several generations in the cooler months of November to April if irrigation were to be applied. The Heat Stress model used is thus consistent with the known distribution of *C. mbila* in Africa.

The model parameters (Table 1) were fitted using the CliMond 10-minute gridded spatial resolution climate dataset (Kriticos et al. 2012) under a natural rainfall scenario. Subsequently, an irrigation scenario (2.5 mm day⁻¹ applied as top-up) was applied. A composite climate suitability map for Africa (Figure 2) was created by combining the natural rainfall and irrigation scenario results using the data from Siebert et al. (2005). Although distribution data are relatively abundant from Kenya, Nigeria, Uganda, and Zimbabwe, there are only scattered records for the rest of Africa. It is known that *C. mbila* occurs in Cape Verde (Reynaud et al. 2009) and it is most likely present in the area from Togo to Senegal. The model projects as unsuitable the single record from west Yemen (Zakhvatkin 1946), but this record was a single sample from the port of Hodeida, so it is unknown whether or not *C. mbila* can in fact persist there.

The model was validated by projecting the distribution in Asia (Figure 3), where there are a few records of *C. mbila* in India and Tajikistan (Ahlawat and Raychaudhuri 1976; Chaudhary et al. 1978; Nagaish and Sinha 1974; Nagpal et al. 1977). Three of the four current location records of *C. mbila* in India are included in the modelled area of suitability. The fourth site, Durgapura in Jaipur, Rajasthan (Choudhary et al. 1978) is unsuitable due to excessive Heat Stress. However, this location is close enough to suitable regions to allow *C. mbila* to migrate

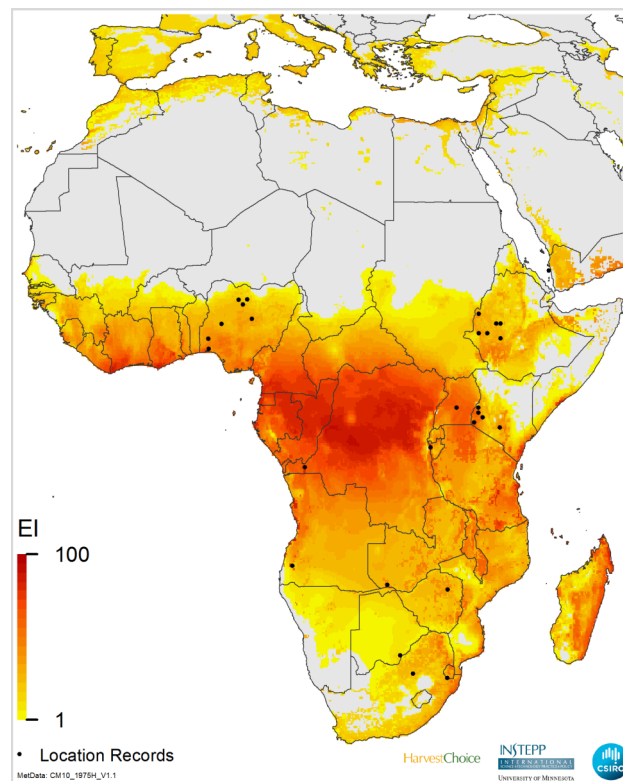


Figure 2. Modelled climate suitability of Africa for *Cicadulina mbila* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were geo-coded from Asanzi et al. 1994, CABI 1986, Damsteegt 1984, Koji et al. 2012, Magegnya et al. 2009, Mesfin et al. 1991, Page et al. 1999, Reynaud et al. 2009, Rose 1973b, Okoth et al. 1987, and Zakhvatkin 1946.

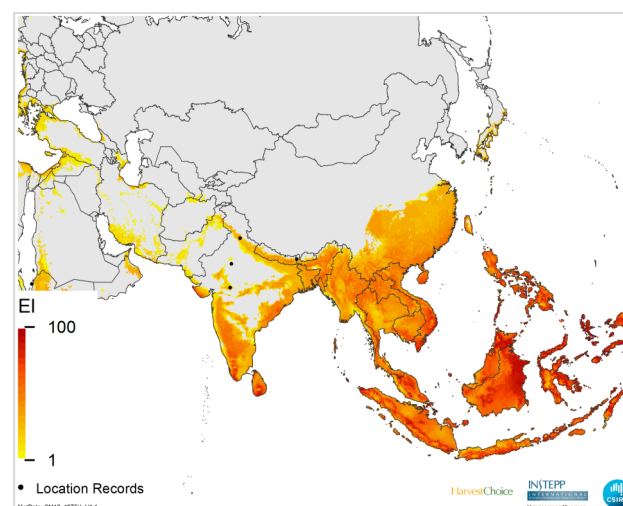


Figure 3. Modelled climate suitability of Asia for *Cicadulina mbila* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were geo-coded from Ahlawat and Raychaudhuri 1976, Chaudhary et al. 1978, Nagaish and Sinha 1974, and Nagpal et al. 1977.

there. Whilst summer temperatures are too high to allow persistence, population growth could occur from mid-October until the end of March with sufficient irrigation.

Finally, we provide a map of the projected global distribution of *C. mbila* (Figure 4). This analysis indicates that *C. mbila* could potentially become established in many countries in Asia. It could also establish in Central

America and in most of South America. In America, it could persist in Texas, Oklahoma, and in the eastern states south of and including Arkansas, Tennessee and North Carolina. There are also some suitable areas in New Mexico and up the west coast of California, Oregon, and Washington. In Australia, most coastal areas are suitable.

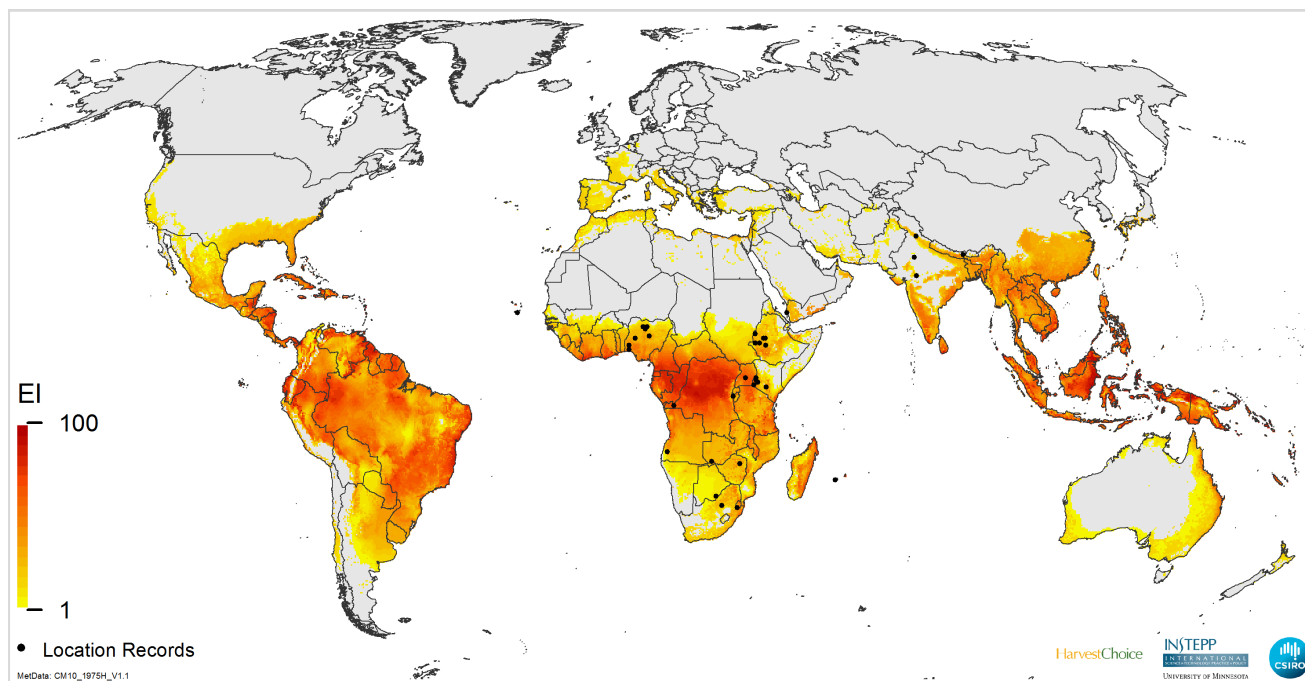


Figure 4. Modelled global climate suitability for *Cicadulina mbila* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were geo-coded from Ahlawat and Raychaudhuri 1976, Asanzi et al. 1994, CABI 1986, Chaudhary et al. 1978, Damsteeg 1984, Koji et al. 2012, Magegnya et al. 2009, Mesfin et al. 1991, Nagaish and Sinha 1974, Nagpal et al. 1977, Page et al. 1999, Reynaud et al. 2009, Rose 1973b, Okoth et al. 1987, and Zakhvatkin 1946.

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