



Original Research Article

Received: 31 Aug 2014, Accepted: 20 Sep 2014, Published: 20 Oct 2014

Determination of Damage Threshold of Cassava Green Mite (Acari: Tetranychidae) on Different Cassava Varieties

Mutisya DL^{1,2}, El Bahawy² EM, Khamala CPM², Kariuki CW¹ and Miano DW²

Author Info

¹KARI-Katamani. P. O.
Box 340-90100. Machakos.
Kenya

²University of Nairobi. P. O.
Box 30197-00100. Kenya

*E-mail of Corresponding
author:

dlmutisya@gmail.com

Key Words

Cassava green mite,
damage score, cyanide
content, biomass.

Abstract

Density threshold has been least considered in efforts to control cassava green mite (CGM) of the *Mononychellus* species. Nine cassava varieties of varied cyanogenic contents were evaluated for CGM density threshold. Mite population of the 10 introduced individual active stages of *Mononychellus progresivus* reached peak densities on 39th day of the most susceptible varieties, and by the 54th day attacked leaves had wilted at 20.0 ± 2 °C and 63 ± 4% test climatic conditions. Mite threshold was determined to be ≥ 27 mites / leaf. Cassava leaf variety cyanogens potential content was between 8.5 to 20.0 mg/kg on the nine varieties evaluated. Variety high cyanogens potential led to higher CGM density growth and subsequent biomass loss. Similarly, high leaf cyanide (HCN) content led to higher biomass loss (%) up to HCN 20mg/Kg as a result of high CGM infestation. This information is beneficial to cassava breeders when developing varieties tolerant to CGM damage and safe for human consumption where cyanogens levels <10mg/kg showed the least leaf damage by CGM. Likewise farmers and crop protection agents can use the determined threshold to decide when to implement control measure for CGM on cassava crop.

Introduction

Cassava, *Manihot esculenta* Crantz is grown as an important staple root crop in the tropics (Nweke, 1996). In eastern Africa cassava is the third rated carbohydrate crop feeding over 100 million in the Great Lakes region (Mohammad et al. 1998). The major herbivore pest on cassava is cassava green mite (CGM) consisting of eight species, *Mononychellus tanajoa* Bondar, *M. progresivus* Doreste, *M. manihoti* Doreste, *M. bondari* Paschoal, *M. caribbeanae* McGregor, *M. mcgregori* Fletchman & Baker and *M. estradai* Baker & Pritchard (Gutierrez, 1987). In Africa both *M. tanajoa* and *M. progresivus* have been reported (Yaninek et al. 1987; Navajas et al. 1994). Mite pest population growth on plant host depends on

presence or absence of deterrent chemical compounds or antibiosis on the plant organ most vulnerable to pest attack (Bellotti et al. 1999). In the same context CGM population growth on cassava plant and the subsequent economic injury level (EIL) would be as a result of deterrence level of variety chemical compound compositions along with other plant characteristics (Komkiewtacz et al. 1993; Higley and Pedigo, 1993). On plant host resistance, cassava mealybug *Phenacoccus manihoti* Mat-Ferr resistance was found correlated to leaf pubescence and unexpanded leaves (Bellotti, 2002). Similarly, spider mite pest resistance or tolerance has been attributed to plant vigor, leaf pubescence and antibiosis mechanism (Kawano and

and Bellotti, 1980; Bellotti et al. 1999). Other invertebrate deterrents reported on cassava are the hydrocyanic acid (HCN) which repels some grasshoppers (Hillocks 2002). The cassava cyanogens compounds are mainly the linamarin (85%) with lesser amounts of lotaustralin free HCN glycosides found in both foliage and root content (Iglesias et al. 2002). No report has detailed how leaf cyanide levels contribute to density growth of *M. progresivus* pest. Recent studies have indicated high mortalities of the predatory mite *Phytoseiulus longipes* when fed *M. progresivus* which feed on cassava leaf tissue (Mutisya et al. 2012). The present study explored how HCN content (mg/kg) levels of different cassava varieties influence *M. progresivus* density growth and subsequent leaf tissue damage and mean density threshold for CGM control .

Materials and methods

Nine cassava varieties were obtained from three main production regions in Kenya for the present study. The varieties were MM99005, MM990183, X-Mariakani from the eastern; Kalezo, Karibuni, Tajirika from coastal and MM97/3567, MM96/2480 and MM96/9308 from western Kenya and all were grown in pots (28cm-diameter x 29 cm-height). The population growth of CGM to the peak at each estimated damage score level was graphed for varietal comparison. The durations (days) to particular damage score of a variety in comparison with other varieties enabled susceptibility or tolerance measurement to CGM attack. Likewise, mite density growth rate was determined at specific time durations of days. The period for experimental monitoring was 55 days since introduction of 10 individuals of CGM adult actives on each variety. On day five, after mite introduction, the number of CGM /leaf on each cassava variety was scored as the starting point. Follow up of mite densities build on each variety leaves were estimated after every three days. This was done by randomly picking (without detaching) the third mature leaf of the plant apex and estimating the number of the mites/leaf and *visual*

damage score (Yaninek et al., 1989). This was continued up to 55th day of the experiment. During the determination of leaf biomass loss on cassava varieties, five leaves (replicated four times) were picked from each variety representing visual damage (D) scores of D.1, D.2, D.3, D.4 and D.5. The leaf damage score was taken from chlorosis severity representing 1=No damage score; 2: ≤25% leaf damage; 3: =50% damage; 4: =75% damage and 5: =100% wilted leaf (Yaninek et al., 1989). The leaf replicate samples for D:1-5 were collected in Khaki paper (No 25) bags and taken to the laboratory for weighing. An electronic weighing balance (Sartorius Basic-BA 310s) of three decimal units (000.000 g) was used to weigh the leaves after brittle drying them in hot oven at 60 °C. To get single leaf mean weight (mg) of the sample leaves, the total weight was divided by four (replicates). To arrive at the mean dry weight (DW) loss or biomass loss at each damage score, D.1 was taken as the leaf DW with no CGM damage score. Cassava leaf cyanide (HCN mg/kg) content was determined by Picric Acid analysis according to Natural Research Institute (1996) procedure.

Kruskal-Wallis non-parametric one-way analysis of variance was used on mite counts, considering the precarious nature of their movement on leaves. Analysis of variance was carried out to determine significance difference of leaf biomass loss (%) and cyanide content of the different cassava varieties, using Student Neumann Keuls (S.N.K) Post Hoc Test for the means were separated.

Results

Mite density growth

Mite population build-up of the 10 introduced individual motile stages of *M. progresivus* reached peak densities on 39th day of the most susceptible varieties and by the 54th day attacked leaves wilted at 20.0 ± 2 °C and $63 \pm 4\%$ test climatic conditions (Fig.1). For the most tolerant varieties it took 47 days to reach peak densities and for one variety (MM97/3567) the mite population did not cause highest damage score even by the 55th day.

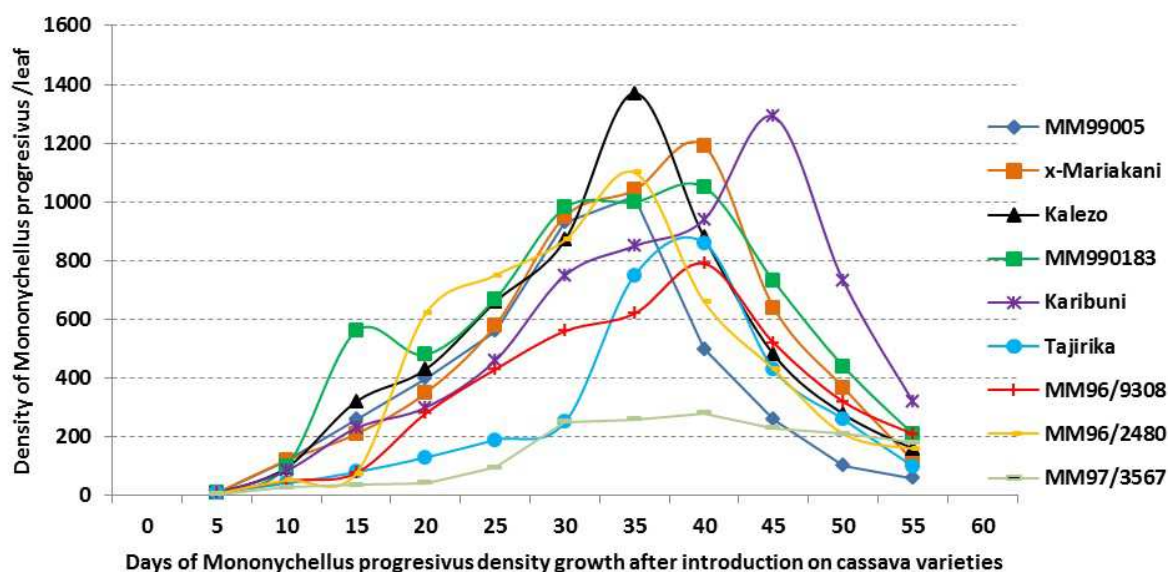


Fig. 1: Dynamics of Cassava green mite *Mononychellus progresivus* density growth on different cassava varieties at 20.0 ± 2 °C and $63 \pm 4\%$ relative humidity conditions.

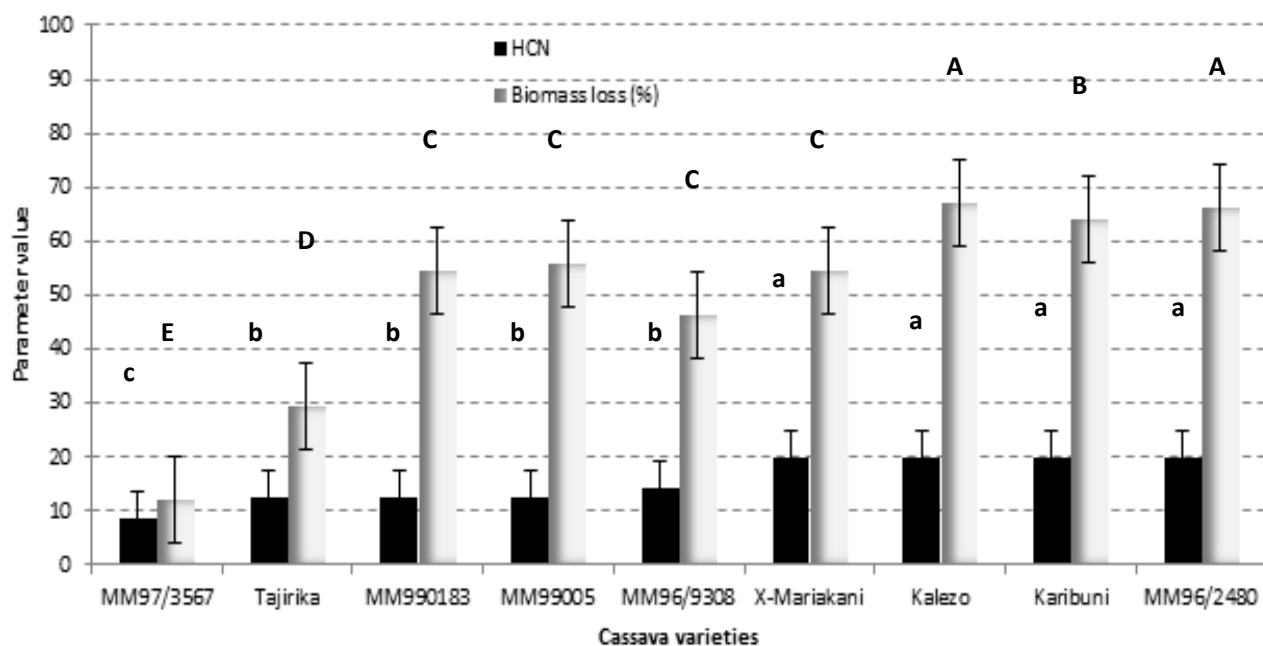


Fig.2: Cassava variety mean (\pm SE) leaf cyanide content (HCN.mg/kg) and subsequent leaf biomass loss (%) by cassava green mite, *Mononychellus progresivus*. Different lower case letters denote significant ($P < 0.05$) levels on HCN mg/kg, and different upper case letters denote significant ($P < 0.05$) leaf biomass loss among varieties.

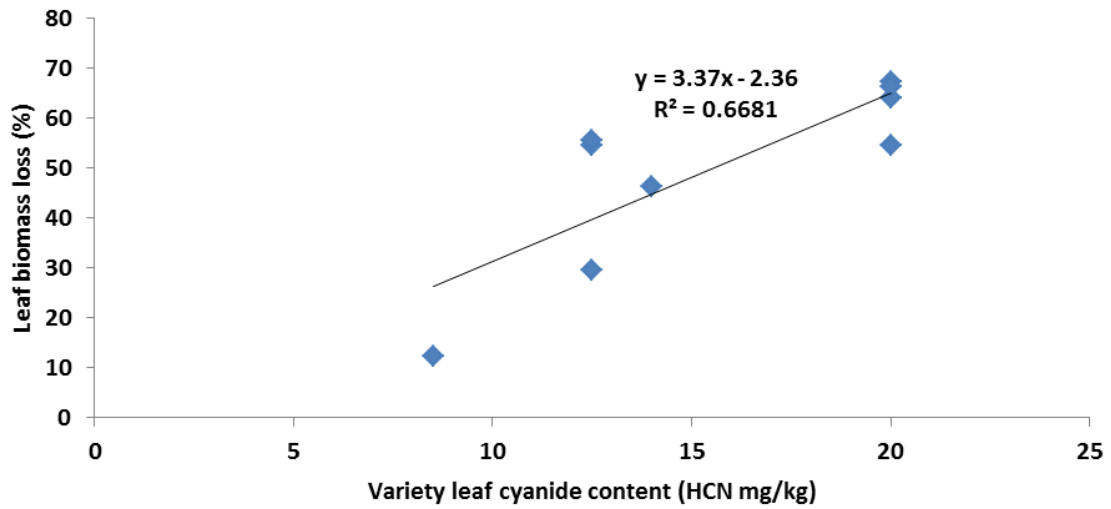


Fig. 3: Relationship between leaf cyanide content (HCN mg/kg) and biomass loss (%) on nine cassava varieties

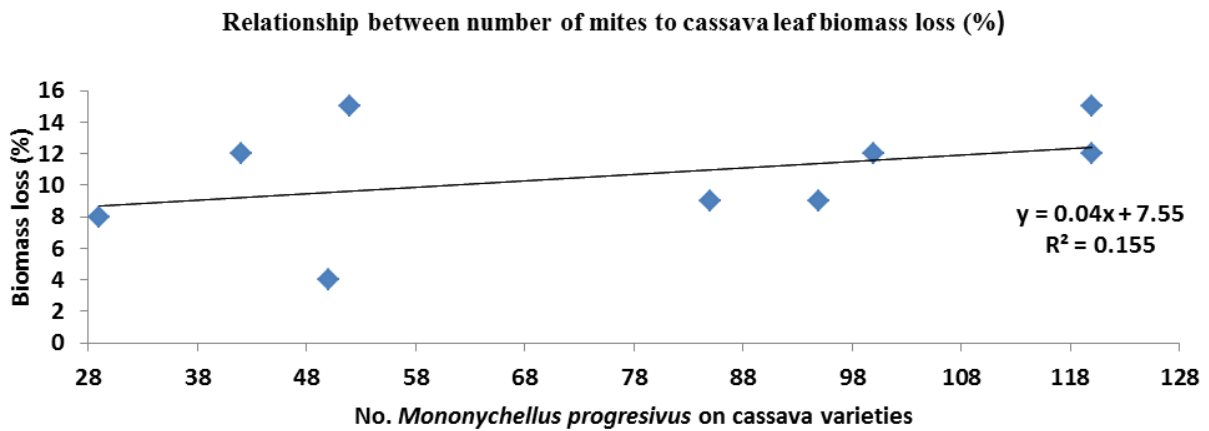


Fig. 3: Relationship between cassava green mite *Mononychellus progresivus* density and leaf biomass percentage loss.

Table 1: Mean (\pm SE) cassava green mite *Mononychellus progresivus* density score in relation to visual damage score (D) and duration (days) in greenhouse (days) at 20.0 ± 2 °C, $63 \pm 4\%$ RH

Mites / days	No CGM	Duration	No. CGM	Duration	No. CGM	Duration	No. CGM	Duration	No. CGM	duration
Variety	(D.1)	(Days)	(D.2)	(Days)	(D.3)	(Days)	(D.4)	(Days)	(D.5)	(Days)
Kalezo	9	5	75 \pm 1.4	8.4 \pm 0.5	320 \pm 4.8	12.7 \pm 0.7	870 \pm 12.6	30.3 \pm 0.4	1370 \pm 7.1	33.0 \pm 0.5
Karibuni	8	5	65 \pm 1.2	9.0 \pm 0.6	300 \pm 4.7	21.0 \pm 0.7	820 \pm 11.2	33.0 \pm 0.5	1170 \pm 7.0	43.0 \pm 0.2
Tajirika	11	5	55 \pm 2.2	13.0 \pm 0.5	280 \pm 4.8	28.0 \pm 0.2	740 \pm 14.5	33.0 \pm 0.6	860 \pm 4.4	35.7 \pm 0.6
MM990183	8	5	75 \pm 1.1	8.5 \pm 0.5	560 \pm 7.1	14.3 \pm 0.5	980 \pm 11.9	33.0 \pm 1.3	1050 \pm 3.6	36.7 \pm 0.6
MM99005	10	5	90 \pm 4.0	8.6 \pm 0.5	325 \pm 1.2	20.6 \pm 0.4	930 \pm 11.8	33.0 \pm 0.9	1020 \pm 5.9	36.0 \pm 0.7
X-Mariakani	9	5	77 \pm 2.9	9.3 \pm 0.7	310 \pm 2.4	18.0 \pm 0.2	950 \pm 11.2	30.1 \pm 0.7	1190 \pm 4.8	36.7 \pm 0.4
MM97/3567	5	5	42 \pm 0.7	21.3 \pm 1.2	250 \pm 3.3	29.3 \pm 0.5	770 \pm 6.7	55.3 \pm 1.0	530 \pm 6.3	55.3 \pm 1.2
MM96/2480	6	5	59 \pm 1.2	9.3 \pm 0.9	625 \pm 8.4	22.3 \pm 1.2	890 \pm 5.1	30.6 \pm 0.5	1100 \pm 2.9	33.6 \pm 1.3
MM96/9308	8	5	71 \pm 5.7	17.0 \pm 0.3	290 \pm 6.7	21.7 \pm 1.2	580 \pm 4.5	28.0 \pm 0.8	770 \pm 6.7	36 \pm 1.3
<i>H-value</i>	-	-	19.81	33.07	30.1	30.49	43.30	29.19	47.06	35.37
<i>P-value</i>	-	-	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Kruskal-Wallis one-way analysis of variance at P

Variety cyanogens potential

Cassava varieties cyanogens potential content ranged between 8.5 to 20.0 mg/kg among the varieties (Fig.2). The varieties MM97/3567 (western), Tajirika (coastal) and MM99005 (eastern) had lowest cyanogens potential of 8.5 ± 4.9 , 12.5 ± 3.2 and 12.3 ± 2.5 , respectively. High leaf cyanide (HCN) content led to higher biomass loss (%) up to HCN 20mg/Kg (Fig. 2). Leaf cyanide content was positively correlated to biomass loss (%) (Fig.3).

Mite density threshold

Visual damage score on the varieties presented different density growth rates and damage levels of *M. progresivus* at specific time durations (days) as shown in Table 1. The damage score of D.3 and D.4 were critical since they represented visual leaf damage of 50 and 75% respectively. There was significant difference ($P < 0.001$) among spider mite densities as well as number of days among the cassava varieties.

Spider mite density increase was similarly positively correlated to the subsequent biomass loss on cassava varieties. Mean variety CGM threshold was determined at ≥ 27 mites / leaf (Fig.3). This CGM infestation was reached in about 10 days on most varieties. Specific varieties had the infestation threshold reached at a particular duration (days) relation to susceptibility to the CGM damage.

Discussion

In the present study, the visual damage scoring has been equated to level of leaf biomass losses (%) which allowed indicative loss of the leaf photosynthetic area on the plant. Thus, some varieties lost higher leaf photosynthetic areas in comparison with others due to their more susceptibility to mite attack which led subsequently to higher root yield loss (Ayanru and Sharma 1984; Yaninek et al. 1989). A positive correlation was evident on leaf cyanide content increase to increased biomass loss (%). Leaf damage score D.2 was caused by an estimate number of ≥ 100 mites per leaf on the evaluated varieties.

It was at this damage level (D.2) reached in about 8.4-9.3 days for susceptible varieties which showed clear chlorosis damage symptoms that justified CGM control. Basing density threshold to ultimate biomass loss (%) it was found that ≥ 27 mites/leaf was the threshold level of CGM density to implement immediate control measure for the pest mite. Fast population growth of CGM was found positively correlated to cyanide levels on cassava leaves within the medium range ($>10 < 30$ HCN mg/kg). The present findings indicate that CGM preferred higher cyanide bearing varieties to low cyanogens ones.

Most Tetranychid mite species feed on the underside of cassava leaf tissue sucking cell-sap and reducing photosynthetic leaf area (Jeppson et al. 1975; Bellotti and Byrne, 1979; Capinera 2008). Yaninek and Gnanvossou (1993) compared dry matter increase of the spider mite life history and concluded that cumulative dry matter increased as CGM cohorts development progressed upward from juvenile to adult life stages of the mite. Kariuki et al (2005) reported that introduced phytoseiid predator, *Typhlodromalus aripo* De Leon reduced by over 90% CGM density on cassava in the warm humid regions of Kenya. Elsewhere in Africa *T. aripo* has been reported to reduce CGM levels below injury levels (Onzo et al. 2009; Zannou et al. 2007). The present study indicates at what density level CGM would cause leaf injury level translatable to economic loss. Environmental conditions dictate the subsequent damage level of the mite on each cassava variety depending on susceptibility to CGM (Yaninek et al. 1989; Ayanru and Sharma, 1984; Byrne et al. 1982). Yaninek et al (1989) reported that cassava crop attacked by *M. tanajoa* Bondar lost 10 to 30% dry matter in the dry season where leaves wilted and recovered 25 to 45% in the subsequent wet season. What was missed in that study was CGM density threshold determined on specific varieties.

Food and Agriculture Organization and World Health Organization (FAO/WHO) recommended cyanide level of cassava roots for human consumption to be 10mg ppm (FAO/WHO, 1991). A common local

cultivar like X-Mariakani was found to have 20.0 HCN mg/kg and highly susceptible to CGM with density growth from less than 100 to over 900 mites /leaf in 30days. In countries where cassava is a staple food crop, breeders can consider development of varieties safe for human consumption guided by low variety cyanogens levels <10 HCN mg/kg of least damage by CGM. Similarly, farmers and crop protection agents can use the determined threshold (≥ 27 mites /leaf) on CGM density to implement immediate control measures of the pest mite. Considering genotype potential of each variety it is necessary in future to evaluate in a screen house how much actual yield loss would occur at the above described leaf biomass losses indicated by the visual scores.

Acknowledgements

The authors would like to acknowledge the East African Productivity Project (EAAPP) for providing funds for the varieties evaluation at KARI-Katumani. I appreciate the work of the anonymous reviewers to the final form of the paper.

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