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Population Dynamics of Cassava Green Mite, *Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae) as Influenced by Varietal Resistance

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Abstract: The population dynamics of *Mononychellus tanajoa* as influenced by varietal resistance of cassava was determined over two cassava planting seasons (dry and wet season), using biweekly samples from 11 cassava genotypes in Ibadan, Nigeria. The population size of *M. tanajoa* and the damage scores were higher during dry than wet season. In 1993, there was a higher mite population and damage peak in January than in March, while in 1994, the peak occurred only in April. Mite population and damage generally varied significantly among genotypes and sampling dates, and decreased as the plant aged. High relative humidity rainfall, and low temperature inhibited the mite population growth. During dry season, the rate of mite increase was higher on the susceptible cassava genotype than on the resistant genotypes while situation was reverse in wet season. The study showed that varietal resistance of cassava had a significant effect on the population growth rates of *M. tanajoa*. January was the favourable period for screening cassava genotypes for resistance to *M. tanajoa* in Ibadan, Nigeria regions.

Key words: Population dynamics, *Mononychellus tanajoa*, cassava resistance

Introduction

The Neotropical mite, *Mononychellus tanajoa* Bondar (Acari: Tetranychidae) that was accidentally introduced into Africa in early 1970s (Nyiira, 1972; IITA, 1992) has become a serious pest of cassava, *Manihot esculenta* Crantz (Euphorbiaceae). Another devastating pest of cassava, the mealy bug, *Phenacoccus manihoti* Matile-Ferrero has been controlled using classical biological control and breeding for resistance (Hahn *et al.*, 1989; Herren and Neuenchwander, 1991). *M. tanajoa* which remains the most important arthropod pest of cassava in Africa, feeds on the young leaves of cassava plant. Crop losses are caused by the removal of plant sap and chlorophyll depletion. Storage root reductions by *M. tanajoa* of 10-80% have been reported in traditional agronomic trials in the Neotropics and Africa (Nyiira, 1976; Shukla, 1976; CIAT, 1977; Byrne *et al.*, 1982; Ndayiragije, 1984; Markham and Robertson, 1987).

Classical biological control and host plant resistance are the main components of integrated pest management package for *M. tanajoa* in Africa. Knowledge of the population dynamics of any pest is important for the success of any control programme. The phenology and seasonal abundance of *M. tanajoa* were reported to be dominated by a combination of weather and host plant effects (Yaninek *et al.*, 1989; CIAT, 1992). However, the importance of cassava varietal resistance on the population dynamics of *M. tanajoa*, which is important for the assessment of the compatibility of host plant resistance and biological control, has not been adequately investigated. This study on a wide range of cassava genotypes could improve our understanding of the dynamics of *M. tanajoa* in the multi-varietal cassava fields of Africa.

Cassava genotypes with varying levels of resistance have been distributed to farmers for planting (IITA, 1993). Exotic phytoseiid, predators of *M. tanajoa* have been released into cassava fields (Toko *et al.*, 1996). However, the biological control of *M. tanajoa* using phytoseiid predators has not made much progress. So, there is a need to study the population dynamics of *M. tanajoa* on different cassava genotypes. Such studies are targeted in formulating an efficient breeding strategy and to facilitate the development of a sustainable integrated management practices for *M. tanajoa* through biological control and host plant resistance.

The objectives of the study were to monitor the population dynamics of *M. tanajoa* for two planting seasons (dry seasons and one wet season), on eleven cassava genotypes and determine the association between weather factors and *M. tanajoa* outbreaks.

Materials and Methods

Field trial: A field trial containing 10 improved and one local cassava genotypes was planted in the research farm of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria in August, 1992. Four of the 11 genotypes were pubescent (TME 1 (local genotype), 91934, 4(2)1425P and 30474), four others were partially glabrous (85/00665, 85/00680, 86/00005 and 86/00009), while the remaining three were non pubescent (30001, 30572 and 4(2)1425N). The genotypes were planted in a randomized complete block design with four replications. Each plot consisted of three rows 15 m long and 1 m apart. Spacing of each plot was 1 x 1 m^2 giving a plant population of 10,000 plants ha^{-1}. To ensure an even pest distribution, a susceptible cultivar, 30001, was planted along the borders of the field as well as between blocks. The plants were naturally infested. Data were collected between November, 1992 and April, 1994 inclusive. Daily weather data were also recorded.

Estimation of the population and damage of *M. tanajoa*: Young leaves (third fully expanded leaves from the tip of the main stem) were plucked from five randomly selected plants per plot at two-week intervals and put in paper bags. The leaves were taken to the laboratory and refrigerated for at least two hours to immobilize the mites and to facilitate the counting. Eggs and actives (sum of all the developmental stages less the eggs) of *M. tanajoa* on the abaxial surface of the leaf were counted. Leaf area was also determined. Mite density cm^{-2} of leaf surface was calculated as the number of mites divided by the leaf area. Mite-days were calculated as the cumulative increase of mites per fortnight according to the following formula of Ojo (1992):

$$\text{Mite-days} = M1 + \{(M1 + M2)/2\} H (D2 - D1 - 1) + M2$$

Where,
M1 = First mite density
M2 = Second mite density
D1 = First sample time (no. 1 Julian day)
D2 = Second sample time (no. 15 Julian day)

The severity of *M. tanajoa* on cassava in the field was based on a scale of 1-5 (Yaninek *et al.*, 1989). A damage score of 1 = no obvious symptoms; 2 = less than 5% of leaf chlorotic; 3 = more than 5%, but less than 50% of leaf chlorotic; 4 = more than 50% of leaf chlorotic with significant reduction in leaf area; and 5 = leaf is dead and has dropped: candle stick appearance of young shoot. In a plot, five randomly selected plants were scored for *M. tanajoa* damage. Mite damage scoring and mite population count was done simultaneously. The weather data at IITA during the study was recorded (Fig. 1).

Statistical analysis: Mite population density and damage among the genotypes and sampling dates were subjected to analysis of variance (ANOVA) procedures (SAS Institute, 1993). Mite density was transformed {square root (x + 0.5)} before performing the analysis. Duncan's new multiple range test was performed to separate significantly different means among genotypes for peak mite damage scores.

Results

Mite population trends: *M. tanajoa* was first observed in the field in November, 1992, when sampling started (Fig. 2). This coincided with the onset of dry season. Total mite population counts for all the genotypes showed an increase between late November, (1992) and early December. *M. tanajoa* population

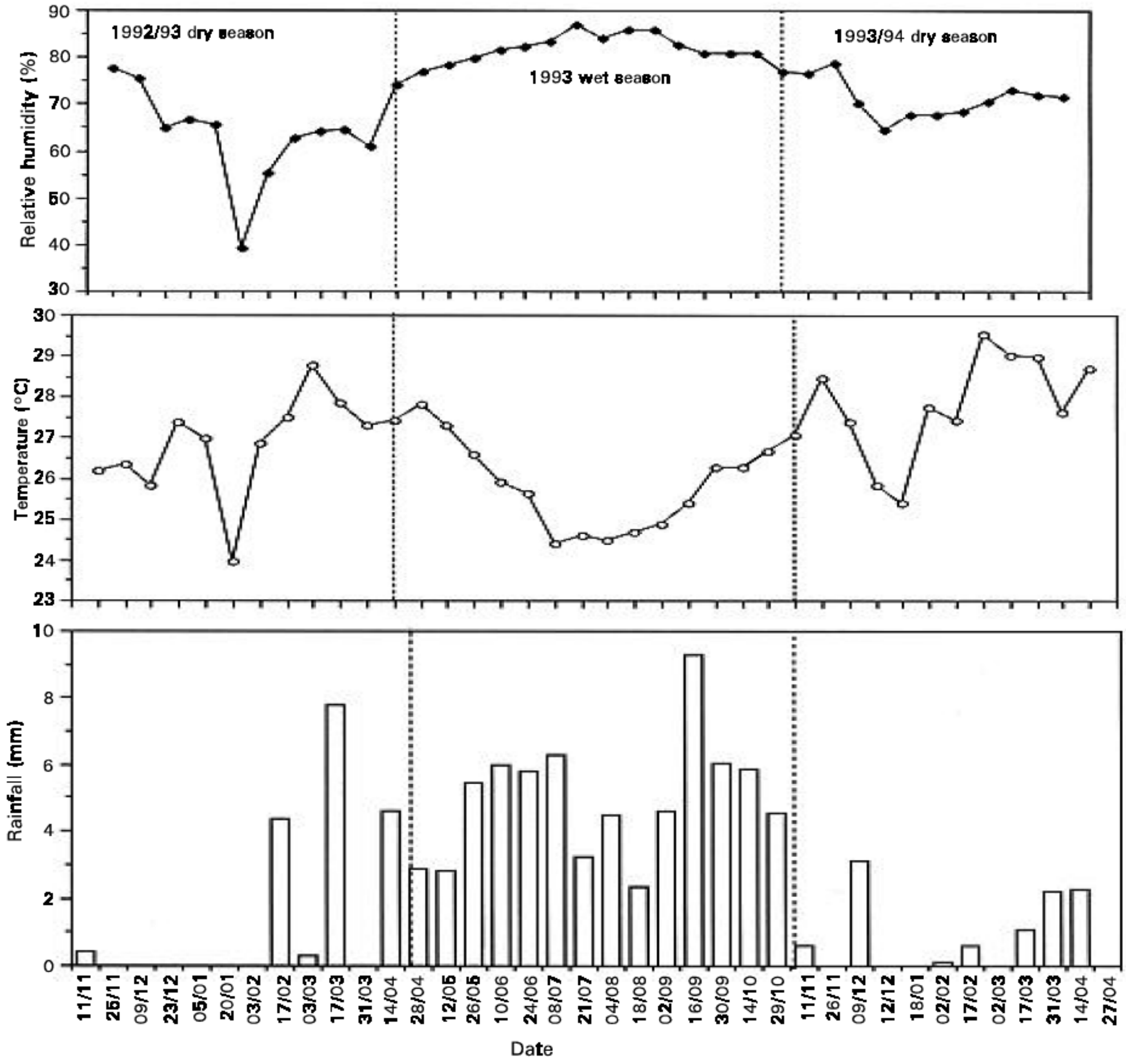

Fig. 1: Mean fortnightly variation in weather factors at the experimental field of IITA, Ibadan

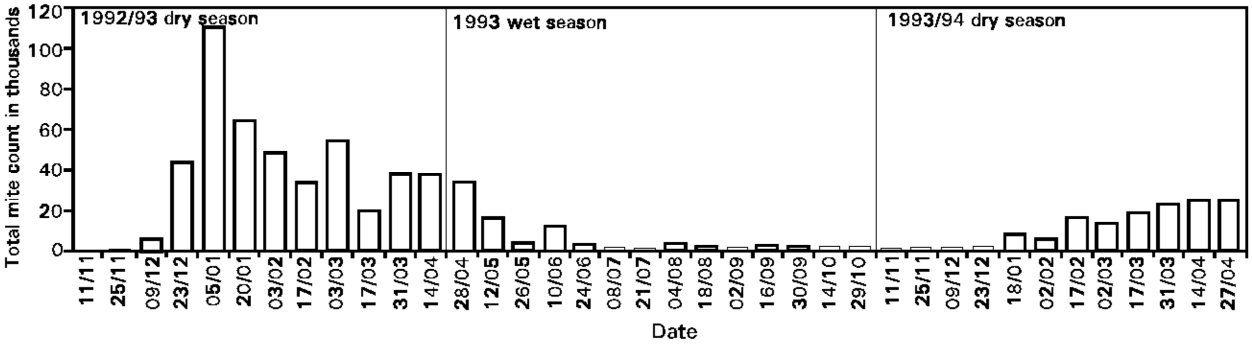

Fig. 2: Fortnightly abundance of *Mononychellus tanajoa* population (total active count /sampling date) for three seasons.

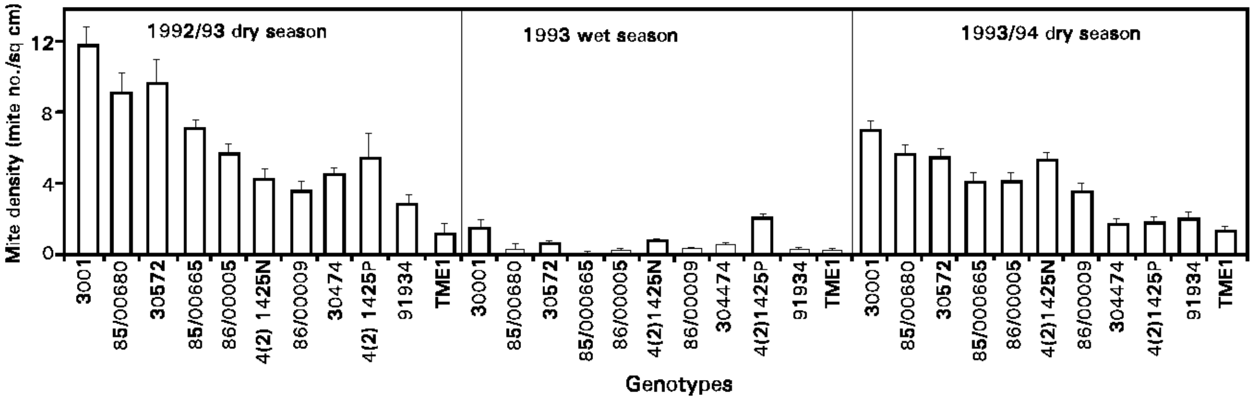

Fig. 3: Mean seasonal *Mononychellus tanajoa* population density of 11 cassava genotypes for three seasons. (Vertical bars are standard error values)

increased drastically in late December, peaking in early January, 1993 (108,599 actives/660 leaves) (Fig. 2). Between December and January mite population increase was over 200-fold. There was a marked reduction in the mite population between early January and mid February. The mite population picked up in early March with a peak, and declined by late March. *M. tanajoa* population also picked up again in April but remained at a lower population level, than in late March. Mite population reduced in May and was very low by July through December 1993 (with a slight increase in August) (Fig. 2). With the onset of warmer weather and the virtual disappearance of rain in January, 1994, there was an approximate logarithmic increase in numbers of *M. tanajoa,* reaching a peak on April 14, 1994. This last peak in the second dry season was smaller than the two peaks of January and March of 1993 (Fig. 2). *M. tanajoa* population was higher in 1993/94 (second) dry season than that of 1993 wet season, and lower than in 1992/93 (first) dry season.

Data pooled over dates within a season showed that there were significant differences ($P < 0.05$) among genotypes during each of the three seasons (Fig. 3).

Damage trends: No apparent damage inflicted by *M. tanajoa* on cassava was observed in November, 1992, when damage was first scored (Fig. 4). All plants were scored 1 for damage. The mite damage increased sharply in December and peaked in late January, 1993 (mean damage = 4.23). A significant reduction ($P < 0.01$) in damage was recorded in mid February (mean damage = 1.67). A sharp increase in damage also occurred in late February and climaxed in March (mean damage = 3.57), but with a smaller peak than the one in January (4.23). Mean mite damage remained high in March through May (1.85 - 3.57), with multiple small peaks. With cooler weather, increased rainfall and relative humidity (r.h.) in May, there was a declined mite damage in late May. Mite damage was very low between June and October (mean ranging from 1.16 to 1.97). With the onset of the dry season, damage increased significantly from November (mean damage = 1.87), through April (mean damage = 3.27), when the last damage score was recorded. This second dry season (1993/94) was characterized by two damage peaks in March and April, 1994, respectively. The damage peak variation was cassava-genotype dependent. Both of these peaks were smaller than the lower peak (March) of the first dry season.

There were significant differences ($P < 0.01$) in mite damage scores among dates. Significant differences ($P < 0.01$) also existed among genotypes within all dates except in November, 1992. Significant differences ($P < 0.01$) were noted among genotypes within each of the three seasons (Fig. 5). Considering the mean damage score of the first dry season, the genotypes could be ranked in ascending order of resistance, that is; 30001 < 30572 < 85/00680 < 85/00665 < 4(2)1425N < 86/00005 < 86/00009 < 30474 < 4(2)1425P < 91934 < TME 1. The means of the two peak damage scores respectively in January and March, 1993, were used to assess the resistance status of 11 genotypes to the mite (Table 1). This was done to conveniently examine the *M. tanajoa* population fluctuations at different levels of resistance. Genotypes with damage mean scores between 1-2.5 were classified as resistant; 2.6-3.6 were classified as moderately resistant; 3.7-5 were classified as susceptible. According to this rating, one genotype (TME 1) was resistant,

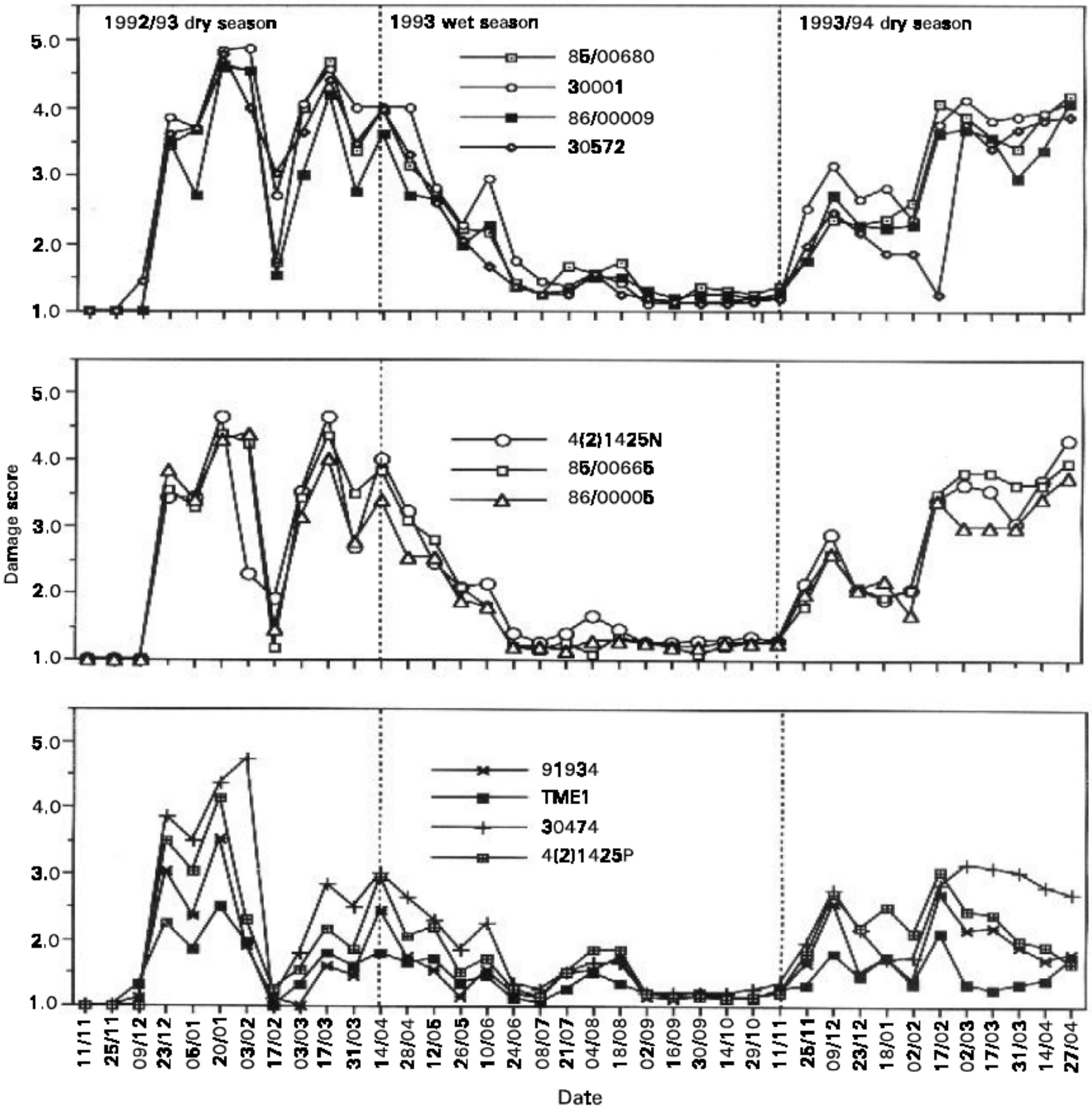

Fig. 4: Fortnightly field *Mononychellus tanajoa* damage scores of 11 cassava genotypes for three seasons

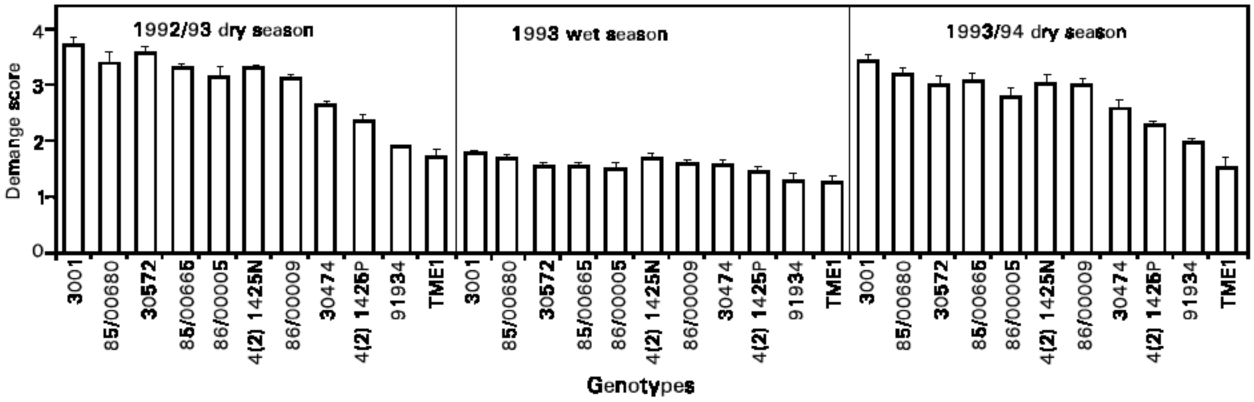

Fig. 5: Means seasonal field *Mononychellus tanajoa* damage scores of 11 cassava genotypes for three seasons (Vertical bars are standard error values

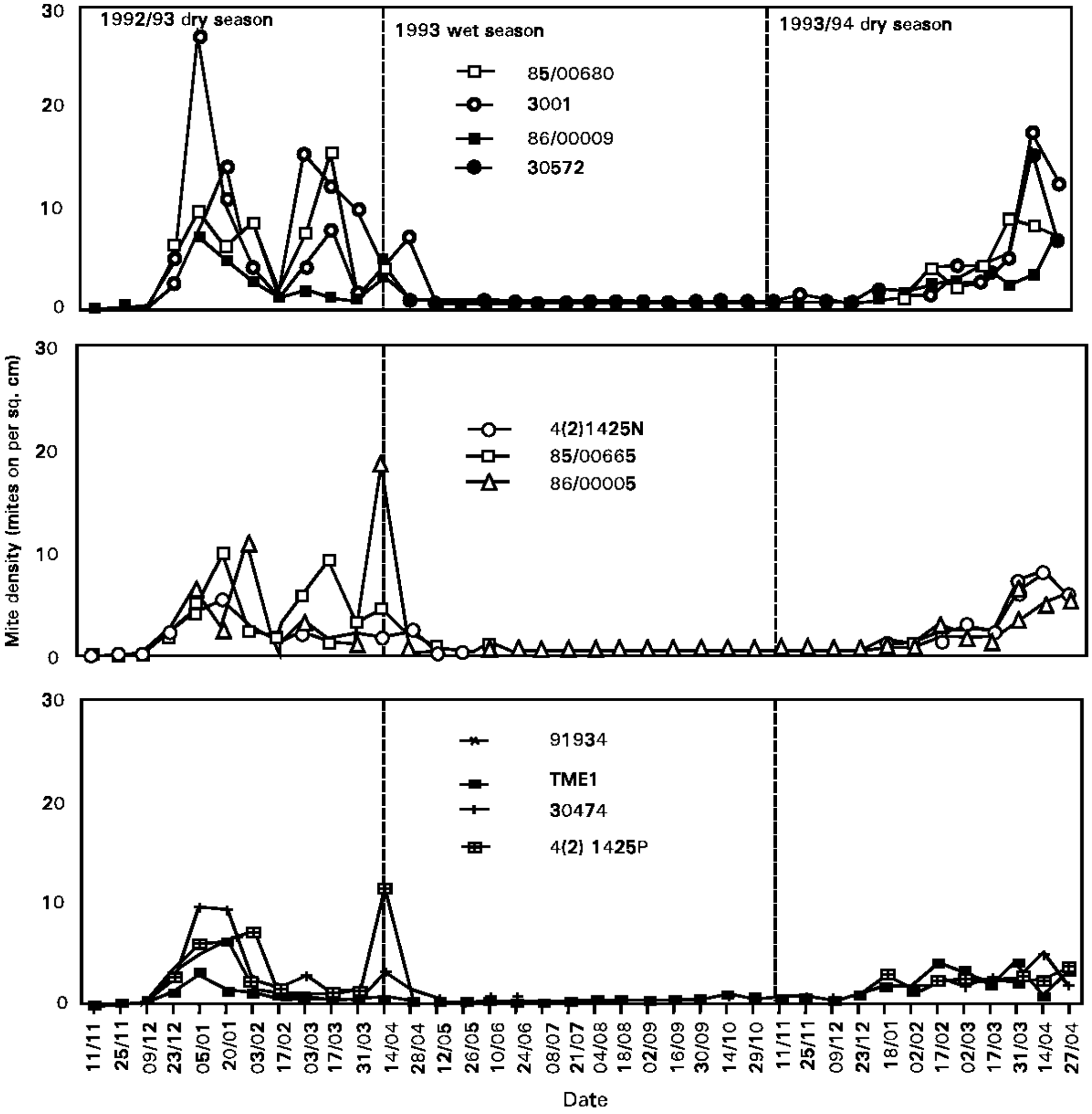

Fig. 6: Fortnightly field *Mononychellus tanajoa* population density of eleven cassava genotypes for three seasons

Table 1: Peak *Mononychellus tanajoa* damage scores of 11 cassava genotypes in January and March, 1993.

	Damage score[a]			Status[b]
Genotypes	January	March	Mean	
30001	4.85 a	4.58 ab	4.7 a	SS
4(2)1425N	4.65 ab	4.65 a	4.7 a	SS
85/00680	4.60 ab	4.68 a	4.6 ab	SS
30572	4.78 a	4.40 ab	4.6 ab	SS
86/00009	4.63 ab	4.18 bc	4.4 bc	SS
85/00665	4.38 bc	4.33 abc	4.3 cd	SS
86/00005	4.30 c	4.00 c	4.1 d	SS
30474	4.38 bc	2.83 d	3.6 e	MM
4(2)1425P	4.15 c	2.15 e	3.1 f	MM
91934	3.53 d	1.60 ef	2.6 g	MM
TME 1	2.5 e	1.8 ef	2.1 h	RR

[a] Means followed by similar letter in a column are not significantly different at $P < 0.05$ according to Duncan=s new multiple range test.
[b] SS = susceptible, MM = moderately resistant and RR = resistant. TME= Tropical Manihot Exotic

three others (30474, 4(2)1425P and 91934) were moderately resistant, while all the remaining seven genotypes were susceptible.

Fluctuation of *M. tanajoa* population on eleven cassava genotypes: The resistant genotype (TME 1) carried lower mite population densities than moderately resistant and susceptible ones on all dates in first dry season (Fig. 6). As the plant aged, TME 1 carried more mites than moderately resistant genotypes and some susceptible genotypes on most dates between December, 1993 and April, 1994 in the second dry season. Moderately resistant genotypes in turn carried fewer mites than susceptible ones in the first dry season. However, the moderately resistant genotype, 4(2)1425P, had carried very high mite population density in April, 1993, ranking second, only after the susceptible genotype 86/00005. In general, in the second dry season, apart from two susceptible genotypes, 86/00005 and 86/00009, moderately resistant genotypes carried fewer mites than susceptible genotypes.

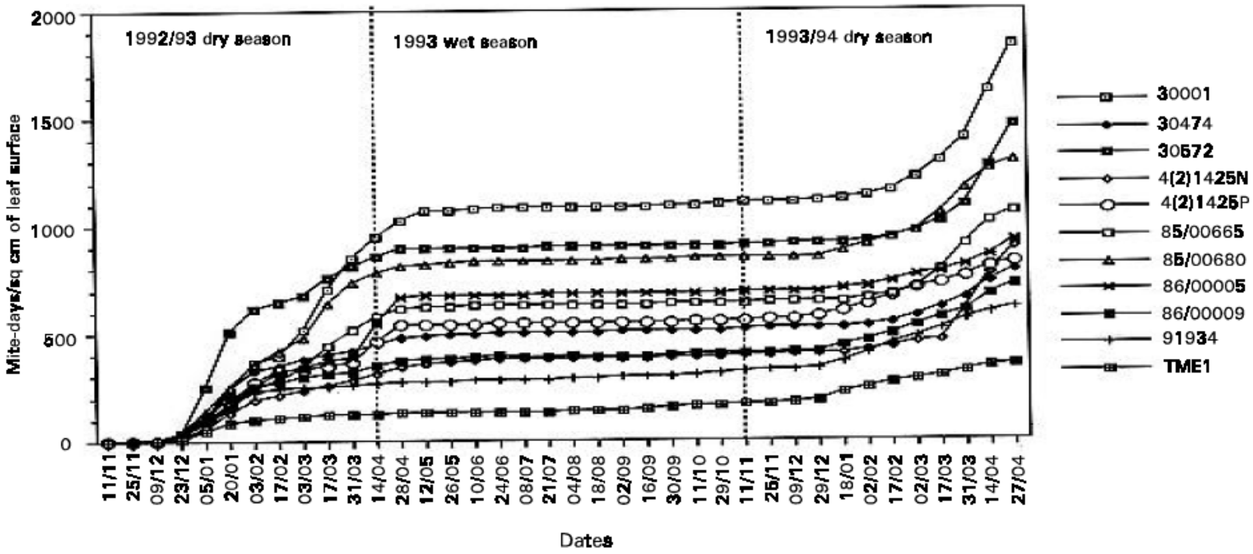

Fig. 7: Field fortnightly mite-days (actives) per unit area of abaxial leaf surface for 11 cassava genotypes over three seasons

All moderately resistant genotypes in turn had less mite density than susceptible genotypes in the second dry season. However, in the first dry season, two susceptible genotypes (4(2)1425N and 86/00009) carried fewer mites than two moderately resistant genotypes (30474 and 4(2)1425P). Apart from 86/00005 and 4(2)1425P with peak populations on 3 February, all the genotypes attained peak populations in January, 1993 (Fig. 6). Susceptible genotype, 86/00005 and a moderately resistant genotype, 4(2)1425P, second population peak in April, while all the other genotypes attained a second but smaller population peak in March. In the second dry season, the mite population peaked in late March/April for all genotypes.

Cumulative mite-days increase revealed that the resistant genotype had the lowest number (< 400) of *M. tanajoa* cm^{-2} of leaf area from November, 1992 through April, 1994 (Fig. 7). Apart from the susceptible genotype, 86/00009 (ca. 750), moderately resistant genotypes accumulated lower mite population (600-840) than susceptible genotypes (900- 1750) by April, 1994. Thus, the rate of *M. tanajoa* population build-up was the highest on susceptible followed by moderately resistant and resistant genotypes.

For all 11 genotypes, the rate of mite population increase was higher during dry than the wet season (Fig. 7). This rate of increase was also higher during the first dry than during the second dry season. During the first dry season, the rate of mite increase was generally higher between 23 December and 20 January, and between 17 March and 27 April of the first dry season than during other periods. However, the rate of mite increase was evident only between 23 December and 3 February, for the resistant (TME 1) and a moderately resistant genotype (91934). During the wet season (27 April-November, 1993), the rate of mite population increase was generally not apparent for all the genotypes. However, the rate of mite increase was more apparent for the most pubescent genotypes (TME 1 and 91934). With the onset of the dry season in December, mite population increased on all the genotypes through April, 1994. However, the rate of mite increase was sharp on a susceptible genotype (4(2)1425N), between 17 March and 7 April.

Discussion

Young cassava plants, are richer in nutrients than older plants (Yaninek *et al.*, 1989). Thus, during the first dry season (when the plants were 4-5 months old), the population of *M. tanajoa* increased steadily between December and January, peaking on 5 January. In addition, high temperature, low r.h. and the absence of rain that supported mite growth also prevailed. There was also a steady reduction in soil moisture during the dry season due to evaporation and uptake of water by the plant. This resulted in a reduction in leaf area, and a reduction in the production of new foliage. The effect of mite feeding activity gradually exhausted the nutritive content of the leaves, climaxing on 5 January 1993, and resulting in the crashing of the population after this date. This decline in mite population was aggravated by rainfall in mid February. Rainfall reduced soil moisture stress, prompted the flush of new leaves that were richer in resources, leading to an increase in mite population growth. In turn, mite population increased continuously and peaked on 17 March 1993. After March, despite vigorous plant growth, mite population declined due to the prevalence of rainfall, low temperature and high r.h. With the virtual cessation of rainfall and the onset of warmer weather and fresh foliage, mite population increased steadily between December, 1993 and April, 1994. On older plants, with leaves of an inferior nutritional quality (for example low nitrogen) than those of younger plants, mite population was lower in the second dry season than in the first one. Yaninek *et al.* (1987) reported that *M. tanajoa* growth was higher on the leaves of young than on the leaves of old plants.

Weather factors are important in controlling *M. tanajoa* populations in Africa and in the Neotropics (Samways, 1979; Yaninek *et al.*, 1987; Ezulike *et al.*, 1991). The results of this study show that the mite population was higher during the dry than during the wet season, regardless of genotype, thus supporting the findings of Akinlosotu (1982) and Yaninek *et al.* (1987). Low mite population during the wet season could be attributed to rainfall that washed mites off the leaves and killed mites with the kinetic energy of its drops. Dew droplets that drowned and killed mites, high r.h. and low temperatures that delayed mite development and growth also contributed to this low mite population (Samways, 1979; Yaninek *et al.*, 1987). During the dry season, high mite population was maintained because of the virtual absence of rainfall, low r.h, and high temperature.

Varietal differences existed for the population density and damage of *M. tanajoa*, with the resistant genotype, TME 1, having an overall lower mite population and mite damage than susceptible and moderately resistant genotypes regardless the season. Since all the genotypes were subjected to the same weather conditions, varietal differences in the population density of *M. tanajoa* could not be attributed to weather factors. Variation in *M. tanajoa* population density among the genotype may be associated with factors inherent in the different genotypes. Resistant crop genotypes to mites have been shown to have high leaf pubescence (Peters and Berry, 1980) and higher canopy retention ability during the dry season (Nukenine *et al.,* 1999). Nukenine (1996) also demonstrated higher concentrations of amino acids (isoleucine and tyrosine) and calcium in leaves of resistant cassava genotypes compared with the leaves of susceptible genotypes. These chemicals could also explain differences in mite population among the resistant, moderately resistant and susceptible cassava genotypes, shown in this study.

After 3 February in the 1992/93 dry season, the rate of mite increase was less evident on the resistant TME 1 and the moderately resistant 91934 when compared with the susceptible genotypes. These two genotypes with a high canopy retention ability, unlike the susceptible genotypes, retained many leaves even at the peak of the dry season (January) and thus, flushed only few new leaves after the rainfall in early February. With nutritionally poor leaves, mite reproduction, development and growth was low on these two genotypes (TME 1 and 91934). However, during the wet season, high leaf pubescence on TME 1 and 91934 probably prevented the mites from being washed away by rainfall, resulting in a higher rate of mite population build-up on these cultivars than on the susceptible ones that were either slightly pubescent or non pubescent.

Susceptible genotypes in the present study generally had higher mite densities than resistant genotypes. The mechanisms of resistance have been classified by the categories of nonpreference, antibiosis and tolerance (Painter, 1951). He stated that nonpreference (avoidance of a plant variety) and antibiosis (perturbation of developmental biology) cause a reduction in pest population. Nonpreference and antibiosis mechanisms may be involved in reducing mite numbers on the leaves of resistant genotypes. Kanno *et al*. (1992) obtained a positive relationship between *M. tanajoa* damage and population in the dry season and attributed this to the presence of antibiosis and nonpreference in the resistant cassava genotypes. Similar findings were reported by Byrne (1980). Since antibiosis and nonpreference cause a reduction in pest densities, the presence of these mechanisms in the cassava genotypes supports the implementation of a successful biological control programme for *M. tanajoa* in the presence of resistant genotypes.

This study has shown that varietal resistance has a significant effect on the population growth rates of *M. tanajoa.* Since the highest mite infestation was recorded in January, 1993, accurate field screening of young cassava plants for resistance to *M. tanajoa* in Ibadan, Nigeria, could be best done in January. Planting cassava early in the wet season could reduce yield losses caused by *M. tanajoa* because the population of the mite reduced with plant age and was very low in the wet season. Finally, weather factors may be important in forecasting mite population outbreaks.

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