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Impact of *Mononychellus progresivus* and *Oligonychus gossypii* (Acari: Tetranychidae) on cassava growth and yield in Central Africa

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SUMMARY

Growth of cassava was investigated in Central Africa (Congo) on crops attacked by two phytophagous mites: *Mononychellus progresivus* and *Oligonychus gossypii.* Change and distribution of dry matter in leaves, stems and roots were monitored for the 24 month crop cycle on infested and mite-free plants. Leaf dry matter increased during the rainy season and decreased during the dry season. Stems contain the reserves used for initiating plant growth after the dry season. Dry matter increased in the roots which form true storage organs. At the start of the second year of cultivation, one third of the root biomass was used to support the recovery of plant growth and development. Mite densities fewer than 50 mobile forms per leaf (maximum number of mites) were not sufficient to cause significant loss of leaf, stem and root dry matter. Nevertheless the mites diverted part of the biomass allocated to the roots thereby reducing the efficiency of storage root production in the infested plot.

CASSAVA, *Manihot esculenta* Crantz, which is grown mainly for its roots, forms the staple food for more than 200 million people in Africa (Herren and Bennett, 1984). It is currently thought to be a key factor in famine control since its cultivation is most appropriate and most productive in an unfavourable economic or technological context (Cock, 1982; Hahn and Keyser, 1985). The two phytophagous mites *Mononychellus progresivus* Doreste and *Oligonychus gossypii* (Zacher) are among the main pests of cassava in Africa (Matthysse, 1978; Yaninek and Onzo, 1988; Gutierrez and Bonato, 1994). *M. progresivus,* or Cassava Green Mite (CGM), is a neotropical species introduced accidentally to Africa in the early 1970s. Spectacular outbreaks were soon observed in African cassava fields, justifying several research studies to evaluate its impact on roots (Nyiira; 1972, 1976; Lyon, 1973; Schukla, 1976; Ndayiragije, 1984; Markham and Robertson, 1987; Yaninek *et al.,* 1990) from which it was reported that outbreaks of CGM can cause yield losses of 13 to 80%. These results were recorded in most cases in traditional agronomic trials with measurements made only at harvesting. Only Yaninek *et al.* (1990) included both a standardized method and study of the phenology and yield formation combined with CGM population dynamics.

O. gossypii or Cotton Red Mite (CRM) has also been reported in Brazil; it is probably of African origin as it has a large number of host plants in that continent (Mattysse, 1978; Yaninek and Onzo, 1988; Gutierrez and Bonato, 1994). It is found in plantations mainly during the dry season and its economic impact has probably been under-estimated (Bonato, 1993).

In this work, cassava growth (production and distribution of dry matter) was monitored from planting to harvesting and the combined effect of *M. progresivus* and *O. gossypii* investigated. The experiments were carried out on cassava field crops during a 24 month crop cycle (normal in central Africa).

MATERIALS AND METHODS

The experiment was carried out at Mantsoumba in southern Congo (Central Africa) on an industrial plantation that specialized in cassava. The two plots (with and without mites) each of the same size 1,700 m^2 were planted at the beginning of November 1989 with the cassava cultivar 1M20 at a density of one cutting per m^2. Prior soil analysis (phosphorus, nitrogen) did not reveal any inter-plot heterogeneity.

The distribution and change in the dry-matter contents of leaves, stems and roots of cassava plants were monitored throughout the 24 month crop cycle. Planting was done in November 1989 and samples were taken every 30 to 40 d from the beginning of May 1990 until the beginning of November 1991 (end of cycle). Ten plants were chosen at random (Schulthess, 1987) from each plot on each occasion. The total amount of leaf, stem and root dry matter per plant was determined after drying for one week at 70°C.

The two plots were sprayed after each sampling with carbaryl (Carbamate at 1.5 kg a.i. per ha) that is non-toxic to phytophagous mites but is toxic to other insect pests and possible predators. In addition the control plot was alternately sprayed with hexythiasox (César) at 25 g a.i. per ha, and fenpropathrin (Danitol) at 200 g a.i. per ha to eliminate all phytophagous mites. Mite populations were monitored in the infested plots using the method of Bonato (1993). The differences between the mite-free and the infested plot were evaluated by means of the Mann-Whitney U-test at each sampling occasion.

RESULTS

Except for the Tetranychidae present, no other pests which could have affected cassava growth were observed during the experiment. Their absence was probably due to the effectiveness of the insecticide treatments.

Leaves

The phenology of the dry matter content of cassava leaves (with and without mites) (Figure 1) can be divided into several phases closely dependent on season. During the first eight months of growth there were increases in leaf numbers and leaf dry matter. From May to the end of September 1990 (the first dry season), the marked slowing or even cessation of growth and development with associated defoliation resulted in a considerable decrease in dry matter. The plants grew again during the following rainy season (1990–1991), i.e. from the end of September 1990 until mid-January 1991, when new leaves were formed and foliar dry matter increased, once again to be followed by a sharp fall in the number of leaves produced and dry matter accumulated during the short January/February dry season. Considerable defoliation was observed during this relatively limited period of one month.

Growth resumed after the short dry season, but less dry matter accumulated and growth remained steady until the middle of the 1991 dry season (end of July 1991). During this period the leaves were small as more leaves were produced than during the preceding season. Leaf dry matter then decreased until October (end of the dry season). Growth recovered at the start of the 1991–1992 rainy season (end of October–beginning of November) when new leaves emerged. Harvesting was carried out at this stage.

There were no significant differences in leaf dry matter and the average numbers of leaves between the infested and mite-free plots (Mann-Whitley U test, $\alpha = 0.05$). The plants seemed able to compensate for the stress caused by the mites (Figure 1) whose density (<50 mobile stages per leaf) was not high enough to cause serious defoliation.

The phenology of leaf dry matter can be summarized as an alternation of two phases: leaf growth and hence dry-matter accumulation during the rainy season and a leaf area decrease and loss of dry matter during the dry season (short and long dry seasons).

Stems

Stem growth started at the end of the rainy season and continued through the dry season (Figure 1). The fall at the end of the second rainy season (1990–1991) corresponded to the mobilization of stem reserves for the initiation of regrowth and formation of new leaves, which were a stronger sink for reserves than the stem. Stems acted as a reserve since stem dry matter increased concurrently with defoliation.

Changes in stem dry matter did not corre-

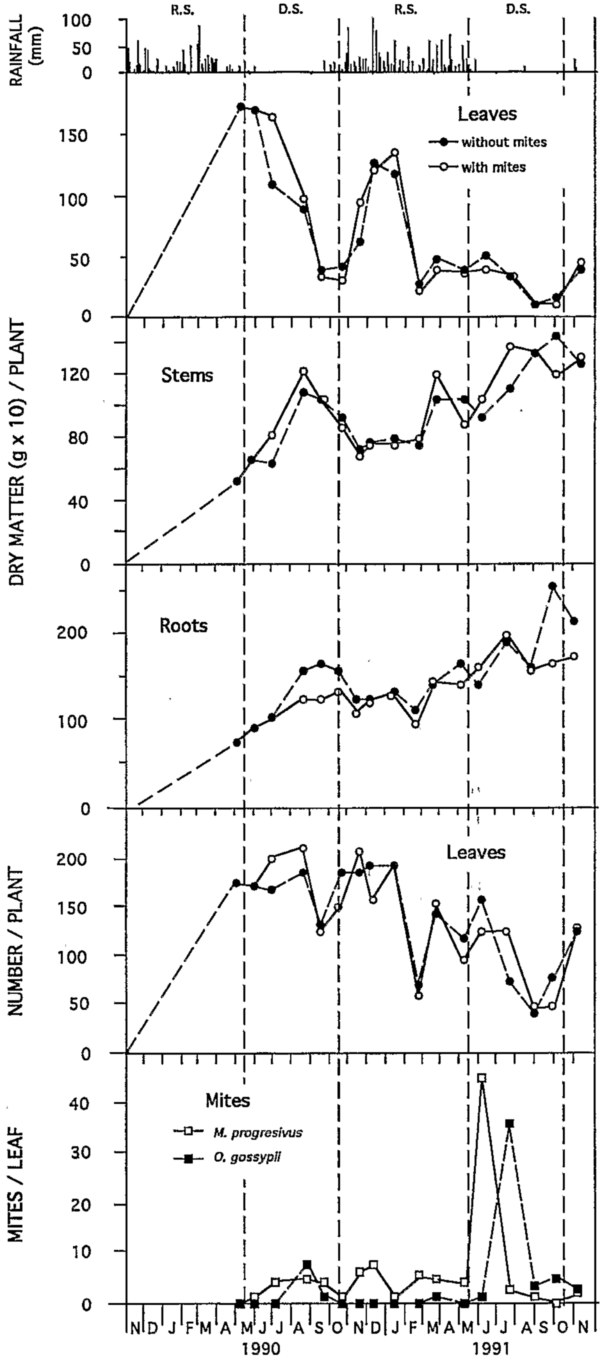

FIG. 1

Daily rainfall in the rainy season (RS) and dry season (DS), dry matter of leaves, stems and roots, and numbers of leaves per plant infested with mites and non-infested; numbers of mites/leaf, *Mononychellus progresivus* and *Oligonychus gossypii.*

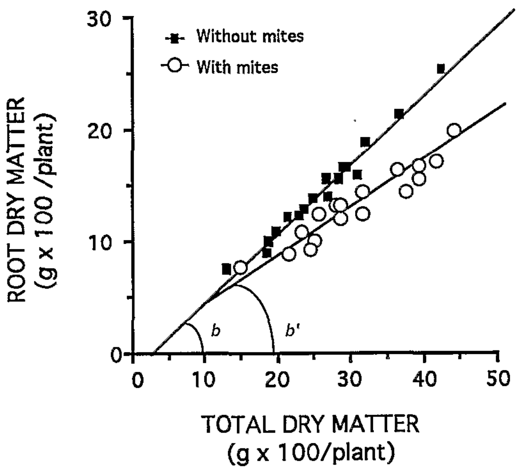

FIG. 2
Efficiency of storage root production (ESRP = *b* and *b'*) calculated after Boerboom (1978) on the mite-free and mite-infested cassava plants.

spond to changes in the number of leaves. Stems grew slowly over the first six months of cultivation and then increased rapidly for the first four months of the first dry season in 1990 (May, June, July and August).

Stem dry matter stopped accumulating at the end of August 1990 then decreased until the start of the 1990–1991 rainy season (end of November). It declined to 40% of the peak dry matter after ten months. Stem dry matter remained constant at this level for the first three months of the rainy season (December 1990 to February 1991). Thereafter it increased again at the end of the rainy season and continued to do so until harvest.

There was no significant difference for stem biomass between the sprayed plot and the control plot (Mann-Whitney U test, $\alpha = 0.05$).

Roots

Changes in root dry matter over the two year cycle are shown in Figure 1. During the first ten months (November 1989 to September 1990), dry matter accumulated in the roots. The first decrease in dry matter occurred at the beginning of the second 1990–1991 rainy season (October–November 1990), followed by a further fall during the short dry season (February 1991) before increasing until harvest.

Comparison of data from the control plot with those from the infested plot did not reveal any significant differences (Mann-Whitney U test, $\alpha = 0.05$). Nevertheless the data for five of the 17 samples from the mite-free plot tended to be higher than the corresponding ones from the infested plot; the first three were recorded during the first growth phase from July to October 1990 and the last two at the end of the second phase in October–November 1991. Moreover, a general examination of the data shows that the values for the infested plot were generally lower than those of the mite-free plot although they were not significantly different.

The harvest index modified according to Boerboom (1978) demonstrated this trend (Figure 2). Boerboom observed that the weight of reserve roots (y) is a linear function of total plant weight (x), demonstrating the distribution of dry matter between the roots and the rest of the plant. The equation is: $y = bx - a$, where b is the efficiency of storage root production (ESRP) and a is a constant.

The ESRP has the merit of being stable in time and also little affected by environmental conditions (De Bruijn, 1979). Regression lines between root dry matter and total plant dry matter (Figure 2) for the infested ($y = 113.81$ $x - 0.388$, $r^2 = 0.92$) and mite-ree plots ($y = 0.619$ $x - 166.49$, $r^2 = 0.97$) are significantly different (analysis of covariance, $\alpha = 0.05$). The greatest ESRP was obtained in the mite-free plot.

DISCUSSION

Other studies of cassava growth (Boerboom, 1978: Howeler and Cadavid, 1983; Veltkamp, 1985; Gutierrez *et al.*, 1988; Gijzen *et al.*, 1990; Yaninek *et al.*, 1990; Schulthess *et al.*, 1991) concern cultivation during the first 12–18 months. Results reported here agree with the results of these authors for the relevant period. Leaf dry matter increases during the first eight months of growth. As Hunt *et al.* (1977) demonstrate, maximum leaf area in cassava is attained between the third and ninth month after planting. The considerable decrease in leaf dry matter observed at the end of the first dry season, resulting in cessation of growth and development with associated defoliation, has also been reported by Gutierrez *et al.* (1988), Yaninek *et al.* (1990) and Schulthess *et al.* (1991). The severe defoliation observed in the short dry season indicates the sensitivity of cassava plants to water stress at this time.

The phenology of leaf, stem and root dry matter, comparable with that reported by other authors using different varieties (Boerboom, 1978; Howeler and Cadavid, 1983; Veltkamp, 1985; Gutierrez *et al.*, 1988; Yaninek *et al.*, 1990; Gijzen *et al.*, 1990; Schulthess *et al.*, 1991), followed a pattern typical for cassava. The loss of leaf dry mater was the consequence of the dry season (short or long) while dry matter losses of stem and root were probably the result of mobilization of reserves for optimum growth of foliage.

It was not possible to demonstrate from the present experiment any significant effect of mites on plant growth and yield as reported by Yaninek *et al.* (1990) because mite densities were not high enough. There was however a difference in the efficiency of storage in roots. The smaller efficiency of plants in the plot not sprayed with acaricide was due to the infestation by mites which diverted part of the dry matter produced by the plants.

There are two main reasons for the modest effect of *M. progresivus* and *O. gossypii* on cassava growth under the conditions of the present test compared with the results of Yaninek *et al.* (1990). First, the mite density observed during outbreaks, fewer than 50 mobile forms per leaf, was lower than that observed by Yaninek *et al.* (1990) who found over 250. Also, the outbreak period lasted only 2–3 months (compared with 3–5 months in the work of Yaninek *et al.*, 1990). The second reason may be the relative resistance of the cassava variety chosen. In susceptible varieties, reduction in photosynthesis and plant growth rates caused by the destruction of leaf laminae by mites are much greater (Hunt *et al.*, 1977; Byrne *et al.*, 1982; Cock, 1984). Perhaps cassava variety 1M20 can tolerate fairly large numbers of mites without great loss of yield.

The results suggest that the presence of the two species of mite may affect growth. Under the conditions of the trial reported, there were no statistically significant effects by the mites on leaf, stem and root weight dry matter. However, a comparison of regression lines for dry root weight against dry plant weight showed significantly greater production efficiency (Boerboom, 1978) in the mite-free plot. The efficiency of storage root production (ESRP) may reveal effects of mite which were not significant in the statistical analysis on each sample. *M. progresivus* and *O. gossypii* can have an economic impact on cassava production which can range from a simple diversion of storage products in the roots to compensate for leaf loss to a considerable loss of biomass. As these mites are distributed throughout most of Africa's cassava belt, integrated control of mite populations would appear to be justified.

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