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CASSAVA GREEN MITE INTERVENTION TECHNOLOGIES

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ABSTRACT

The cassava green mite, *Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae), became a conspicuous pest of cassava soon after its accidental introduction into Africa in the early 1970s. It has since spread across the entire cassava belt of the continent causing an estimated 30 to 80 percent reduction in yield and threatening the food security of resource-poor farmers. Biological control, host plant resistance and cultural practices are all promising pest management interventions. The classical biological control initiative coordinated by the International Institute of Tropical Agriculure (IITA) is currently the largest single cassava green mite pest management activity in Africa. Recent successes with several exotic phytoseiid mite predators and the introduction of a virulent strain of an exotic fungal pathogen enhances the prospects for classical biological control in targeted ecologies. Evidence of moderate genetic resistance prompted an increasing number of cassava breeding programmes to screen for mite damage symptoms during germplasm selection. New varieties are now being developed and their impact on the pest evaluated on-farm. However, adoption and distribution of new cultivars continue to be slow. Multi-trophic cassava agroecosystem research identified cultural practices that hinder the development of cassava green mite populations. Cultivars, soil fertility, time of planting, cropping system and time of harvest all influence the build-up of damaging pest populations. Packaging and disseminating this information to extension agents and farmers remains to be done. Much of the recent plant protection effort has focused on developing technologies without appropriate diagnosis, and relatively little effort has been made to implement, evaluate and integrate these interventions in the field. New intervention technologies will be difficult to introduce where cassava is of secondary economic importance. However, as the cassava market expands, more demand will be made for appropriate cassava green mite management solutions. Integrating these interventions into a comprehensive plant protection strategy remains a challenge.

Key Words: Cassava, *Mononychellus tanajoa,* **classical biological control, host plant resistance, cultural control.**

RÉSUMÉ

L'acarien vert du manioc, *Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae), est devenu un ravageur notoire du manioc peu après son introduction accidentelle en Afrique au début des années 70. Depuis, il s'est propagé dans toute la zone de production du manioc du continent, causant des baisses de rendement estimées 30-80% et menaçant la sécurité alimentaire des paysans à faibles ressources. La lutte biologique, la résistance de la plante hôte et les pratiques culturales sont toutes des interventions prometteuses en matière de protection. L'initiative de lutte biologique classique, dont la coordination est assurée par l'IITA, est actuellement la plus vaste activité de lutte consacrée à un seul ravageur, en l'occurence l'acarien vert du manioc. Les récents succés remportés avec plusieurs prédateurs phytoséiides exotiques, et l'introduction d'une souche virulente de champignon pathogène exotique, renforcent les perspectives de lutte biologique classique dans des écologies ciblées. Certaines manifestations de résistance génétique moderée incitent de plus en plus de programmes d'amélioration du manioc à cribler et sélectionner du germoplasme résistant aux acariens. De nouvelles variétés sont actuellement mises au

point, et leur impact sur le ravageur est évalué en milieu réel. Cependant, l'adoption et la diffusion des nouveaux cultivars sont encore lentes. La recherche sur les méchanismes multitrophiques de l'écosystème manioc a permis d'identifier des pratiques culturales qui entravent le développement des populations d'acariens verts. Les çultivars, la fertilité du sol, la date de la plantation, le système cultural et la date de la récolte sont autant de facteurs qui influent sur l'accroissement de la population des ravageurs. Il s'agit de conditionner ces informations et de les diffuser aux vulgarisateurs et aux paysans. Jusqu'ici, la protection des végétaux se consacrait essentiellement à la mise au point de technologies sans diagnostic préalable et relativement peu d'efforts étaient consentis pour mettre en oeuvre, évaluer et intégrer ces interventions au champ. Les nouvelles techniques d'intervention seront difficiles à introduire là où le manioc n'a qu'une importance économique secondaire. Toutefois, avec l'expansion du marché du manioc, la demande de solutions appropriées de lutte contre l'acarien vert du manioc augmentera. L'intégration de ces interventions dans une stratégie globale de protection végétale reste un défi à relever.

***Mots Clés*: Manioc, *Mononychellus tanajoa* , lutte biologique classique, résistance de la plante-hôte, pratiques culturales**

INTRODUCTION

Although cassava (*Manihot esculenta* Crantz) has been present in parts of Africa for more than 400 years, its importance as a food staple is relatively recent. Cassava production systems continue to change as increasing production demands degrade existing ecosystems, reduce traditional fallow periods and cultivation extends into new, and often, marginal areas. Local germplasm is limited in variability compared to the crop's neotropical area of origin and the exotic nature of the crop in Africa makes cassava especially susceptible to exotic pests that thrive in the absence of well-adapted natural enemies (Yaninek and Schulthess, 1993). The introduction of *Mononychellus tanajoa* (Bondar)(Acari: Tetranychidae) into Africa in the absence of well-adapted natural enemies and resistant germplasm has caused a major ecological perturbation.

In the early 1970s, the neotropical spider mite *M. tanajoa*, an exotic species new to Africa, was discovered attacking cassava in East Africa (Nyiira, 1972). This mite quickly spread throughout the cassava belt and now threatens food security in marginal areas where cassava is often the only crop available for harvest when all others have failed. Today, *M. tanajoa* is the most important arthropod pest on cassava in many regions of the continent, causing yield losses estimated to be from 30 to 80%. In South America, where the mite and the crop are indigenous, locally selected cultivars and well-adapted natural enemies keep this pest in check.

Prior to its discovery in Africa, virtually nothing was known of *M. tanajoa* (Yaninek and Herren, 1988). It was originally described in 1938 from cassava in Bahia, Brazil (Bondar, 1938), but only achieved notoriety 33 years later when it was found in Uganda (Nyiira, 1972). Historically, there had been no serious mite problems in small-scale food crop production in tropical Africa, thus no need for local expertise in acarology. This left national programmes at a loss for the next step. Early efforts to control the mite included the use of chemicals, but the futility of this approach quickly became clear given the low income of most cassava farmers (Yaninek and Herren, 1988). Control efforts eventually shifted to resistance breeding, then later included classical biological control (Yaninek, 1994).

INTERVENTION TECHNOLOGIES

Appropriate *M. tanajoa* intervention technologies should consider both the origin and nature of the pest. Combinations of cultural practices, resistant germplasm and biological control of *M. tanajoa* in traditional African farming systems are currently being pursued. A synopsis of the progress to date in developing ecologically sound *M. tanajoa* intervention technologies follows.

Cultural Practices. Relatively little work has been done on cultural practices that ameliorate the *M. tanajoa* problem. Modifications in existing farming practices began soon after the pest was discovered in Africa. Some farmers detopped infested plants, as recommended, but this often led to greater damage as new shoots proliferated.

Highly susceptible varieties were quickly replaced with less susceptible varieties (Yaninek and Herren, 1988) and farmers quickly learned to live with the problem. They are now probably reluctant to adopt technologies which add only incrementally to their productivity.

Several recommended cultural practices have been identified based on systems research. Good cassava production starts with good quality planting material free of avoidable plant pathogen and pest contaminants. Practical experience with *M. tanajoa* suggests that cassava planted early in the wet season suffers low mite-induced yield reductions compared with cassava planted later in the season, and that a positive relationship exists between soil fertility, plant vigour and mite density (Gutierrez *et al.*, 1988). Fallow management can reduce undesirable weeds, while maintaining desirable refugia for natural enemies.

Only a few recommendations concerning *M. tanajoa* and agronomy are available, and most come as incidental observations from non-agronomy trials (Yaninek *et al.*, 1989c; Toko *et al.*, in press). What is needed is an evaluation of traditional cassava-based cultivation systems to provide the agronomic and socioeconomic context in which plant protection strategies can be developed so as to be accepted and effective. This would also provide a basis for comparing the relative value of "improved" technologies. Useful cultural practices still need to be compiled and catalogued into clear recommendations, then made widely available. Disseminating this information to farmers through extension services would be the next step. A syllabus of recommended practices should be developed and adapted by national extension services and then passed onto to farmers through routine extension activities.

Resistant Germplasm. Cassava pests have been studied for many years in attempts to develop host plant resistance. Although most of the early breeding effort focused on developing high yielding and early maturing cultivars, a number of cassava cultivars have been developed for resistance against several important pests including *M. tanajoa* in Africa (Mahungu *et al.*, 1994). One strategy for breeding resistance in cassava has been to identify factors that influence pest incidence and screening efficiency, and to develop improved screening techniques to ensure that the genetic variability existing in the target organisms was efficiently assessed (Hahn *et al.*, 1989). This strategy has led to the development of cassava cultivars and breeding populations with resistance to some plant diseases, and is currently being used for *M. tanajoa*. Currently, efforts are underway to evaluate leaf pubescence and drought tolerance as deterrents to mite damage. Because of the limited genetic base available in the African germplasm, additional sources of resistance are needed. This is being addressed, in part, by introducing additional germplasm from the crop's area of origin. The importance of local cultivars should not be overlooked in this regard. However, new genes alone cannot guarantee a crop's performance in the field. This requires a selection strategy based on deliberate decentralised and multi-locational testing.

Biological Control. Cassava in the Neotropics is relatively tolerant of indigenous pests, particularly locally adapted varieties used in traditional farming systems (Bellotti *et al.*, 1987). Here natural enemies of *M. tanajoa* have been assessed and shown to preserve at least 30% of the potential production (Braun *et al.*, 1989; Moraes, unpubl. data). This prompted the International Institute of Tropical Agriculture (IITA) to initiate classical biological control to complement the ongoing effort in resistance breeding. Since the Biological Control Programme of IITA follows a plant protection strategy based on ecologically-sound agroecosystem principles, a thorough understanding of the biotic potential of *M. tanajoa* in its area of origin and in the relatively new farming systems in Africa has been pursued. Selective aspects of the pest's biology and key interactions in the surrounding agroecosystem have been characterised so that appropriate corrective measures can be developed and tested (Yaninek *et al.*, 1989c).

Since the initiation of the classical biological control campaign to control *M. tanajoa*, 11 species (24 distinct populations) of neotropical phytoseiids have been selected and shipped to Africa for experimental releases (Yaninek *et al.*, 1993). Initially, natural enemies were selected because of their abundance and frequency on cassava. Between 1984 and 1988, nearly 5.2 million phytoseiids belonging to 7 species of Colombian origin were imported to Africa and released at 343 sites in 10 countries. None of these species and populations ever became established in the wide range of agronomic and ecological conditions tested, apparently because of inadequate alternative food sources when *M. tanajoa* densities were low and during extended periods of low relative humidity (Rogg and Yaninek, 1990; Yaninek *et al.*, 1993).

Foreign exploration was adjusted in 1988 to focus on Neotropical regions that were agrometeorologically homologous to areas in Africa where the potential for severe *M. tanajoa* damage exists (Yaninek and Bellotti, 1987). Natural enemies associated temporally and spatially with *M. tanajoa* and capable of surviving periods of low *M. tanajoa* densities on alternative food sources in the new exploration sites were given selection priority. Several natural enemy candidates were immediately identified in northeast Brazil and shipped to Africa. More than 5.3 million phytoseiids of the species *Neoseiulus anonymus* (Chant & Baker), *N. idaeus* Denmark & Muma, *Typhlodromalus aripo* (DeLeon) and *T. limonicus* (Garman & McGregor) of Brazilian origin were released at 291 sites in 9 countries between 1989 and 1993. *Neoseiulus idaeus* has since become established in Benin and Kenya, and *T. limonicus* and *T. aripo* in Benin and Ghana (Yaninek *et al.*, 1992, 1993; Yaninek, unpublished data).

Prospects for the classical biological control of *M. tanajoa* using phytoseiid predators can be inferred from the impact of natural enemies in the neotropics and from their observed phenology in Africa. Studies in Colombia and northeast Brazil indicate that predation by *T. limonicus* and *N. idaeus* on *M. tanajoa* can conserve as much as 25% and 32% of the cassava storage-root production, respectively. *Neoseiulus idaeus* occurs on cassava when *M. tanajoa* is most abundant, and survives periods of low prey densities by moving to alternative prey on associated plants. *Typhlodromalus limonicus* remains on cassava throughout the cropping season, regardless of prey density, and spreads rapidly when prey are abundant. *Typhlodromalus limonicus* survives periods of low prey numbers by feeding on exudates produced by leaves near the shoot tips. *Typhlodromalus aripo* densities averaging nearly 30 phytoseiids per tip have been recorded on all the plants assessed three month after release. *Mononychellus tanajoa* populations in release fields are about half those of control fields. *Typhlodromalus aripo* is spreading rapidly, averaging nearly 2 km per month.

Other natural enemies known to be important biological control agents of tetranychid mites include pathogenic fungi. The fungus, *Neozygites* sp., (Zygomycetes: Entomophthorales), a well known pathogen of spider mites, was recently found attacking *M. tanajoa* during foreign exploration in humid valleys of northeastern Brazil. Since half of the African cassava belt falls within rain forest and humid savanna zones, a natural enemy adapted to these conditions is of particular interest. Preliminary field and laboratory investigations suggest that this fungus may be the single most important natural enemy of *M. tanajoa* in these areas during critical times of the year. Studies on specificity, infectivity and general epidemiology have been completed in Brazil and virulent strains of *Neozygites* shipped to IITA for culturing and experimental releases.

The experimental release campaign at IITA continues with the promising populations of *N. idaeus*, *T. limonicus* and *T. aripo* from Brazil, and soon with virulent strains of *Neozygites* sp. New colonies of the phytoseiid species are initiated periodically from field-collected individuals and new importations from Brazil to invigorate the laboratory colonies. Other promising species and populations of phytoseiids from a variety of locations in the neotropics continue to be selected and imported for experimental releases. This allows a wider pool of candidate natural enemies for testing alongside the proven Brazilian phytoseiid species. Currently, there is a search for "frost-tolerant" phytoseiids that can be released in the mid-altitude cassava areas of southern Zaire, Zambia and Malawi. The fungus will initially be used to target *M. tanajoa* found in seasonal humid regions, regardless of total rainfall.

A STRATEGY TO INTEGRATE TECHNOLOGIES

Integrating the management of pests of cassava into a strategy which meets the needs of individual farmers requires a conceptual framework for development and implementation. Concern for pests, diseases and weeds without regard for the availability of appropriate interventions, local preferences, labour and market constraints will be of little interest to client farmers. A number of promising technologies are already available for a range of cassava production constraints. However, many have never been tested on farmers' fields, and even fewer are available to extension agents and their client farmers. Interventions developed in an inter-disciplinary manner should have a better chance of success. A systems analysis which includes multi-trophic interactions for any given agroecosystem and the socioeconomic concerns of the farmer provides a paradigm for linking the ecological, agronomic and socioeconomic milieu in which constraints are evaluated and informed decisions can be made.

The Ecologically Sustainable Cassava Plant Protection (ESCaPP) project in West Africa is a working model (Yaninek *et al.*, 1994). ESCaPP is a regional project to develop, test and adapt sustainable cassava plant protection technologies for the most important arthropod, pathogen and weed pests found in West Africa. Multi-disciplinary teams of national plant protection experts join regionally with international experts to share expertise and pool efforts across agroecologies. Project activities are divided into three interrelated and overlapping phases. Firstly, the major cassava pests are being identified in targeted agroecologies through diagnostic surveys. Secondly, farmers' participation highlights the development and testing of appropriate intervention technologies. The third phase is an evaluation of the training objectives and technology implementation. Training, including in-service and postgraduate, is an important feature of all phases of the project.

CONCLUSION

The cassava green mite problem has noteworthy implications at several levels. Ecologically, the mite lives and feeds on young leaves and green stems, and increases in population density during the transition period between wet and dry seasons (Yaninek *et al.*, 1989a). When populations reach and sustain high levels, the mite becomes an agronomic pest that reduces yields by damaging the photosynthetically active leaf surface area of the plant. Socioeconomically, the significance of this pest depends on the importance of the crop for the farmer. Without adequate and appropriate intervention technologies, mite problems will persist, and perhaps become intensified, as agroecosystems collapse under the strain of poorly adapted natural enemies, limited germplasm and ineffective agronomic practices. Therefore, *M. tanajoa* as a pest poses multi-dimensional problems, and requires multi-dimensional solutions.

The intervention technologies presently being developed for *M. tanajoa* include biological control, host plant resistance and cultural practices. Most efforts remain discipline-specific with little opportunity for outside input. Cultural practices are being developed with little socioeconomic input and limited client farmer interaction. The work on resistant germplasm must be decentralised to ensure that local agroecological conditions are part of the selection and breeding background. Local cultivars which often include many desirable agronomic characteristics need to be included in these evaluations. However, once suitable germplasm has been identified, selected and tested on-farm, the problem of multiplication, distribution and adoption still remains. Classical biological control using exotic natural enemies from the neotropics shows promise in certain agroecologies. An initial constraint was the identification of predators suitably adapted to local climatic conditions. The problem now is to provide sufficient quantities of exotic phytoseiids in a timely manner to national programmes for widespread experimental releases.

Few *M. tanajoa* technologies have been properly tested on-farm, and fewer still distributed and implemented through national programmes. The challenge now is to integrate these disparate developments into an inter-disciplinary effort to diagnose, develop and implement sustainable plant protection technologies. The ESCaPP model could serve the needs of integration, decentralisation and implementation. Meanwhile, intervention developments will continue as before, unless and until the various disciplines combine with the single objective of improving the production of small-scale cassava farmers by reducing the mite problem.

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