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Research Application Summary

Evidence on effectiveness of parasitoids as biological control agents in integrated crop pest management programmes in Africa

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Abstract

Despite advances in science, technology and innovations, the extent and depth of food insecurity in the developing world remains unconscionable. About 800 million people which constitutes one-sixth of the developing world's population do not have access to sufficient food to lead to healthy, productive lives. Globally, a major challenge to food security is the increasing pest and diseases infestation that decimates agricultural productivity. In the case of the developing world, food insecurity is closely associated with poverty and many households cannot afford use of new advances in agricultural production to reduce pest infestation on their crops. The use of biological control is therefore very critical and a user-friendly approach particularly for smallholder farmers who cannot afford use of pesticides. In addition, biological control is environment-friendly and should be promoted. Parasitoids of Hymenopteran super families, mainly in the Apocrita (e.g., *Encarsia formosa*, *Epidinocarsis lopez,*, *Gyranusoidea tebygi)* have been successfully introduced and established for crop pest management. In this paper, we review and present evidence on the effectiveness of parasitoids in crop pest management with a view to promote their application among smallholder farming systems in Africa.

Key words: Food security, Hymenopteran super families, pest infestation, smallholder farmers

Résumé

Malgré les progrès effectués en science, technologie et innovation, l'ampleur de l'insécurité alimentaire reste démesurée dans le monde moins-avancé. Environ 800 millions de personnes, faisant un sixième de la population du monde sous-développé n'ont pas accès à une alimentation suffisante et saine conduisant à de vies productives. De façon globale, le défi majeur auquel fait face la sécurité alimentaire est la croissante infestation des pestes et maladies qui déciment la productivité agricole. Dans le cas du monde en développement, l'insécurité alimentaire est intimement liée à la pauvreté et nombreux ménages ne peuvent pas s'offrir l'usage de nouvelles avancées en production agricole pour la réduction dégâts causés par les pestes et maladies sur leurs cultures. L'usage de control biologique est donc très important et bénéfique pour les producteurs agricoles de petite échelle qui ne peuvent pas s'acheter les pesticides à utiliser. De plus, le control biologique est inoffensif à l'environnement et doit être promu. Les Parasitoïdes de la super famille des Hymenopteran principalement au sein des Apocrita (ex : *Encarsia formosa*, *Epidinocarsis lopez,*, *Gyranusoidea tebygi)* ont été introduites et établies avec succès pour le contrôle des pestes culturaux. Dans le présent document, nous avons revu et présenté l'évidence sur l'efficacité des parasitoïdes dans le contrôle des pestes culturales avec pour objectif de promouvoir leur application au sein des systèmes agraires des producteurs de petite échelle en Afrique.

Mots clés : Sécurité alimentaire, super famille des Hymenopteran, infestation par des pestes, producteurs de petite échelle

Introduction

Pest management in Africa and globally has experienced a total revolution since World War II when synthetic organic compounds got into agriculture and public health (Banwo and Adamu, 2010). However, it has become apparent that there are many limitations in the use of chemicals for pest management. In agriculture, problems of pest resurgence, secondary pest outbreaks, pest resistance and adverse effects of pesticides on the environment, including human poisoning and toxicity to other non-target organisms, has led to the search for alternative approaches to the pest outbreak problem (Banwo and Adamu, 2010). Experiences from the Integrated Pest Management (IPM) examples shows that crop yields can effectively be increased with less expensive and environmentally less harmful pest management systems and thus significantly reducing external costs (AU-IAPSC, 2015). New ideas on integrated pest management (IPM) strategies have been developed followed by intensification of the search for biological control agents, which can now be incorporated into IPM programmes (Banwo and Adamu, 2010). Biological control has been a valuable tactic in pest management programs for many years (Orr, 2009). It involves the use of one type of organism to reduce the population density of another (Soloneski *et al.,* 2013) and has proved to be an important and effective strategy in pest management, particularly of exotic and invasive pests (Hoy, 1989) which could be through classical, augmentation or conservation biological control. Considerable effort has gone into biological control of pests in many parts of the world but most importantly into parasitoids because of their host specificity (Strand and Obrycki, 1996). Parasitoids are entomophagous insects which are only parasitic in their immature stages, kill their host in the process of development, and have free-living adults that do not move their hosts to nests or hideouts.

Parasitoid wasps are important natural enemies of some of Africa's most devastating crop pests. The adults lay their eggs inside a host herbivore, and as the immature parasitoid develops, feeding and reproduction in the pest are slowed or halted. Eventually the adult parasitoid emerges from the host killing it in the process (Pearce *et al*., 2008). The following scenarios provide a review of evidence of some of the successful cases of pest management using parasitoids in Integrated Pest Management (IPM) programs in Africa.

Africa-wide Cassava mealybug control. In Africa, the cassava mealybug (*Phenacoccus manihoti*) was first reported in Zaire (today's Democratic Republic of Congo) in 1973 having been accidentally introduced through planting materials from South America (Herren and Lema, 1982). Within ten years, it threatened to wipe out the continent's crop of cassava, the staple food for more than 200 million people in Sub-Saharan Africa (Herren *et al*., 1987; Herren and Neuenschwander, 1991). The pest spread to more than 16 African countries in the region in that short period. It was however effectively controlled by an introduced encyrtid parasitoid *Epidinocarsis lopezi*, an arrhenotokous encyrtid parasitoid specific to *P. manihoti* (Gutierrez *et al*., 1988). The efficacy of the parasitoid was demonstrated in exclusion experiments (Neuenschwander *et al*., 1986), and the parasitoid has since been established in different ecological zones in African countries (Herren *et al*., 1987) in more than 24 countries keeping the pest under control.

Mango mealybug control. Mango (*Mangifera indica* L., Anacardiaceae), an ancient fruit of Indian origin, constitutes an important source of energy and nutrients for millions of people in the tropics. In Africa, mango used to be relatively free from damage by insect pests and diseases (Bokonon-Ganta *et al*., 2002). In 1986, however, the mango mealybug, *Rastrococcus invadens* Williams (Homoptera: Pseudococcidae) of Southeast Asian origin, which was accidentally introduced to West Africa, probably on infested plant material (Williams, 1986), was reported to cause serious damage to various fruit trees, especially mango, in Bénin, Ghana, and Togo (Agounké *et al*., 1988). It has since invaded Cameroon, the Republic of Congo, Côte d'Ivoire, Democratic Republic of Congo, Gabon, Nigeria, and Sierra Leone and thought to be unreported in some countries. In 1987, a regional project on the biological control of the mango mealybug was launched with the aim of introducing exotic parasitoids to supplement indigenous predators that were not capable of controlling *R. invadens* (Agounké *et al*., 1988).

The pest status of the mango mealybug was so obvious that no quantitative crop loss assessment was done before the first releases of the biological control agents (Neuenschwander, 1993). A parasitic wasp, *Gyranusoidea tebygi* Noyes (Hymenoptera: Encyrtidae), was imported from India and studied in quarantine. The impact of *G. tebygi* on populations of *R. invadens* was demonstrated by exclusion experiments and population dynamic studies (Boavida and Neuenschwander, 1995; Boavida *et al*., 1995) and later, by multiple regression analysis of survey data on a larger scale in Benin. The percentage of infested trees declined from 31% in 1989 to 17.5% in 1991, and average mealybug densities declined steadily from 9.7 females/48 leaves in 1989 to 6.4 females/48 leaves in 1991 (Bokonon-Ganta and Neuenschwander, 1995). The importation, rearing, and release and successful establishment of a second parasitoid wasp, *Anagyrus mangicola* Noyes (Hymenoptera: Encyrtidae) brought a further local reduction of the pest populations.

Coconut whitefly. The coconut whitefly, *Aleurotrachelus atratus* is the most economically important pest of coconut. For example, in Grand Comoros, 90% of coconut palms were severely infested by the whiteflies *A. atratus* and *Paraleyrodes bondari* Peracchi, with *A. atratus* accounting for 90% of the whiteflies found. In Mozambique, 70.74% of the reduction in coconut produced is explained by attack of whiteflies (Cugala *et al*., 2013). The sooty mould that develops on the honeydew excreted by whiteflies significantly affects coconut palm growth and yields. Heavy infestations can even result in death of the palms. Crops growing under infested coconuts, such as vanilla, banana, physic nut and guava, are also damaged. In Africa, it is now known to be invasive in many tropical countries (Martin, 2005) on several islands of the Indian Ocean: Madagascar and Mauritius and La Reunion (Youssoufa *et al*., 2006); it was also reported in Cape Verde in 2003, Comoros Islands in 2002, Seychelles Islands (Cugala *et al*., 2013) and was quoted from continental Africa; Mozambique in 2011 and Uganda (Gerling *et al*., 2006). The parasitoid *Eretmocerus cocois,* which was introduced to Ngazidja (Comoros Islands) for the biological control of *A. atratus* in the Comoros proved to be an effective bio-control agent of *A. atratus* (Cave, 2008) in Comoros and currently the pest appears to be successfully controlled by this parasitoid in areas where it has been introduced. The parasitoid species *Eretmocerus cocois* and *Encarsia basicincta* are very promising as biological control agents of *A. atratus* and have been reported, reared and/or released in other African countries including Comoro Islands, La Rèunion, Seychelles, (PRPV, 2016) where *A. atratus* population is now under control due to the activities of the same parasitoids species.

The fruit fly. Fruit flies (Diptera: Tephritidae) are among the most important and widespread pests of fruits and vegetables in Africa and worldwide. Although many species are of African origin, Asian invasive species have also invaded the African continent, among them being the *Bactrocera* species (Mwatawala *et al*., 2006). The fruit fly (*Bactrocera invadens*) is one of the *Bactrocera* species that invaded the African continent. It was recorded for the first time in 2003 from the Kenyan coast (Ekesi and Billah, 2006). In the absence of control methods, damage and crop losses due to *B. invadens* can be up to 100% (Cugala, 2009). Fruit fly control methods in many African countries are based on regular insecticide sprays but the cost of insecticides is inhibitive for small scale farmers (Cugala *et al*., 2009). In Eastern and Southern Africa, five indigenous fruit fly species (*Ceratitis cosyra*, *C. fasciventris, C. rosa, C. anonae* and *C. capitata*) attack mango (Ekesi and Billah, 2007). Several surveys across the region showed a 30% to 70% yield loss in mango due to these native fruit flies, depending on the locality, variety and season (Lux *et al*. 2003; Ekesi *et al*., 2009). However, since the invasion by *Bactrocera invadens* in East Africa in 2003, damage to mango has increased to over 80% (Goergen *et al*., 2011). The rapid spread and devastating impact of *B. invadens* is a serious concern to the mango industry in Kenya and Africa at large. The export of host fruit species of *B. invadens*, such as mangos from Uganda, Tanzania and Kenya, are already banned by the Seychelles, Mauritius and South Africa. An introduced parasitoid *Fopius arizanus* has greatly reduced the population of fruit flies especially *Bactrocera invadens* in the near East (Ekesi *et al*., 2011).

The beneficial impacts of the parasitoids in IPM include substantial increases in crop yields, large reductions in pest populations, and unquantified, but probably large, environmental benefits due to the non-use of persistent chemical insecticides (Coulibaly *et al*., 2004).

Several other cases of successful pest control using parasitoids have been reported in Africa indicating the effectives of parasitoids as biological control agents in integrated pest management (IPM) some of which are shown in Table 1.

Table 1. Cases of successful pest control using parasitoids in Integrated Pest Management in Africa

Parasitoid species	Host(s)	Reference
Eretmocerus emiratus	*Bemisia tabaci* (Biotype "B" *argentifolii* Bellows and Perring)	Gould *et al*., 2008
Encarsia formosa	*Bemisia tabaci*	Ashouri *et al*., 2012
Eretmocerus mundus	*Bemisia tabaci*	Gerling and Fried, 1997
Eretmocerus cocoisEncarsia basicincta	*Aleurotrachelus atratus*	PRPV, 2016
Epidinocarsis lopezi	Cassava mealybug	Neuenschwander, 1990
Gyranusoidea tebygiAnagyrus mangicola Noyes	Mango mealybug	Boavida and Neuenschwander, 1995
Fopius arisanus	Mango Fruit fly	Ekesi *et al*., 2011
Trichogramma evanescens(Westwood)	*Sitotroga cerealella* (Olive).	Amany *et al*., 2014
Diadegma mollipla (Holmgren),*Cotesia plutellae* (Kurdjumov), *Diadegma semiclausum,Oomyzus sokolowskii, Diadromus collaris* Gravenhorst	*Plutella xylostella*	Cobblah *et al*., 2012 Haseeb *et al*., 2005 Kfir, 2004

Conclusions

The use of biological control in pest management systems has had a long, rich history. While there are a variety of impediments, there also exist many opportunities for the continued use and expanded role of parasitoids in the management of insect pest problems. Changes in pest management tactics are resulting from a variety of factors, including environmental and human safety concerns, development of insecticide-resistance, increases in pesticide cost and availability, and market demand. The continual influx of alien arthropod species resulting from increased international trade presents new pests of agriculture annually. Regardless of the production system, IPM will have an important role to play, and the use of parasitoids can be an integral part of IPM.

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