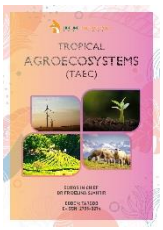
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2735-0274 (Online)
CODEN: TARGDB

Tropical Agroecosystems (TAEC)

DOI: http://doi.org/10.26480/taec.01.2023.29.33



REVIEW ARTICLE

MANAGEMENT OF INSECT PESTS OF BAMBARA GROUNDNUT (VIGNA SUBTERRANEAN (L.) VERDC.) IN NIGERIA

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ARTICLE DETAILS

Article History:

Received 23 October 2023
Revised 15 November 2023
Accepted 05 December 2023
Available online 12 December 2023

ABSTRACT

Tribolium castaneum, commonly known as the red flour beetle is a major stored grain pest and found in granaries of wheat, cereals, beans, pasta, crackers, mixed cake, dried flowers and pet food, seeds, chocolate, meal, spices, nuts and even in museum dried artistic specimens. The insect is 3.5 mm long reddish brown beetle. The beetle can survive up to three years of age as an adult and is regarded as a sedentary insect. The insect has the ability to disperse via flight up to considerable long distances. The particular beetle has a close resemblance to confused flour beetle except it has three defining clubs at the end of each antenna. Its antennae are club type with the inclusion of three segments. The beetle has a curvy thorax. The use of plant materials as traditional protectants of stored products is an old practice used all over the world. The protection of stored products generally involves mixing grains with plant based protectants. Provision of a sound background for *T. castaneum* species identification as well as for the establishment of higher taxonomic classification and for consideration on the beetles evolutionary development, will have a long way in reducing if not total prevention of resistant menace of various species to adoption of management strategies of *T. castaneum*.

KEYWORDS

Bambara groundnut, *Tribolium castaneum*, Pests, Insects, beetle

1. INTRODUCTION

Bambara groundnut (*Vigna subterranean* (L.) Verdc.) is an underutilised African legume crop which is grown at low levels very extensively throughout sub-Saharan Africa (Okonkwo and Opara 2010; Bamshaiye et al., 2011). Bambara groundnut with botanical name *Voandzeia subterranean* (L.) *thousars*, synonyms of *Vigna subterranean*, belongs to the plantea of the family of fabaceae and sub family of Faboidea (Bamshaiye et al., 2011). Bambara groundnut is a legume crop that is an important food source for rural households in sub-Saharan Africa. Studies had revealed the detailed nutritional composition to be crude protein, moisture, crude fat, ash and total carbohydrate (Aremu et al., 2006). It contains an appreciable amount of lysine and a minimum amount of trypsin and chymotrypsin (Olanipekun et al., 2012).

Bambara groundnut is commonly called, beans, ground bean, earth pea and kaffir pea, depending on location and tradition. In Africa, it is commonly referred to as "Jugo beans" (South Africa), "Ntoyocibemba" (Republic of Zambia), "Gurjiya or Kwaruru" (Hausa, Nigeria), "Okpa" (Ibo, Nigeria), "Epa- Roro" (Yoruba, Nigeria) and "Nyimo beans" (Zimbabwe) (Bamshaiye et al., 2011). Bambara groundnut is cultivated in many semi-arid African countries such as Ghana, Nigeria and South Africa with a secondary cultivation centre in South East Asia namely Thailand, Indonesia and parts of Malaysia. Traditionally, it was cultivated in extreme, extreme, tropical environments by small-scale farmers without access to irrigation and/or fertilisers and with little guidance on improved practices (Mabhaudi et al., 2013). Bambara groundnut is known to be drought tolerant, can grow in areas of high or low rainfall. It has been reported that this legume can produce yields where annual rainfall is below 500 mm and the optimum is between 900-1000 mm per year (Bamshaiye et al., 2011).

The crop appears to be remarkably free from pests and diseases (Purseglove, 1992). This agrees with who mentioned that the crop is relatively pest and disease free apart from weevil attack during storage (Doku, 1995). No serious pest or diseases are reported for this crop but damage is sometimes caused by leaf hoppers (*Hilda patruelis and Empoascafacialis*) (Isadeha, 2018). Have also made similar observations that bambara groundnut is relatively free of the insect pests that plague other legumes, such as the cowpea and peanut (Tanimu and Aliyu, 1995). And on the whole, pesticides are hardly used by farmers when cultivating bambara groundnut. Bambara groundnut is considered to be generally less affected by diseases and pests than groundnut or cowpea, but several diseases and pests can cause serious damage to the crop. The most important fungal diseases are Cercospora leaf spot (*Cercospora spp.*), powdery mildew (*Erysiple polygoni*) and Fusaruim wilt (*Fusarium oxysporum*) (Brink et al., 2006). According to in dry weather, pod attacks by termites have been consistently observed and root knot nematode (*Meloidogyne javanica*) also attacks the roots of the plant in sandy soils (Goli, 1995). Bambara groundnut (*Vigna subterranean* (L.) Verdc.) is often attacked by insect pest during storage, this result in high reduction of nutrient value of the crop seed (Bambara groundnut) under storage. Infested grain attracts low

Quick Response Code	Access this article online	
	Website: www.taec.com.my	DOI: 10.26480/taec.01.2023.29.33

Cite The Article: Oyewale, R. O. T. O. Ogbirishi, H.M. Ibrahim, M.O. Akinyele, R. O. Olaniyi and R.O. Ibrahim (2023). Management of Insect Pests of Bambara Groundnut (Vigna Subterranean (L.) Verdc.) in Nigeria. *Tropical Agroecosystems, 4(1): 29-33.*

market value. Elevated levels of the genetic and environmental variance are often expressed in extreme habitat which alternate the beetle's development process, thus leading to inefficiency of adopted control measures. Resistance development of the beetle to control measures with minimal efficacy.

Provision of a sound background for Red Flour Beetles (*Tribolium castaneum*) species identification as well as for the establishment of higher taxonomic classification and for consideration on the beetles evolutionary development, will have a long way in reducing if not total prevention of resistant menace of various species to adoption of management strategies of *Tribolium castaneum*.

1.1 Origin and Distribution of Bambara Groundnut

Bambara groundnut (*Vignasubterranea* L. Verdcourt) is an indigenous African crop and reported to have originated from north-eastern Nigeria and Northern Cameroon where the wild forms are still found (PROTA, 2006). The crop has been widely cultivated in tropical regions since the seventeenth century. Bambara groundnut is cultivated in many semi-arid African countries such as Ghana, Nigeria and South Africa with a secondary cultivation centre in South East Asia namely Thailand, Indonesia and parts of Malaysia. Traditionally, it was cultivated in extreme, tropical environments by small-scale farmers without access to irrigation and/or fertilisers and with little guidance on improved practices (Mabhaudi et al., 2013). The centre of origin of bambara groundnut is probably north – eastern Nigeria and northern Cameroon. It is found in the wild from central Nigeria eastwards to southern Sudan, and is now cultivated throughout tropical Africa and to a lesser extent in tropical parts of America, Asia and Australia (Brink et al., 2006). Bambara groundnut was domesticated in the semi-arid zone of West Africa, probably around the headwaters of the Niger River, from where it spread in ancient times to Central Africa, and more recently to the Malagasy Republic, Asia and South America (Tweneboah, 2000).

In Africa, the crop is the third most commonly eaten legume after groundnut and cowpea (Omoikhoje, 2008). This legume makes a balanced food, as it contains sufficient quantities of carbohydrates, protein, fat, fiber, ash and mineral with high proportions of lysine and methionine compared to whole fresh cow milk (Murevanhema, 2013). Bambara groundnut is a hardy plant particularly well suited to the growing conditions found in the Savanna regions with a Sudanese and Sudano–Guinean climate (Baudoin and Mergaei, 2001).

1.2 Importance 5of 5Bambara 5groundnut

It is largely grown for human consumption, although the remaining biomass can be fed to cattle and other domestic animals (Anchirinah et al., 2001). The seed is consumed in different ways and at different stages of maturity as a vegetable or snack. The young fresh seeds may be boiled and eaten as a snack in a manner similar to boiled peanut. The seed is made into a pudding (or steamed-paste) called Moi-Moi or Okpa (bean porridge) in some parts of Nigeria (Okpuzo et al., 2009). It is a major source of plant protein in sub-Saharan Africa and constitutes an important part of the local diet, culture and economy (Boateng et al., 2013). Milk produced from bambara groundnut is comparable to that produced from soybean with bambara groundnut milk containing more protein compared with protein in the soy milk (Adu-Dapaah et al., 2016). The seed provides a balance of carbohydrates, protein and fats, when compared to most high protein legumes which are used to balance protein deficiencies in sorghum (*Sorghum bicolour* [L.] Moench) and maize (*Zea mays* L.) based diets (Massawe et al., 2005). It is rich in iron, and the protein contains high lysine and methionine levels.

1.3 Bambara Groundnut Production in Nigeria

World annual production of bambara groundnut was about 330,000 tons (PROTA, 2006) with 45-50 % from West Africa. Nigeria is regarded as the largest producer of bambara groundnut in Africa at about 0.1 million tonnes (Hillocks et al., 2012). The crop has the potential of yielding >3000 kg ha^{-1} in both greenhouse and field trials (Hillocks et al., 2012). In spite of the useful characteristics in bambara groundnut, farmers in sub-Saharan Africa obtain low yields and this requires research attention to develop improved varieties and crop management practices. In Nigeria, especially in the East, bambara groundnut is an important food crop and can be used in traditional preparation of various recipes. The seeds are roasted, pulverized, and used in preparing soup (Adu-Dapaah and Sangwan, 2004) or roasted and chewed with palm kernel. The fresh immature green seed is produced and consumed raw as a vegetable or cooked, while dry seeds can be processed to flour to prepare diverse forms of bambara groundnut such as Okpa and cake (Okpuzor et al., 2010). In African countries such as Nigeria and Ghana, the seeds are pound and made into flour. The flour is usually added to maize to enrich traditional preparations (Akpalu et al., 2013) and used to make a variety of cakes, or are mixed with cereals and used to prepare several types of porridge (Bamashiye et al., 2011).

1.4 The landraces of bambara groundnut dominant in Nigeria are;

- KN211-2 (Coat colour: Cream)
- KN211-3 (Coat colour: Cream-brown strip)
- KN212-14 (Coat colour: Black/White Strip)
- KN212-15 (Purple/black strip)

1.5 Bambara groundnut intercropping pattern

According to high carbohydrate and relatively high protein content as well as sufficient quantities of fat make the bambara groundnut a complete food (Mahazib et al., 2013). According to research bambara groundnut seeds have been found to be richer than peanuts (groundnuts) in essential amino acids such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine by (Bamashiye et al., 2011). To provides the following nutritional breakdown: carbohydrates: 54.5 protein 17 and fat 5.3. Bambara groundnut is a good source of fibre, calcium, iron and potassium (De Kock, 2013). The red seeds could be useful in areas where iron deficiency is a problem, as they contain almost twice as much iron as the cream seeds (de Koch, 2013). Bambara groundnut is important for households because the beans are important source of food security, being nutritious and high in protein. Although, in common with other legumes, bambara is deficient in sulphur-containing amino acids some genotypes contain higher amounts of methionine and lysine than is found in other legumes (NRC, 2006; Azam-Ali et al., 2001). The cropping system is semi-permanent and the Bambara groundnut can be cultivated as single crop or as intercrop. Best suited intercrops are sorghum, millet, maize, peanut, yams and cassava. For woodland savannas of Côte d'Ivoire the highest yield is attainable with a plant density of 25 plants per square meter, (Kouassi and Zoro, 2010).

1.6 Unique Characteristics of Bambara Groundnut Production

I. Drought tolerant, it grow in areas of high or low rainfall. It has been reported that this legume can produce yields where annual rainfall is below 500 mm and the optimum is between 900-1000 mm per year (Bamshaiye et al., 2011)

II. Nitrogen fixing legume; (Yakubuet al., 2010) report that in Nigerian soils Bambara groundnut was found to fix 28.4 Kg N/ha in phosphorus poor soils, but increased to 41kg/ha upon application P fertiliser.

III. Photoperiod control of Bambara groundnut is essential for proper growth, as it mostly affects pod set and filling (Kendabie et al., 2012). Considerable differences exist between landraces under long-day photoperiod exposure (Kendabie et al., 2012). Four classes of landraces have been identified:

- Qualitative short-day (e.g. Ankpa 4);
- Quantitative short-day (e.g. TN, Gresik, LunT);
- Quantitative long-day (e.g. IITA-686, DodR); and
- Photoperiod insensitive/day-neutral (e.g. S19-3, Uniswa-Red, Dip C).

2. Constraint to Bambara Groundnut Production

2.1 Agronomic constraint

Most of the varieties are local, and are thus limited in their genetic potential. Both haulm and seed yields are therefore invariably low. Until very recently, there were no recommended sowing dates, optimum plant density values, or fertilizer rates. There is also inadequate information on the type and intensity of mixture with other crop types in the farming systems

practiced by local farmers. Pod-shedding is also a problem with certain varieties, or the crop may fail to set pods, owing either to the wrong timing of agronomic practices, or to crop injury during weed removal.

2.2 Diseases of Bambara groundnut

Because bambara groundnut is grown during the rainy season, a period of high temperatures and humidity, it is highly susceptible to fungal diseases, which are common during this period. Attacks of rust and leaf blight, caused by *Puccinia sp*. and *Colletotrichum* sp., respectively, have been reported in the crop when grown on station. Isolated cases of rosette disease also have been reported in bambara groundnut.

2.3 Viruses

Diseases play an important role in the productivity of bambara groundnut. Viruses of bambara groundnut have been reported in Nigeria (Thottappilly and Rossel, 1997) including *Cowpea aphid-borne mosaic virus, Black-eye cowpea mosaic virus*, *Peanut mottle potyvirus*, *Cowpea mottle comovirus*, and *Cowpea mosaic comovirus* (*Cowpea yellow mosaic virus*). Others are *Cowpea mild mottle carlavirus*, *Cucumber mosaic cucumovirus* and *Southern bean mosaic sobemovirus*. The virulence of the aforementioned viruses to bambara groundnut could be that the crop belongs to the same genus (*Vigna*) as cowpea. Some of the principal vectors responsible for the spread of these viruses were aphids, whiteflies and beetles (Thottappilly and Rossel, 1997).

2.4 Fungi

Fusarium wilt has been found to be an important disease of bambara groundnut in Kenya (Cynthia et al., 2017). Furthermore, rust and leaf blight, especially *Puccini* and *Colletotrichum spp*, respectively have been reported to be prevalent in periods of high temperature and humidity in the Nigerian Guinea Savannah (Tanimu and Aliyu, 1997). Bambara groundnut sustains infection to leaf spot (*Cercospora canescens Ellis and Martin*), leaf blotch (*Phomopsis sp.*), powdery mildew (*Erysiphe sp.*) and *Sclerotium rolfsii Sacc*. (Gwekwerere, 1997). The presence of *S. rolfsii (Sacc.)* has been reported in South Africa and late blight (*Corticium solani*) by in Ghana by (Swanevelder 1998; Doku, 1997).

2.5 Nematodes

Damage by parasitic nematodes (*Meloidogyne incognita* [Kofoid and White] and *M. Javanica* [Treub.]) on bambara groundnut have been reported by researchers in Africa including Botswana and South Africa (Karikari et al., 1997; Kenya and Ngugi, 1997; Zimbabwe et al., 1997; Swanevelder, 1998).

2.6 Insect pests of Bambara Groundnut

Bambara groundnut is relatively free of the insect pests that plague other legumes, such as the cowpea and peanut. On the whole, pesticides are hardly used by farmers when cultivating bambara groundnut. However, the presence of some viral diseases transmitted by insects suggests simultaneous infestation of the crop by *hemipterans*, such as aphids, mealy bugs and scale insects. Few insect pests that have been reported to attack Bambara groundnut include groundnut leafhoppers (*Hilda patruelis Stal*), the larvae of *Diacrisia maculosa* L. and *Lamprosema* indicate *Fabricius* (Mabika and Mafongoya, 1997). *Piezotrachelus ugandum L.* and *Rivellia spp* were observed to cause damage on developing pods and root nodules, respectively (Swanevelder, 1998). Termites have been found to attack pods in dry weather (Karikari et al., 1997). In West Africa, chrysomelid (*Callosobruchus maculatus F. and C. subinnotatus* Pic.) have been found to be the principal storage insect pests but the latter is more damaging (Maina and Lale, 2004). Additionally, *C. maculatus* causes extensive damage on wide range of stored legume seeds (Maina and Lale, 2004).

2.7 Bambara groundnut storage pest, red flour beetle (*Tribolium castaneum)*

The red and confused flour beetles live in the same environment and compete for resources (Ryan et al., 1970; Willis and Roth , 1950). The red flour beetle may fly, especially before a storm, but the confused flour beetle does not fly. Eggs, larvae, and pupae from both species are very similar. Females show polyandrous mating behavior and researchers explained that polyandry helps in conserving the fertility, thus assuring greater numbers in progeny (Aditi, 2007). Adult females have greater survivability and can live up to three years and they have the capacity of laying 400-500 sticky, clear white eggs. These eggs can hatch within 1-2 weeks. Its larvae are smaller in size (4-5 mm long), cylindrical, with brownish white color leading up to 5-12 instars. The particular larvae can be distinguished from other species as they have two pointed ends bossy segmented. The beetle can produce 4-5 generations in a year under favorable conditions.

2.8 Distribution of Red Flour Beetle

The red flour beetle is of Indo-Australian origin and is found in temperate areas, but will survive the winter in protected places, especially where there is central heat (Tripathi et al., 2001; Smith and Whitman, 1992). The confused flour beetle, originally of African origin, has a different distribution in that it occurs worldwide in cooler climates. The confused flour beetle apparently received this name due to confusion over about its identity as it is so similar to the red flour beetle at first glance (Walter, 1990). These two beetles are in the family Tenebrionidae.

2.9 Storage Method

The pods of bambara groundnut are sun-dried to a moisture content of 12 % and stored in bags or drums in granaries or in the house. Seeds are stored with or without pod. They may be shelled first with mortar and pestle, flails or modified groundnut shellers. The shelling percentage ranges from 70–77 % by pod weight. Bambara groundnut is a typical dual-purpose crop: usually part of the harvest is sold and the rest is kept for own consumption. At the Institute for Agricultural Research in Samaru, seeds are packed with phostoxin tablets in sealed drums, to control *Callosobruchus sp*.

3. Management of Bambara Groundnut Insect Pests

3.1 Biological approaches

Viable organisms regarding biological management methods include bacteria, mycoflora, viral strains, predators and parasitoids which are considered natural and eco-friendly and they already exist in our ecosystem. But so far the Successful organisms only include bacteria naming *Bacillus thuringiensis* Berliner against the red flour beetle (Abdel-Razek 2002). As the stored commodities need acute management and other biological agents may also have some negative impacts upon stored commodities so biological management of red flour beetle remained suppressed.

3.2 Physical and ecological management

It involves the usage of particle films having kaolinite dust against red flour beetle (Arthur, 2002). Activated silica carrying inert dust was traditionally used in developing countries for the management of red flour beetle in storage granaries (Golob, 1997). Similarly, aero gels of silica and diatomaceous earth have inhibitory effects on cuticle lipids of the beetle (Lord, 2001). Another conventional and rational approach that is common at household level involves the solar heating of stored commodities in tropical, arid and semi-arid areas in South East Asia, which disinfects the grains as well as kills the red flour beetle eggs and larvae (Chauhan , 2002).

3.3 Botanical insecticides

Recently, scientists reported the potential of a large number of botanically derived materials against red flour beetle (Padin 2013; Bilal 2015; Joel 2015; Nattudurai 2015; Saeed, 2016). The use of plant materials as traditional protectants of stored products is an old practice used all over the world (Talukder, 2009). The protection of stored products generally involves mixing grains with plant based protectants (Tapondjou, 2001). The plants studied during the last 20 years have inferred that neem (*Azadirachta indica*) extracts and its compounds have proved best for the control of insect pests and pathogens as well (Schmuttere, 1990). Neem provides better control of the larvae at their different developmental stages, particularly soon after emergence from eggs, while the mid stage instars and late instars are not affected much (Xie, 1995). Neem has no adverse effect on the predators, including lady beetles, lacewings, spiders and

predatory bugs (Ma, 2000).

The insecticidal activities of neem against different insect pests have also been evaluated (Sharma, 1999). To found the leaf extract of neem as the most effective repellent, against *T. castaneum* on groundnut seeds (Sahayaraj and Paulraj, 2000). From made safety assessments for various neem derived preparations and compared the outcomes with the ingestion of residues on the food, treated with neem preparations (Boeke et al., 2004).

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