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MINI REVIEW

SOIL PESTS OF GROUNDNUT IN SUB-SAHARAN AFRICA—A REVIEW

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Abstract—Termites (Isoptera: Termidae), white grubs (Coleoptera: Scarabaeidae) and millipedes (Myriapoda: Odontopygidae) are the major groups of soil pests that are widespread and of economic importance in groundnut production in sub-Saharan Africa. Other Coleopteran pests such as wireworms (Elateridae) and false wireworms (Tenebrionidae) are found to be of occasional importance. Farmers' cultural practices such as improper application of organic manure, leaving crop residues in farms, delay in planting and harvesting, and abiotic factors such as rainfall and soil texture also influence soil pest occurrence and damage. Groundnut farmers in most parts of sub-Saharan Africa seldom apply effective control measures against soil pests. This paper reviews the major soil pests of groundnuts and their damage, and discusses adopted control practices and their applicability in integrated pest management (IPM) modules, with an emphasis on the use of resistant groundnut varieties, cultural practices, botanicals and minimal application of synthetic insecticides.

Key Words: Arachis hypogaea, groundnut, cultural practices, termites, white grubs, millipedes, integrated pest management

Résumé—Les termites (Isoptère: Termitidae), les vers blancs (Coléoptère: Scarabaeidae) et les millipedes (Myriapode: Odontopygidae) sont les groupes majeurs des nuisibles du sol les plus répandus et économiquement importants en Afrique sous-sahara. Les autres Coléoptères identifiés, tels que les vulgaires de Taupins (Elateridae) et les Tenebrionidae sont occasionnellement importants. Les pratiques culturelles des cultivateurs tels que l'application incorrecte de fumure organique, l'abandonment de résidus des cultures aux champs, retardement du semis et de la récolte, ainsi que des facteurs environnementaux come la pluviométrie et texture du sol enfluencaient la presence et l'endommagement causés par les nuisibles du sol. La plupart des cultivateurs arachidiers en Afrique sous-sahara applique rarement les mesures de lutte contre les nuisibles du sol. Ce rapport explique les methodes de lutte adoptées contre les nuisibles du sol et propose leur incorporation dans la lutte intégrée avec un appui sur l'utilisation de la résistance variétale, les pratiques culturelles, les produits botaniques et l'application minimale des produits chimiques.

Mots Clés: Arachis hypogaea, nuisibles du sol, pratiques culturelles, termites, vers blancs, millipedes, lutte intégrée

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Introduction

Groundnut (*Arachis hypogaea* L.) is a leguminous plant grown worldwide, predominantly in developing countries. According to FAO (1996) about 90% of the total world production comes from developing countries and approximately 67% from the semi-arid tropics (SAT). Africa alone produces 5.2 million tonnes, representing 20% of the global production (Debrah and Waliyar, 1998), with production concentrated in the SAT countries. Production in West Africa as a whole showed a decline from 1966 to 1985. This was, however, followed by a period of growth between 1985 to 1995 due to cultivation of the crop on more acreage of available land (Debrah and Waliyar, 1998).

Groundnut constitutes a major source of foreign exchange as an export commodity as well as generating local income for farmers. Rich in protein and oils, it is used in the manufacture of cooking oil as well as in making a paste for the preparation of groundnut sauce in many African communities. It is also eaten boiled, fried or roasted, and its by-products can be used as animal feed.

Groundnut is grown singly or intercropped with other legumes and cereals. In West Africa, for example, it is intercropped with sorghum, millet, maize and cowpea, sometimes in complex combinations and arrangements which may involve more than two crops, depending on the location and individual needs. Productivity in farmers' fields varies between 0.5–1 tonne per hectare of kernels.

Production decline of groundnut in Africa is attributed to factors such as drought, pests, diseases (Yayock et al., 1976; Lynch et al., 1986), temperature variability (Yayock, 1978) and inappropriate cultural practices. In addition, unstable government agricultural policies, for instance the dissolution of the Produce Board, created by the government to facilitate the procurement of farm inputs and the marketing of groundnuts in Nigeria, have also contributed toward the fall in groundnut production. The potential for increasing groundnut production exists in the vast arable areas of Africa. However, biotic constraints such as insect pests and diseases discourage farmers from taking up groundnut cultivation. Furthermore, the financial implications associated with the acquisition and development of more cultivable lands preclude the participation of resource-poor farmers (which constitute the greater part of agricultural producers) in Africa in large-scale, more profitable agriculture. There is a need, therefore, to maximise the yield in smallholder farmers' fields by controlling pests and diseases and providing an environment for increased productivity.

Many insect pests are known to be associated with groundnut damage in the SAT region of Africa. Apart from the aphid *Aphis craccivora* Koch, a vector of the devastating groundnut rosette virus, other important species are soil pests, (Appert, 1966; Feakin, 1973; Johnson et al., 1981). Soil pests have been found to be a major cause of groundnut yield losses in the SAT countries of Africa (Wightman et al., 1990). Important taxa associated with groundnut damage in Africa include termites (Isoptera), millipedes (Diplopoda), scarabaeid larvae (Coleoptera) usually referred to as whitegrubs, elaterid larvae (Coleoptera) commonly known as wireworms, and tenebrionid larvae (Coleoptera), known as false wireworms. The latter two groups are only of occasional economic importance.

This review article seeks to provide an up-to-date account of the major findings of groundnut research conducted in sub-Saharan Africa with the aim of directing the focus of future research in the integrated management of groundnut soil pests.

Soil Pest Fauna Associated with Groundnut

Termite species that damage groundnut belong to the most advanced group—the sub-family Macrotermitinae—which has evolved a wide range of social specialisation that allows the species to adapt to different agricultural ecosystems and makes control difficult. Among these species the genera, *Microtermes* and *Odontotermes* are the most damaging, while *Macrotermes* spp. cause occasional damage (Table 1).

Many species of white grubs are associated with groundnut damage in parts of sub-Saharan Africa (Table 2). While some species are wide-spread in the continent, others are localised and sporadic. The predominance of *Schyzonycha* species in West and southern African groundnut

Table 1. Distribution of termite species (family Termitidae) associated with groundnut in sub-Saharan Africa

Species	Location	Reference
Microtermes lepidus Sjöstedt.	Sudan, Nigeria Mali, Niger, Burkina Faso	Hebblethwaite and Logan, 1985 Johnson et al., 1981; Umeh et al., 1999
M. parvulus Sjöstedt.	Burkina-Faso Senegal	Umeh et al., 1999 Appert, 1966
Microtermes sp.	The Gambia Niger Nigeria Botswana, Malawi, Zambia, Zimbabwe	Feakin, 1973 Umeh et al., 1999 Johnson et al., 1981 Wightman and Wightman, 1994
Odontotermes badius Sjöstedt.	South Africa	Feakin, 1973
O. amanicus Sjöstedt.	Malawi	Feakin, 1973; Wightman and Wightman, 1994
O. bomaenis Sjöstedt.	Zambia	Wightman and Wightman, 1994
O. rectanguloides Sjöstedt.	Zimbabwe	Wightman and Wightman, 1994
O. smeathmani Sjöstedt.	Nigeria	Johnson et al., 1981
O. transvaalensis Sjöstedt.	Botswana, Malawi, Zimbabwe	Wightman and Wightman, 1994
Odontotermes sp.	Tanzania	Feakin, 1973
O. vulgaris	Senegal	Appert, 1966
Pseudocanthotermes militaris Hagen	Mali Malawi, Zambia	Umeh et al., 1999 Wightman and Wightman, 1994
Pericapritermes sp.	Mali	Umeh et al., 1999
Macrotermes bellicosus Smeathman	Sudan	Feakin, 1973
Macrotermes subhyalinus Rambur	Nigeria	Perry, 1967
Macrocerotermes sp.	Mali Malawi	Umeh et al., 1999 Wightman and Wightman, 1994
Amitermes evuncifer Silvestri	The Gambia Nigeria	Feakin, 1973 Sands, 1962
Ancistrotermes latinotus Holgren	Malawi, Zambia, Zimbabwe	Wightman and Wightman, 1994
Ancistrotermes crucifer Sjöstedt.	The Gambia	Feakin, 1973
Allodontotermes tenax Silvestri	Zambia, Zimbabwe	Wightman and Wightman, 1994

fields showed the importance of the genus as a pest of groundnut (Johnson et al., 1981; Van Eeden et al., 1991; Wightman and Wightman, 1994; Umeh et al., 1999). *Zophosis* sp. (Tenebrionidae) adults were frequently recorded in groundnut fields in West and southern Africa (Wightman and Wightman, 1994; Umeh, 1999). During a survey of the semi-arid zones of some West African countries including Mali, Niger and Nigeria, two or more of *Zophosis* sp. adults were often recovered from wilting plants during groundnut maturity (October–November), although their incidence was very low.

In West Africa most of the economically important millipede species of groundnut belong to the family Odontopygidae. Frequently encountered species include *Peridontopyge* spp. (Umeh et al., 1999). Demange (1975) listed some species of the family Odontopygidae which are considered to be harmful to groundnut in Senegal, viz. *Peridontopyge anoni* Brölemann, *P. pervillata* Silvestri, *P. rubescens* Atterns, *P. spinosissima* Silvestri, *P. trauni* Silvestri, *Synedesmogenus mimeuri* Brölemann, and *Haplothysanus chapellei* Demange. Millipede damage was also reported from Malawi, the Luangwa valley of Zambia (Wightman and Wightman, 1994) and Ghana (Asafo-Adjei et al., 1998) but the species were not named. Groundnut seedling damage has also been reported in Central African Republic (Pierrard, 1972; Pierrard and Biernaux, 1974) and Burkina Faso (Mauries, 1968).

Table 2. Distribution of coleopteran pests of groundnut in sub-Saharan Africa

Species	Location	Reference
Scarabaeidae		
Adoretus cribosus Harris	South Africa	Van Eeden et al., 1991
Adoretus spp.	Malawi, Zambia, Zimbabwe	Wightman and Wightman, 1994
Anomala transvaalensis Arrow	South Africa	Van Eeden et al., 1991
Anomala spp.	Botswana, Malawi, Zambia, Zimbabwe	Wightman and Wightman, 1994
Eulepida mashona Arrow	Malawi	Mercer, 1978
Heteronychus sp.	Niger	Umeh et al., 1999
Schyzonycha africana Cast	Nigeria	Johnson et al., 1981
	Mali, Niger	Umeh et al., 1999
S. fusca Kolbe	Malawi	Wightman and Wightman, 1994
S. straminea Peringuey	Malawi	Wightman and Wightman, 1994
Schyzonycha spp.	Malawi, Zimbabwe	Wightman and Wightman, 1994
Trochalus sp.	Burkina-Faso	Umeh et al., 1999
	Malawi	Wightman and Wightman, 1994
Elateridae		
Cardiophorus sp.	Mali	Umeh et al., 1999
	Malawi	Wightman and Wightman, 1994
Dyakus sp.	Malawi	Wightman and Wightman, 1994
Heteroderus flavostriatus Boheman	Malawi	Van Eeden et al., 1991
Tenebrionidae		
Anchophthalmus plicipennis Peringuey (adult)	Malawi	Wightman and Wightman, 1994
Drosochrus sp.	Malawi	Wightman and Wightman, 1994
Gonocephalum simplex F.	Malawi	Wightman and Wightman, 1994
Somaticus spp.	South Africa	Van Eeden et al., 1991
Zophosis sp. (adult)	Mali, Niger, Nigeria	Umeh et al., 1999
	Malawi	Wightman and Wightman, 1994

Nature of Damage

Seedling stage

Termites attack the crop at all stages of development. However, infestation during the early stages of the crop is less severe except during prolonged dry spells (Umeh, unpublished data). They damage plants by constructing foraging galleries in them. The root may be destroyed below the crown leading to sudden wilt whereby the leaves usually remain green while the whole plant gradually dries up (Mercer, 1978).

White grubs attack plants at all stages of growth. The presence of white grubs on seedlings is indicated by stunting or wilting. Plants are often infested in a row. Wightman and Wightman (1994) reported infestations of twenty grubs per hundred plants to more than one grub per plant in central Malawi and northern Zambia. White grubs feed mainly on the tap roots and/or peripheral roots, and thus reduce water absorption capacity, leading to stunting or death. Depressions cut by white grubs in the crown region of tap roots are often invaded by rot-causing fungi such as *Aspergillus niger, Sclerotium rolfsii, Fusarium* spp., and *Rhizoctonia solani* (Perry, 1967; FW, pers. observ.).

Between planting and approximately 20 days after planting, immature and adult millipedes attack groundnut seedlings, feeding on the emerging cotyledons and moving to the root system at the collar region. The cortex is often damaged while the vascular tissue is unaffected. The development of plants surviving the attack is often retarded. In Bengou (Niger), *Peridontopyge* spp. preferentially attack the young seedlings (of ≤15 days) rather than older ones of 30 days and above (Umeh et al., 1999). About 9.3% of the plants were attacked and damaged plants were often predisposed to fungal infections. Similar observations were made in Mali, Burkina Faso and Nigeria. Rossion (1974) found that the severity of millipede attack was inversely proportional to the rate of growth of the attacked groundnut plants; estimated stand losses ranged between 3 and 5% due to direct attack and from 5–10% as a result of secondary infection by microorganisms.

Vegetative and maturity stages

As groundnut matures, termite damage becomes more pronounced and appears in various forms. Most often, termites invade the root system and hollow out the tap root around 45 days after planting. The tunnels so created are filled with soil (Johnson et al., 1981). This type of damage is typical of the small-sized *Microtermes* spp. which are the most abundant and widely distributed termite pests of groundnut. In West Africa, termite damage showing standing plants covered by soil sheet, is usually caused by *Odontotermes* spp. (Johnson et al., 1981; Umeh, 1998) and by *Ancistrotermes* in southern Africa (Wightman and Wightman, 1994). *Macrotermes* spp. damage plants by cutting the base of the stem. Attacked plants disappear rapidly due to removal of plant tissues by termites and the high rate of decay under tropical climatic conditions. Umeh (1998) observed that groundnut damage by *Macrotermes* was not widespread in West Africa.

Damage to mature pods is common and widespread in many parts of Africa. Termites, coleopteran larvae and millipedes penetrate pods and feed on kernels. Pod penetration by termites is frequently caused by *Microtermes* and to a lesser extent by *Odontotermes*. The empty spaces created after the consumption of kernels are filled with soil. Termites can also increase the number of gleanings by cutting through the pegs (Johnson et al., 1981). Scarification of pods is by far the most common type of termite damage at plant maturity, a factor often aggravated by late harvest. This involves the removal of the soft corky layer between the fibrous veins, caused mostly by *Microtermes* spp. in western Africa (Johnson et al., 1981; Umeh, 1998) and by *Ancistrotermes* and *Odontotermes* spp. in southern Africa (Wightman and Wightman, 1994). Scarification does not affect groundnut directly but promotes the rate of colonisation by fungi such as *Aspergillus flavus* (Umeh et al., 1998) which produces the carcinogen aflatoxin in groundnut (Porter et al., 1972; Johnson and Gumel, 1981; Waliyar et al., 1994; Wightman and Wightman, 1994).

In West Africa, damage to roots is more prevalent than pod damage at sites where white grubs are present. Feeder roots are severed in younger plants and cuts are inflicted at the crown region of the root. The weakened plants die due to lack of water absorption capacity, or remain stunted. In addition, whitegrubs also cut out pods from the base of groundnut pegs and destroy larger, soft pods.

Millipedes attack maturing groundnut during pod formation, i.e. when the pods are still soft (IRHO, 1982). Surface damage of flowers by foragers may also occur. This was widespread in Senegal where millipedes were considered to be one of the most important pests of groundnut (Gillon and Gillon, 1976). Immature pods from severed pegs are often perforated and thus suffer secondary infection or invasion by rot-causing organisms such as *Aspergillus flavus* (Rossion, 1976).

Factors Influencing Soil Pest Occurrence and Damage

Rainfall

Johnson et al. (1981) showed that there was a significant negative relationship between the percentage of tap roots invaded by *Microtermes* sp. and annual rainfall. Similarly, during the latter part of the cropping season when the soil moisture is reduced, V.C. Umeh, S. Traoré and F. Waliyar (unpublished data) observed that localities in West Africa with less than 800 mm annual rainfall had greater termite infestation and damage than those with high rainfall.

Conversely, whitegrub and millipede damage to groundnut tends to be more severe in Sahelian zones with relatively higher annual rainfall. Umeh (1997a) observed higher stand losses of 13% and 9% due to *Peridontopyge* spp. in the Sahelian zones of Mali and Nigeria respectively (with 1100 mm annual rainfall) compared to areas with lower annual rainfall.

Soil texture

Groundnut is best cultivated in well-drained soils, usually of sandy and sandy loam texture. However, these soils are known to favour easier penetration and attack by some soil pests such as white grubs. Unlike *Microtermes* spp. which are observed in all soil types, white grubs seem to prefer soils with sandy or loamy sand textures and are seldom observed in clayey soils (Umeh et al., 1999; Wightman and Wightman, 1994), whose compact nature may not allow easy penetration (Umeh et al., 1999). Gallery formation by *Microtermes* is not favoured in loose soils of a sandy nature due to lack of sufficient clay for gallery construction. Under such conditions, *Microtermes* is often confined to the root region (Greaves and Florence, 1966).

Crop residues and organic manure

In most parts of sub-Saharan Africa where groundnut is cultivated either as a sole crop or an intercrop, cereals such as sorghum, millet and maize form part of the agrosystem. In monocropped groundnut, the preceding crop is either one or more of the above cereals. Very often residues of cereal are left behind by farmers after the cropping season when they constitute food materials for the smaller and larger Macrotermitinae such as *Microtermes* and *Odontotermes* respectively (Umeh and Ivbijaro, 1997). Although these termite genera have distinct nests where collected food is conserved in the form of fungus gardens, they continue to feed on crop residues until the next crop of groundnut. Umeh (1998) observed *Microtermes* infestation in 68% of surveyed farms in parts of West Africa where the presence of crop residues was rated as 'high', and termite infestation in 100% of those rated as having 'very high' residues.

The excessive use of organic manure in groundnut farms has been observed to increase the incidence of white grubs, especially when manure is applied during the cropping season. However, farmers interviewed during a survey claimed that lower infestation was observed when the manure was applied to the preceding crop, i.e. a year before the target crop (Umeh, 1997). Wightman and Wightman (1994) also reported that high levels of organic matter supported greater infestation of white grubs on groundnut. Non-decomposed organic matter such as ploughed weeds, green manure and crop residues were also associated with termite attack on cotton in Malawi and Sudan (ARCM, 1971; Matthews, 1989; Ripper and George, 1965). It is therefore recommended that enough time be allowed between manure application and the introduction of groundnut, in order to minimise white grub damage.

Delay in planting and harvest

Planting should be carried out early enough to avoid drought periods. Moisture deficiency may stress a crop and lead to attack by termites due to low vigour (Harris, 1971). Research has shown that pod damage by termites increases with delay in harvest (McDonald and Harkness, 1968). In West Africa, some farmers harvest their groundnut crop after harvesting other crops, thus allowing continued termite damage on pods. Furthermore, most groundnut-producing areas in sub-Saharan Africa experience drought and high temperatures during the later part of the growing season, conditions that favour termite infestation as well as *A. flavus* infection of pods leading to aflatoxin formation in seeds (Johnson and Gumel, 1981; Sanders et al., 1981; Hill et al., 1983; Blankenship et al., 1984; Cole et al., 1985). Timely harvesting will minimise pod damage by soil pests, probable colonisation by *A. flavus* and aflatoxin contamination.

Control Measures

Cultural practices

Deep ploughing or hand hoe tillage exposes soil pests to desiccation and to predators, thus reducing their numbers. Pre-planting tillage also destroys the tunnels caused by termites and minimises their foraging activities and associated damage to groundnut. However, some soil pests burrow deep into the soil during adverse conditions and are therefore not affected by cultivation.

The complete destruction of mounds and removal of queen termites are effective control measures against mound-building species belonging to the sub-family Macrotermitinae such as *Macrotermes* spp. Partial destruction of mounds is unlikely to solve the problem if nymphs and alates are present during the time of dequeening because replacement reproductives may develop (Darlington, 1985; Sieber, 1985).

Mercer (1978) reported that close spacing in groundnut helps to deter termite infestation, although the reason for this was not stated. However, high density sowing, followed by thinning of surviving plants where necessary to reduce competition, offsets anticipated losses due to termites (Harris, 1971; Wardell, 1987; Wood and Cowie, 1988).

Crop rotation may be useful in reducing the buildup of soil pests. However, this can only be practised where enough land area is available. A setback is that winged adults of some insect species such as termite alates are capable of moving in from other sites (Hillock et al., 1996) if preferred hosts are planted in the field used for rotation.

Hand collection has been found to be effective in the control of some soil pests. In India adult whitegrubs such as *Holotrichia* spp. are dislodged from trees and killed by hand. When undertaken on a regional basis, this practice led to significant reduction in white grub damage (Veeresh, 1983). It has not been attempted for soil pest control in sub-Saharan Africa. To be acceptable to farmers in many parts of Africa, agricultural extension agents may need to convince the farmers that some of the beetles in their fields are actually adults of the whitegrubs which they see causing damage to their farms.

Chemical control

Seeds are treated before planting with a broad spectrum pesticide to deter soil pest attack. Many chemical pesticides are known to be effective against soil pests (Rao et al., 1978; May, 1986; Logan et al., 1992). However, certain factors are to be considered before their application. Among these is the persistence of the pesticide to cover the crop cycle (usually 90–130 days). The number of applications of lower-persistence pesticides required to maintain control vis-à-vis the cost of control that permits economic returns could be a cause for concern. The number and timing of applications should depend on the intensity of the target pests, and the crop residues that harbour them in the farms. Rossion (1976) suggested that pesticides meant for millipedes should be applied at a period when they are usually abundant on the soil surface so as to achieve effective control. Survival of soil pests is also affected by the soil type and the pesticide used. Forschler and Townsend (1996) showed that the estimated lethal concentrations for some termiticides were at least 7 times lower in sandy soils compared with sandy loam or sandy clay soils. Therefore, the soil type should be taken into account during insecticide treatment to ensure effective control.

The control of soil pests such as termites has been achieved in the past by the use of organochlorine insecticides, particularly the cyclodienes (Feakin, 1973; Cowie et al., 1989; Rao et al., 1978). However, the health and environmental hazards associated with this group of insecticides led to their ban not only in the developed countries but also in some developing countries. Other groups of efficacious insecticides such as organophosphates, carbamates and pyrethroids have been used against soil pests but their low persistence in soils always calls for repeated applications. Recently, controlled-release formulations of some non-persistent insecticides were tried and found to be effective and long lasting against soil pests, particularly termites (May, 1986; Logan et al., 1992). However these formulations are not cost-effective for the majority of low-income farmers in Africa. Research should therefore focus on the development of cheap, effective and long-lasting pesticides alternatives.

Some carbamate and organophosphate insecticides are known to be effective against whitegrubs (Bakhetia and Brar, 1983; Siva Rao et al., 1984). It is believed that these insecticides could provide adequate control of whitegrubs before losing their potency since whitegrubs have only one generation per year (Wightman and Wightman, 1990).

Botanicals

Many plant extracts are known to be either toxic or repellent to pests of agriculture. However, no concrete recommendations leading to their large-scale utilisation is yet in sight as compared with synthetic pesticides. Many laboratory bioassays have demonstrated the efficacy of these plant extracts on termites (Carter and Mauldin, 1981; Lin and Wang, 1988). Extracts such as those of the neem tree have been found to be efficacious against termites on cassava–maize intercrops (Umeh and Ivbijaro, 1998). However, the application of plant extracts for the control of soil pests of field groundnut is yet to be explored. Since they are effective against soil pests and less hazardous, there is a need to harness the insecticidal activity in these promising natural pesticides that abound in sub-Saharan Africa for the control of soil pests of groundnut. Since they are easily biodegradable (non-persistent) and environmentally benign, long-lasting control can be achieved by increasing the number of applications.

Natural enemies

The role of natural enemies in the population dynamics and the reduction of damage by soil pests in groundnuts is still obscure. Although it is known that many invertebrates and vertebrates feed on some soil pests, no serious attempts have been made to harness these for pest control purposes. Noteworthy, however, are various species of ants which exercise considerable pressure on termite populations (Mathur, 1962; Malaka, 1973; Ella and Malaka, 1977). However it should be borne in mind that some natural enemy species may also be deleterious to groundnut production; for example, doryline ants which were found attacking termites in maize trials (VCU, unpublished data), were also associated with damage to groundnut pods in parts of southern Africa (Wightman and Wightman, 1994).

Varietal resistance

Over the years, some groundnut varieties have been selected and tested for resistance to soil pests at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India and some African countries. Among tested resistant varieties, NCAc numbers 2240T, 2242, 2243 and 343 (ICG 2271) possess a degree of resistance to pod scarification (Amin and Mohammad, 1982; Amin et al., 1985). Lynch (1990) also found a high degree of resistance in some of these varieties in Burkina Faso, and considerable increase in yield, especially with NCAc 343, compared to locally cultivated groundnut varieties. This variety was also reported as having resistance to several pod borers (Amin, 1987). Resistance of groundnuts to soil pests is a promising means of reducing yield losses. In order to recommend such varieties for a particular sub-region, it is necessary to test them in the sub-region so as to ascertain the stability of their resistance and adaptability for better productivity. Research in this direction should also include the search for multiple resistance to pests and diseases, which calls for a multidisciplinary approach.

Conclusion

The studies conducted so far on soil pest damage indicate the need for an integrated approach which should emphasise the use of cultural control, plant-derived insecticides and resistant varieties to bring damage to below economic threshold levels in farmers' fields. The desired improved production system should be such that it is compatible with the agronomic, cultural, political and socioeconomic frameworks of the sub-Saharan African countries. It must also be affordable to the smallholder farmers. In this vein, groundnut researchers in Africa need to put together integrated pest management technologies that cannot only minimise yield losses caused by pests and diseases but that are also easily adoptable by farmers.

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