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THE ROLE OF GREEN PESTICIDES FOR SUSTAINABLE GREEN ECONOMY

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Abstract. Food security and poverty alleviation has remained the primary agenda in the East Africa regional food policies. Prevention of food losses during post-harvest storage is of paramount economic importance. The use of synthetic chemical insecticides is either not permitted or used restrictively because of the residue problem and health risks to consumers. In view of the above, there is a need for plants that may provide potential alternatives to currently used insect control agents as they constitute a rich source of bioactive molecules such as limonoids, alkaloids, phenol and others. Available literature indicates that plants could be source for new insecticides. Therefore, there is a great potential for a plant derived insecticidal compounds. This review paper mainly focuses on green pesticide which is safe, eco-friendly, relatively less expensive, locally available and ensures sustainable food security in sub-Saharan Africa countries. Therefore, in order to increase food safety and develop integrated and sustainable strategies for plant protection, which are safe to the consumer, producer and the environment, the use of green pesticides need to be promoted.

Keywords: food security, green pesticides, synthetic chemicals, harvest

Introduction

The concept of "green pesticides" refers to all types of nature-oriented and beneficial pest control materials that can contribute to reduce the pest population and increase food production. Food grain losses due to insect infestation during storage are a serious problem, particularly in the developing countries (Talukder et al., 2004; Dubey et al., 2008). Losses caused by insects include not only the direct consumption of kernels, but also accumulation of exuviate, webbing and cadavers. High levels of the insect detritus may result in grain that is unfit for human consumption and loss of the food commodities, both, in terms of quality and quantity. Insect invasion induced changes in the storage environment may cause warm moist 'hotspots' that provide suitable conditions for storage fungi that cause further losses. The attainment of food security in sub-Saharan Africa and Asia can only be realized from increase in productivity through the use of sustainable good agricultural practices and prevention of losses caused by pests in the field and along the value chain. It is estimated that between 60-80% of all grain produced in the tropics is stored at the farm level (Golob et al., 1999). Grains (cereals, legumes, oilseeds) contribute the bulk of the world's calories and protein (Obeng-Ofori, 2010).The reduction of postharvest grain losses, especially those caused by insects, microorganisms, rodents, and birds, can increase available food supplies, particularly in less developed countries where the losses may be largest and the need is greatest. Post-harvest losses are recognized as being one of the critical constraints upon food security among resource poor farmers across Africa (Owusu et al., 2007). The use of synthetic insecticides for grain protection in traditional farm stores in Africa has been partially successful (Ogendo et al., 2004). However, the subsistence nature of agriculture, the poor dissemination of information, and the high cost and inconsistent supply of synthetic pesticides have emerged as reasons for farmers' reluctance to adopting synthetic pesticides (Tembo & Murfitt, 1995; Ogendo et al., 2004). Moreover, the use of synthetic chemicals has also been restricted because of their carcinogenicity, teratogenicity, high and acute residual toxicity, ability to create hormonal imbalance, supermatotoxicity, long degradation period and food residues (Feng & Zheng, 2007; Pretty, 2009; Dubey et al., 2011; Khater, 2011). Repetitive use has resulted in pesticide residue hazards, upsetting the balance of nature through disruption of the natural enemies, pollinators and other wild life, extensive ground water contamination, evolution of resistance and revival of treated populations, outbreaks of secondary pests. i.e., those normally kept under control by their natural enemies (Khater, 2011). These problems, and the possibility of misuse of pesticides, and the accompanying undesired effects, demand a dynamic search for alternative pest control practices. Traditionally, farmers have used various forms of cultural practices and herbal products for the control of post-harvest insect pests, and local communities still continue to use an array of insecticidal plants for the control of specific pests (Feng & Zheng, 2007).

Green pesticides are safe, eco-friendly and are more compatible with the environmental components than synthetic pesticides (Isman & Machial, 2006). Thus in the present concept of green pesticides, some rational attempts have been made to include substances such as plant extracts, hormones, pheromones and toxins from organic origin and also encompass many aspects of pest control such as microbial, entomophagous nematodes, plant derived pesticides, secondary metabolites from microorganisms, pheromones and genes used to transform crops to express resistance to pests. More recently, the encouragement of use of products from natural resources and even the extremely biodegradable synthetic and semi synthetic products in pest management has been considered to constitute the umbrella of green pesticides (Koul et al., 2003; Koul, 2005; Dhaliwal & Koul, 2007). However, it will be beyond the scope of any article to discuss all of them at one place. In this review article, I would like to give emphasis on bio pesticides as green pesticides.

Bio-pesticides is a term that includes many aspects of pest control such as microbial (viral, bacterial and fungal) organisms, entomophagous nematodes, plant-derived pesticides (botanicals), secondary metabolites from micro-organisms (antibiotics), insect pheromones applied for mating disruption, monitoring or lure and kill strategies and genes used to transform crops to express resistance to insect, fungal and viral attacks or to render them tolerant of herbicide application (Copping & Menn, 2000). In other words, bio-pesticides are an important group of naturally occurring, often slow-acting crop protectants that are usually safer to humans and the environment than conventional pesticides, and with minimal residual effects. Botanicals include crude extracts and isolated or purified compounds from various plants species and commercial products. Not unlike pyrethrum, rotenone and neem, plant essential oils or the plants from which they are obtained have been used for centuries to protect stored commodities or to repel pests from human habitations and use as fragrances, condiments or spices, as well as medicinal uses (Isman & Machial, 2006). Quantitatively, the most important botanical is pyrethrum, followed by neem, rotenone and essential oils, typical used as insecticides (pyrethrum, rotenone, rape seed oil, quassia extract, neem oil, nicotine), repellents (citronella), fungicides (laminarine, fennel oil, lecithine), herbicides (pine oil), developing inhibitors (caravay seed oil) and adjuvants such as stickers and spreaders (pine oil) (Isman, 2006).

Botanical insecticides

The increasing serious problems of resistance and residue to pesticides and contamination of the biosphere associated with large-scale use of broad spectrum synthetic pesticides have led to the need for effective biodegradable pesticides with greater selectivity. This awareness has created a worldwide interest in the development of alternative strategies, including the discovery of newer insecticides (Heyde et al., 1984; Dayan et al., 2009). However, newer insecticides will have to meet entirely different standards. They must be pest specific, non-phytotoxic, non-toxic to mammals, eco-friendly, less prone to pesticide resistance, relatively less expensive and locally available (Hermawan et al., 1997). This has led to re-examination of the century-old practices of protecting stored products using plant-derivatives, which have been known to resist insect attack (Lale, 1992; Ewete et al., 1996; Sahayaraj, 2008). Plant-derived materials are more readily biodegradable, less likely to contaminate the environment and may be less toxic to mammals. There are many examples of very toxic plant compounds. Therefore, today, researchers are seeking new classes of naturally occurring insecticides that might be compatible with newer pest control approaches (Talukder & Howse, 1995; Yao et al., 2008).

Classification of botanical insecticides

On the basis of physiological activities on insects (Jacobson, 1982) conventionally classified the plant components in to six groups, namely repellents, feeding deterrents/ anti-feedants, toxicants, growth retardants, chemisterilants and attractants. Focus on the toxicants and grain protectants an activity of essential oil, extracts and its constituents has sharpened since the 1980s.

Repellents

The repellents are desirable chemicals as they offer protection with minimal impacton the ecosystem, as they drive away the insect-pest from the treated materials by stimulating olfactory or other receptors. Repellents from plant origins are considered safe in pest control; minimize pesticide residue; ensure safety of the people, food and environment (Maia & Moore, 2011).The plant extracts, powders and essential oil from the different bioactive plants were reported as repellent against stored grain insect pests (Xie et al., 1995; Owusu, 2001; Boeke et al., 2004; Koul et al., 2008). For example, the essential oil of *Artemisia annua* was found as repellent against *Triboliumcastaneum* and *Callosobruchusmaculates* (Tripathi et al., 2004).

Antifeedant-feeding deterrents

Anti-feedants, sometimes referred to as "feeding deterrents" are defined as chemicals that inhibit feeding or disrupt insect feeding by rendering the treated materials unattractive or unpalatable (Saxena et al., 1988; Munakata, 1997). Some naturally occurring anti-feedants, which have been characterized, include glycosides of steroidal alkaloids, aromatic steroids, hydroxylated steroid steroid meliantriol, and triterpene hemizectal etc. (Talukder & Howse, 2000). Essential oil constituents such as thymol, citronellal and terpineol are effective as feeding deterrent against tobacco cutworm, *Spodoptera litura* synergism or additive effects of combination of mono terpenoids from essential oils have been reported against *Spodopteralitura* larvae (Hummelbrunner & Isman, 2001). The screening of several medicinal herbs showed that root bark of *Dictamnus-dasycarpus* possessed significant feeding deterrence against two stored-product insects (Liu et al., 2002).

Toxicants

Research on new toxicants of plant origin has not declined in recent years despite the increased research devoted to the discovery of synthetic insecticides (Talukder & Howse, 1995). Worldwide reports on plant derivate showed that many plant products are toxic to stored product insects (Su & Horvat, 1987; Su, 1991; Weaver et al., 1991; Obeng-Ofori & Reichmuth, 1997; Tripathi et al., 2000; Channoo et al., 2002; Isman, 2006; Ngamo et al., 2007). Talukder (1995) listed the use of forty three plant species expressing toxicant effects of different species of stored-products insects. Pascual & Robledo (1998) carried out screening of plant extracts from 50 different wild plant species of south-eastern Spain for insecticidal activity towards *Triboliumcastaneum* and reported that four species namely, *Anabasis hispanica, Seneciolopezii, Bellardiatrixago and Asphodelusfistulosus* were found by promising. Two major constituents of the essential oil of garlic, *Alliumsativum*, methylallyl disulfide and diallyl trisulfide were to be potent toxicant and fumigantants against *Sitophiluszeamais* and *Triboliumcastaneum* (Huang et al., 2000). Rahman (1990) reported that nicotine, an active component of *Nicotianatabacum,* is a strong organic poison which acts as a contact-stomach poison with insecticidal properties. This compound is, of course, very toxic to humans as well. The essential oil vapors distilled from anise, cumin, eucalyptus, oregano and rosemary were also reported as fumigantants and caused 100% mortality of the eggs of *Triboliumconfusum* and *Ephestiakuehniella* (Tunc et al., 2000). Many species of the genus *Ocimum* oils, extracts and their bioactive compounds have been reported to have insecticidal activities against various insect species (Obeng-Ofori et al., 1998; Keita et al., 2001).

Chemosterilants-reproduction inhibitors

Many researchers reported that plant parts, oil, extracts and powder mixed with grain reduced insect oviposition, egg hatchability, post embryonic development and progeny production (Saxena et al., 1986; Schmidt et al., 1991; Asawalam & Adesiyan, 2001). Lists of forty three plant species have been reported as reproduction inhibitors against stored product insects. Reports have also indicated that plant derivatives including the essential oils caused mortality of insect eggs. Many ground plants parts, extracts, oils and vapor also suppress many insects.

Insect growth and development inhibitors

Plant extracts showed deleterious effect on the growth and development of insects and reduced larval pupal and adult weight significantly, lengthened the larval and pupal periods and reduced pupal recovery and adult eclosion (Khanam et al., 1990). Rajasekaran & Kumaraswami (1985) reported that grains coated with plant extracts completely inhibited the development of insect like *Sitophilusoryzae.* Plant derivatives also reduce the survival rates of larvae and pupae, and adult emergence. Development of eggs and immature stages inside grain kernel were also inhibited by plant derivatives. The crude extract also retarded development and caused mortality of larvae, cuticle melanisation and high mortality in adults (Jamil et al., 1984).

Phytochemical of green pesticides – plant extracts

Plants are capable of synthesizing an overwhelming variety of small organic molecules called secondary metabolites, usually with very complex and unique carbon skeleton structures. By definition, secondary metabolites are not essential for the growth and development of a plant but rather are required for the interaction of plants with their environment (Rice & Coats, 1994; Isman, 2000). The biosynthesis of several secondary metabolites is constitutive, whereas in many plants it can be induced and enhanced by biological stress conditions, such as wounding or infection. They represent a large reservoir of chemical structures with biological activity. It has been estimated that 14 - 28% of higher plant species are used medicinally and that 74% of pharmacologically active plant derived components were discovered after following up on the ethno medicinal uses of the plants. Plants and their secondary metabolites are an important source for biopesticides and the development of new pesticides. Plant extracts and their derivatives are a source of many chemical compounds with potential insecticide and processed forms of botanical insecticides are isolated and purified compounds through extractions and distillation. For instance, nicotine, nicotine (alkaloid) and limonoids are distilled from plant extracts. Limonoids are highly oxygenated, modified terpenoids and have recently attracted attention because compounds belonging to this group have exhibited a range of biological activities like insecticidal, insect anti-feedants and growth regulating activity on insects as well as antibacterial, antifungal, ant-malarial, anticancer, antiviral and a number of other pharmacological activities on humans. Alkaloids are nitrogenous compounds that shown insecticides properties at low concentration and are often toxic to vertebrate (Adesida & Okorie, 1973).

Currently, different botanicals have been formulated for large scale application as biopesticides in eco-friendly management of plant pests and are being used as alternatives to synthetic pesticides in crop protection. These products have low mammalian toxicity and are cost effective. Such products of higher plant origin may be exploited as eco-chemical and bio rational approach in integrated plant protection programs (Khater, 2011). In order to increase food safety and develop integrated and sustainable strategies for plant protection, which are safe to the consumer, producer and the environment, the use of green pesticides need to be promoted.

Conclusion

Information on negative side effects of synthetic pesticides and environmental risks resulting from their indiscriminate application has renewed interest towards bio pesticides as an eco-chemical approach in insect management. In the context of agricultural insect management, bio pesticides are well suited for use in organic food production and may play a great role in the production and protection of food in developing countries. The current trends of modern society towards 'green consumerism' desiring fewer synthetic ingredients in food may favors plant-based products which are 'generally recognized as safe' in eco-friendly management of plant insect as biopesticides.

Bio insecticides are one option in insect management and crop protection. The advantages of bio insecticides lie in their lack of persistence and bioaccumulation in the environment, selectivity towards beneficial insects and low toxicity to humans. Bio pesticides chemicals will play a significant role in the future for insect control in both industrialized and developing countries. Biodiversity-rich countries such as Asia, East Africa and others should quickly bio-prospect their traditionally used plants to document pesticide plants in order to check future cases of bio piracy and establish their sovereign right on the bio pesticides developed from such indigenous plants for sustainable insect management in stored grain.

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