Current Status of Plant Products as Botanical Pesticides in storage pest management

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ABSTRACT

The increasing concern over the level of pesticide residues in food has encouraged researchers to look for alternatives of synthetic pesticides. Their indiscriminate use has led to the development of resistant strains of pests as well as different environmental and human health problems. Recently, in different parts of the world, attention has been paid towards exploitation of higher plant products as novel chemotherapeutants in plant protection. Because of non phytotoxicity, systemicity, easy biodegradability and stimulatory nature of host metabolism, plant products possess the potential in pest management. Used widely until the 1940's, these natural pesticides were displaced by modern synthetic pesticides that at the time seemed cheaper, easier and long lasting. The popularity of botanical pesticides is once again increasing and some plant products are being used globally as green pesticides. The body of scientific literature documenting bioactivity of plant derivatives to different pests continues to expand, yet only a handful of botanicals are currently used in agriculture. Pyrethroids and neem products are well established commercially as botanical pesticides and recently some essential oils of higher plants have also been used as antimicrobials against storage pests because of their relatively safe status and wide acceptance by the consumers. Some of the volatile oils, which often contain the principal aromatic and flavouring components of herbs and spices, have been recommended as plant based antimicrobials to retard microbial contamination and reduction in spoilage of food commodities. Furthermore, some of the antimicrobial plant products also possess strong antioxidant activities which are favourable properties to combat free radical mediated organoleptic deterioration of plant commodities and enhancing their shelf life. In the context of agricultural pest management, botanical pesticides are best suited for use in organic food production in industrialized countries but can play a much greater role in the production and post harvest protection of food products in developing countries.

Keywords: Botanical pesticides, plant protection, storage pests

INTRODUCTION

In developing countries agriculture is the driving force for broad-based economic growth. One of the major problems with agriculture now-a-days is demand the production of more and more in order to provide food for the population which is in permanent augmentation. In realizing this, one of the stumbling blocks seems to be the yield losses due to pests. One of the most important constraints of having every day sufficient food is the post harvest preservation of its quality and quantity. During storage, food grains and products are severely destroyed by insects and other pests.

In spite of the use of all available means of plant protection, about one-third of the yearly harvest of the world is destroyed by the pests. Losses at times are so severe so as to lead to famine in large areas in many countries of the world. So priority should be given to post harvest studies, particularly in humid tropical climates, where at least half of the food supply may be lost between harvest and consumption.

OBSERVATIONS AND DISCUSSION

Qualitative and Quantitative Biodeterioration of Food Commodoties

The deterioration in the stored food commodities is mainly caused by triple agencies *viz*. fungi, insects and rodents under different conditions of storage. Pulses are important sources of protein for vegetarian population. Chickpea (*Cicer arietinum* L.), commonly known as gram, is an important pulse crop. In India, it is grown in 7.29 m ha with an average productivity of 792 kg ha^{-1} covering 75% of world acreage (Anonymous, 2004). It is a crop of both tropical and temperate regions. In general, estimates of yield losses by insects and diseases range from 5 to 10% in temperate regions and 50–100% in tropical regions (Van Emden *et al*., 1988). Insect pests cause heavy losses to stored grains including pulses, especially in humid and warm areas of the world.

Production of mycotoxins by several fungi has added a new dimension to the gravity of the problem. Fungi are significant destroyers of foodstuffs during storage, rendering them unfit for human consumption by retarding their nutritive value and sometimes by production of mycotoxins. According to FAO estimates, 25% of the world food crops are affected by mycotoxins each year. They pose chronic health risks: prolonged exposure through diet has been linked to cancer and kidney, liver, and immune-system disease.Mycotoxins occur more frequently under tropical conditions and diets in many developing countries are more heavily concentrated in crops susceptible to mycotoxins. Generally, tropical conditions such as high temperatures and moisture, monsoons, unseasonal rains during harvest, and flash floods lead to fungal proliferation and mycotoxins. Poor harvesting practices, improper storage, and sub optimal conditions during transport and marketing can also contribute to fungal growth and proliferation of mycotoxins.

Synthetic Pesticides and Their Side Effects

Fungicides are the primary means of controlling post harvest diseases. The current methods for managing stored grain pests depend heavily on synthetic pesticides. However, repeated use of certain chemical fungicides in packing houses has led to the appearance of fungicide-resistant populations of storage pathogens. In recent years there has been considerable pressure by consumers to reduce or eliminate chemical fungicides in foods. Further, the use of synthetic chemicals to control post harvest biodeterioration has been restricted due to their carcinogenicity, teratogenecity, high and acute residual toxicity, hormonal imbalance, long degradation period, environmental pollution and their adverse effects on food and side effects on humans (Brent and Hollomon, 1998; Dubey *et al*., 2007; Kumar *et al*., 2007). The use of synthetic chemicals as antimicrobials for the management of plant pathogens has undoubtedly increased crop protection but with some deterioration of environmental quality and human health (Cutler and Cutler, 1999). Their uninterrupted and indiscriminate use has not only led to the development of resistant strains but accumulation of toxic residues on food grains used for human consumption has led to the health problems (Sharma and Meshram, 2006).

Another method is the use of synthetic fumigants, which has also led to increased cost of application, pest-resistance, lethal effects on non target organisms and toxicity to users (Okonkwo and Okoye, 1996). At the 1997 Montreal Protocol Meeting, industrialized nations of the world agreed to phase out the fumigant methyl bromide by 2005 due to the problem of ozone depletion, whereas, developing nations have committed to reduce the use by 20 per cent in 2005 and phase out in 2015. Further, insect resistance to phosphine is a matter of serious concern. There is increasing public concern over the level of pesticide residues in food. This concern has encouraged researchers to look for alternative solutions to synthetic pesticides. Food safety is receiving increased attention worldwide as the important links between food and health are increasingly recognized. Improving food safety is an essential element of improving food security, which exists when populations have access to sufficient and healthy food. At the same time, as food trade expands throughout the world, food safety has become a shared concern among developed and developing countries.

Higher plants products as alternatives to synthetic pesticides

Recently, in different parts of the world, attention has been paid towards exploitation of plant products as novel chemotherapeutants in plant protection. Because of non phytotoxicity, systemicity, easy biodegradability and stimulatory nature of host metabolism, plant products possess the potential to be of value in pest management (Mishra and Dubey, 1994). During the past few decades, the interest in the use of plant products has increased; chiefly natural origin with low mammalian toxicity (Subramanyam and Roesli, 2000). Many tropical medicinal plants and spices have been used as pest control agents (Lale, 1992). Peasant farmers and researchers often claim successful use of plant materials in insect pest control including ash (Ajayi *et al*., 1987), vegetable oils (Sahayaraj, 2008) and powders of plant parts (Lajide *et al*., 1998).

Numerous studies have documented the about antifungal (Suhr and Nielson, 2003; Mishra and Dubey, 1994; Elgayyar *et al*., 2001) and antibacterial (Canillac and Mourey, 2001) effect of plant essential oils. Examination of indigenous local herbs and plant materials have also been reported from around the world example, India (Ahmad and Beg, 2001), Australia (Cox *et al*., 1998), Argentina (Penna *et al*., 2001) and Finland (Rauha *et al*., 2000). Higher plants contain a wide spectrum of secondary metabolites such as phenols, flavonoids, quinones, tannins, essential oils, alkaloids, saponins and sterols. Such plant-derived chemicals may be exploited for their different biological properties. Biologicals, because of their natural origin are biodegradable and do not leave toxic residues or by products.

Botanical insecticides have long been touted as attractive alternatives to synthetic chemical insecticides for pest management because botanicals pose little threat to the environment or to human health. The body of scientific literature documenting bioactivity of plant derivatives to arthropod pests continues to expand, yet only a handful of botanicals are currently used in agriculture in the industrialized world, and there are prospects for commercial development of new botanical products. Pyrethrum and neem are well established commercially, pesticides based on plant essential oils have recently entered in the market, and the use of rotenone appears to be waning. A number of plant substances have been considered for use as insect antifeedants or repellents, but apart from some natural mosquito repellents, only a little commercial success has ensued for plant substances that modify arthropod behavior. Several factors appear to limit the success of botanicals, most notably regulatory barriers and the availability of competing products (newer synthetics, fermentation products, microbials) that are cost-effective and relatively safe compared with their predecessors. In the context of agricultural pest management, botanical insecticides are best suited for use in organic food production in industrialized countries but can play a much greater role in the production and postharvest protection of food in developing countries (Isman, 2006).

Accordingly, use of green pesticides particularly for stored grain pests is being recommended globally and use of essential oils seem to be the best choice. Studies have shown that essential oils are readily biodegradable and less detrimental to non-target organisms as compared to synthetic pesticides (Baysal, 1997). Application of plant products especially essential oils is a very attractive method for controlling post harvest diseases. Production of essential oils by plants is believed to be predominantly a defense mechanism against pathogens and pests (Oxenham, 2003) and indeed, essential oils have been shown to possess antimicrobial and antifungal properties. Essential oils and their components are gaining increasing interest because of their relatively safe status, their wide acceptance by the consumers and their exploitation for potential multi-purpose functional use. The problem of the development of resistant strains of fungi and insects may be solved by the use of essential oils of higher plants as fumigants in the management of storage pests because of synergism between different components of the oils (Varma and Dubey, 1999; Dubey *et al*., 2007).

Although various essential oils have been screened for their pesticidal activity against various pests but detailed studies *viz*. antifungal, insecticidal, repellency, oviposition, ovicidal, antiaflatoxigenic activity, phytochemistry and safety limit profile have not been done properly with most of the oils. Therefore, there is urgent need to bioprospect the pesticidal property of different essential oils and detailed *in vitro* and *in vivo* investigations are required for their recommendation of their practical application as pesticides for the control of post harvest biodeterioration of food commodities and thereby enhancing shelf life of the commodities. Most of the active compounds of essential oils are specific to particular insect groups and not to mammals (Isman, 2000), many of them are not dangerous to humans. They should be considered in pest management strategies. One of the most important steps in the use of these aromatic plants is to precise the persistence of their insecticidal activity (Ngamo *et al*., 2007). The components with phenolic structures, such as carvacrol, eugenol and thymol, were highly active against the test microorganisms. Furthermore, the significance of the phenolic ring was demonstrated by the lack of activity of the monoterpene cyclic hydrocarbon *p*-cymene. The high activity of the phenolic components may be further explained in terms of the alkyl substitution into the phenol nucleus, which is known to enhance the antimicrobial activity of phenols (Pelczar *et al*., 1988). The presence of an acetate moiety in the structure appeared to increase the activity of the parent compound. Aldehydes, notably formaldehyde and glutaraldehyde, are known to possess powerful antimicrobial activity. It has been proposed that an aldehyde group conjugated to a carbon to carbon double bond is a highly electronegative arrangement, which may explain their activity (Moleyar and Narasimham, 1986), suggesting an increase in electronegativity increases the antibacterial activity (Kurita *et al*., 1979; Kurita *et al*., 1981). Such electronegative compounds may interfere in biological processes involving electron transfer and react with vital nitrogen components, e.g. proteins and nucleic acids and therefore inhibit the growth of the microorganisms. A number of the components tested are ketones. The presence of an oxygen function in the framework increases the antimicrobial properties of terpenoids (Naigre *et al*., 1996). From this study, and by using the contact method, the bacteriostatic and fungistatic action of terpenoids was increased when carbonylated. The inclusion of a double bond increased the activity of limonene relative to *p*-cymene, which demonstrated no activity against the test bacteria.

As food preservatives, volatile oils may have their greatest potential use. Spices, which are used as integral ingredients in cuisine or added as flavouring agents to foods, are present in insufficient quantities for their antimicrobial properties to be significant. However, spices are often contaminated with bacterial and fungal spores due to their volatile oil content, often with antimicrobial activity, being enclosed within oil glands and not being released onto the surface of the spice matter. Volatile oils, which often contain the principal aromatic and flavouring components of herbs and spices, if added to foodstuffs, would cause no loss of organoleptic properties, would retard microbial contamination and therefore reduce the onset of spoilage. In addition, small quantities would be required for this effect. Furthermore, evidence suggests that these oils possess strong antioxidant activities (Dorman, 1999; Youdim *et al*., 1999), which are favourable properties to combat free radical-mediated organoleptic deterioration (Dorman and Deans, 2000).

CONCLUSION

Efforts should be made scientifically to document the pesticidal plants and to investigate the biocontrol efficacy of plant diseases of the plant products. Field trials are required to assess the practical applicability of the botanical pesticides. Biosafety studies should be conducted to ascertain their toxicity to humans, animals and crop plants.

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