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Management of Storage Pest using Indigenous Material-A Review

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Abstract: A large number of insect pests have been reported to be associated with stored grains. Almost all species have remarkably high rates of multiplication and, may destroy 10-15 per cent of the grain and contaminate the rest with undesirable odours and flavours. The major pests of stored grains include beetles (*Callosobruchus* sp, *Trogoderma granarium*, and *Tribolium confusum*), weevils (*Sitophilus oryzae, S. granarius* etc.), moth (*Corcyra cephalonica*) and rodents. Botanical extracts kill and repel pests, affect insect growth and development, have antifeedant and arrestant effects. Continuous and indiscriminate use of pesticides has not only led to the development of resistant strains but also accumulation of toxic residues on food grains used for human consumption. Recently, in different areas of the world, attention has been given towards exploitation of plant products as new approach in grain protection. Various scientific literatures already documented on bioactivity of plant derivatives to different storage pests. Higher plants like neem have also been used as antimicrobials against storage pests because of their relatively safe status and wide acceptance by the consumers. Various herbs and spices (e.g. turmeric, garlic, cloves etc.) have been used by peoples for management of storage pest. Plant products could offer a solution for the problems of availability, health risks, costs and resistance in the case of synthetic pesticides. There is need of more research regarding the biocontrol efficacy, practical applicability of the botanical pesticides. Biosafety studies should be conducted to ascertain their toxicity to humans, animals and crop plants.

Keywords*:* Botanicals, storage pests, protection

INTRODUCTION

Food grains form an important part of the vegetarian Indian diet. Grain production has been steadily increasing due to advancement in production technology, but improper storage results in high losses in grains. The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010). A large number of insect pests have been reported to be associated with stored grains. Almost all species have remarkably high rates of multiplication and, within one season, may destroy 10-15 per cent of the grain and contaminate the rest with undesirable odours and flavours. The major pests of stored grains include beetles (*Callosobrunchus* sp, *Trogoderma granarium, Tribolium confusum*), weevils (*Acanthoscel ides obtectus*), moth (*Corcyra cephalonica*) and rodents. The control measures include two types of treatment i. e. prophylactic and curative. The prophylactic treatment involves the use of pesticides like Malathion (50% EC), DDVP (76% EC) and Deltamethrin (2.5% WP). Curative treatment involves use of fumigant aluminium phosphate to control infested stock or godown in airtight condition. For controlling rodents rat cages, poison baits and use of rat borrow fumigation is recommended (India Agronet, 2009). Tissue of higher plants contain arrays of biochemicals, known as “secondary plant chemicals” (or alleochemicals), which are defensive in function. They include alkaloids, steroids, phenolics, saponins, resins, essential

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oils, various organic acids and other compounds. It is well known that secondary plant metabolites may act as kairomones, allomones, stimulants or deterents of feeding and oviposition, and as antifeedants, insecticides and insect hormone mimics. Many plant allelochemicals including azadirachtin, nicotine, pyrethrins and rotenoids have been developed as commercial insecticides (Talukder, 2006). Botanical extracts kill and repel pests, affect insect growth and development, have antifeedant and arrestant effects, and have antifungal, antiviral, and antibacterial properties against pathogens (Prakash and Rao, 1986, 1997). They can be grouped into five major chemical categories: nitrogen compounds (primarily alkaloids), terpenoids, phenolics, proteinase inhibitors, and growth regulators. In developing countries, pesticidal plants offer unique and challenging opportunities for exploration and development of their own botanicals. Following is an overview pointing out the effectiveness, uses, safety, and commercialization of the plant based insecticides.

SYNTHETIC PESTICIDES AND THEIR SIDE EFFECTS

The current methods for managing stored grain pests depend heavily on synthetic pesticides. Their uninterrupted and indiscriminate use has not only led to the development of resistant strains (Champ and Dyte, 1976; Georghiou and Tejeda, 1991) but also 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). 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. 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.

THE USE OF PLANT PRODUCTS AS PROTECTANTS

Plant products could offer a solution for the problems of availability, health risks, costs and resistance in the case of synthetic pesticides, and for the lack of equipment for hermetic storage, gamma irradiation and controlled atmospheres. The mixing with plant oils is an ancient Indian and African method of protecting grains against insect attack (Pereira, 1983) and most of the reported studies with plant oils have involved use against stored grain insect pests. An increasing number of plant oils have been screened for preventing post-harvest losses due to insects (Golob and Webley, 1980). Several kinds of materials are used as a means of stored food protection, including chemical fumigation, treatment with synthetic pesticides, botanicals and inert materials, only the last two will be treated, reasons for which has already been mentioned earlier.

TYPES OF BOTANICALS USED IN STORED FOOD PROTECTION

Botanicals are plants or plant-derived products having active ingredients for the control of storage pests. These are (i) spices, and (ii) medicinal and other plants. Spices: In addition to being used to flavor foods, spices have been used from ancient times to protect stored products from pests. Traditionally, pieces of dried spices or ground spices were used to sprinkle over or mix with stored foods, but recently the use of extracts or oils has been experimentally tried with encouraging results. Medicinal and other Plants: In addition to spices, many other botanicals have also been used to combat stored pests. Among these are medicinal plants, which are normally used to cure human's illness, but can also be used to protect stored food; others are plants which are known to have effects on stored pests. Leaf extract of all the plants (*Prosophis* sp., *Nerium* sp., *Ocimum* sp., *Acalypha*

Table 1: Most common spices used in storage food protection

Common name	*Scientific name*	*Effect on target pest*	*References*
Ginger	*Zingiber officinale*	*C. chinensis, T. castaneum*	(Ho, 1995)
Turmeric	*Curcuma longa*	*T. castaneum* and *S. Zeamais* and *number of other storage pests*	(Jilani and Su, 1983; Jilani and Saxena, 1990; Chandler et al., 1991; Unjitwatana et al.,1997)
Clove	*Syzygium aromaticum*	*S. zeamais* and *eggs of T. castaneum, S. oryzae* and *T. castaneum*	(Grainge and Ahmed, 1988; Ho, 1995; Grainge and Ahmed, 1988).
Garlic	*Allium sativum*	*T. castaneum* and *S. zeamais*	(Ho, 1995)
Greater Galangal	*Alpinia galanga*	*T. castaneum* and *S. zeamais*	(Mohiuddin, 1987)
Black Pepper	*Piper nigrum*	*C. chinensis*	(Morallo-Rejesus et al., 1990)

sp., *Catharanthus* sp., and *Vitex* sp.) caused significant ovipositional deterrent effect aginst pulse beetle. Leaf extract of *Vitex* sp. leaf extract caused maximum reduction in egg viablity (61.7%) followed by *Catheranthus* sp. leaf extract (56.7%). Vitex sp treated seeds at 5% level caused maximum reduction in adult emergence (85.0%) followed by Catheranthus sp. (83.7%), *Acalypha sp.* (73.3%), *Nerium sp.* (70.0%), *Ocium* sp. (68.7%) and minimum reduction was recored in case of *Prosphis* sp. (68.0%) (Sathyseelan et al., 2008). The repellent activity of plant powders of *A. mexicana, P. juliflora* and *T. purpurea* were tested against T. castaneum. In general, all the plant powders showed repellent activity (Pugazhvendan et al., 2009). Bean seeds treated with pyrethrum excelled other treatments by having low number of holes per seed, damaged seeds, percent of damaged seeds and weight loss. Garlic performed better in reducing number of holes per seed, damaged seeds, percentage damaged seeds and weight loss than no pesticide application treatment (Mulungu, 2007). The sweet flag rhizome powder @ 10.0 g /kg of seed found better by recording significantly higher germination percentage (87.00%), vigour index (2694) and dry weight of seedlings (329.50mg) and lower electrical conductivity (0.488 dSm^{-1}) and insect infestation (3.33%) compared to untreated control. Derbalah (2012) revealed that, the tested botanical extracts (*Cassia senna, Caesalpinia gilliesii, Thespesia populnea* var. acutiloba, *Chrysanthemum frutescens, Euonymus japonicus, Bauhinia purpurea*, and *Cassia fistula*) showed high efficiency against *T. granarium* with respect to mortality and progeny of the adults. *C. senna* was the most effective botanical extract against *T. granarium.* The seeds of sugar apple toxic to many insects. Its leaves have certain ingredients that inhibit the growth of certain stored grain insects. Indian Privet leaves exhibit insecticidal property against stored grain insects (Narong Chomchalow, 2003). Abdullahi et al. (2011) revealed that *Vittallaria paradoxa* has great potential for use as a plant-based biopesticide for controlling pulse beetle *Callosobruchus maculatus.* The ethanol seed extract of bitter gourd, karanja and urmoi showed grain protective effects over wheat grains up to 30 days. The extracts did not show any adverse effect on germination capability of wheat seeds even after 3 months of treatments (Islam, 2002). Lime peel oil is effective in the protection of maize against weevil *Sitophilus zeamais* (Abdullahi et al., 2011). Mamun et al. (2009) showed that extracts of plants (*Bazna (Zanthoxylum rhetsa*), Ghora-neem (*Melia sempervirens*), Hijal (*Barringtonia acutangula*), Karanja (*Pongamia pinnata*), Mahogoni (*Swietenia mahagoni*) and Neem (*Azadirachta indica*)) had direct toxic effect on red flour beetle. Among them, Neem seed extract showed the highest toxic effect (mortality, 52.50%), whereas Hijal leaf extract possessed the lowest toxic effect (mortality, 22.24%). Dodder vine extract was found effective in checking oviposition, adult progeny development and severity of seed damage. Seeds treated with 5 per cent concentration of dodder vine extract were less preferred for oviposition, adult emergence and seed weight loss by *Callosobruchus chinensis* and this conc. might be useful in protection of pulse seed (Rahman et al., 2010). The reduction in fecundity of *Callosobruchus maculatus* (F.) may be attributed to the toxicity of plant extracts and plant powders (kaner leaf extract (*Nerium indicum*), khejri leaf extract (*Prosopis cineraria*), neem leaf extract (*Azadirachta indica*), safeda leaf extract (*Eucalyptus globulus*), tomato leaf extract (*Lycopersicum esculentum*) and mustard seed extract (*Brassica compestris*) and four plant powders viz., black pepper powder (*Piper nigrum*), garlic clove powder (*Allium sativum*), tulsi leaf powder (*Ocimum sanctum*) and turmeric rhizome powder (*Curcuma longa*), affecting the normal physiology of the insects (Singh, 2011). Volatile oil of *Citrus reticulate* resulted in 100 per cent mortality of Sitophilus oryzae after 24 hours of exposure followed by Curcuma longa (90.00 %), *Psidium guajava* (52.50%) and *Pogostemon cablin* (20.00%). Among powders, powder of Zingiber officinale was proved to be effective to some extent resulting in 23.34 per cent mortality followed by *P. Guajava* and *C. reticulate* at 6.67 per cent respectively after 72 hours of exposure (Chayengia et al, 2010). The percentage of ovipsition deterrence from the infested chickpea due to infestion of Cowpea weevil, *Callosobruchus maculatus* was significantly reduced in treatments to which oils of sesame (98.49%), olive (96.54%) and sunflower (95.37%) had been added (Mohamed, 2012). Muhammad et al. (2005) indicate that neem oil has a strong insecticidal effect on stored grain beetles when used in proportions ranging from 5 to 20 percent applied on packing bags. The least number of F1 adults emerged from black gram seeds treated with neem oil. The nishinda oil extract was the most toxic of three extracts tested (nishinda, eucalyptus and bankalmi). Bablah ash was the most effective compared to the powdered leaves of nishinda, eucalyptus and bankalmi. The powdered leaves and extracts of nishinda, eucalyptus and bankalmi, at a 3% mixture, provided good protection for black gram seeds by reducing insect oviposition, F1 adult emergence, and grain infestation rates. The oil treatment did not show adverse effects on germination capability of seeds, even after three months of treatment (Rahman and Talukder, 2006). Kiradoo and Srivastava (2010) suggested that formulations of both the species of *Ocimum* have a potential to act as ovipositional deterrent and can be employed against *C. chinensis* for its control *Ocimum sanctum* and *Ocimum basilicum.* Application of mustard oil combined with *Paecilomyces fumosoroseus* on foam covering gunny bags provided promising oviposition deterrency, toxicity and suppressing Bruchidius Incarnates infestation, persistence and protecting broad bean seeds from beetles' infestation for 120 days during storage (Sabbour and Shadia, 2010). The highest bioactivity (90 - 100% mortality) was manifested by the crude ethanol extracts of *Azadirachta indica* (Neem), *Anona reticulate* (Anona) and *Ocimum sanctum* (Maduruthala/sacred bail) among the crude ethanol extracts tested. Clove powder was the most effective among the four powders tested for adult mortality followed by root dust of papaya. Among the plant powders tested, Maduruthala (*O. sanctum*) was the most effective for suppressing oviposition significantly followed by Getathumba (*Leucas zeylanica*) (Ratnasekera and Rajapakse, 2012). In a study a storage structure was constructed by using the plant stacks of *Ipomea carnea* and filled with bengalgram. No infestation was found for a longer period and in the initial five months of storing there was no weight loss in this structure (Ahmed and Dwyer, 1988). Branches of *Vitex negundo* with green leaves were kept among the gunny bags to repel the storage pests (Roy and Mondal, 1998). Mixing of grains with the powders of V. negundo and neem in between the layers of bags filled with grains gave protection for paddy was reported (Vivekanandan; 1994).

SAFETY PERSPECTIVE

It should not be assumed that just because the botanical pesticides are naturally derived that they are safe to use and consume by humans, and some form of safety assessment needs to be considered. In order to assess their mammalian toxicity, some of the more promising plant species were tested for toxic effects against vertebrates (Belmain et al., 2001). 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. Evidence collected from small-scale farmers indicates that they prefer pesticidal plant materials over other forms of pest control during storage. However, individual farmer knowledge about different plants and how best to use them varies considerably. The identification of novel compounds or modes of action found in the botanicals could lead to the development of new commercial products for the wider benefit of humanity and the country of origin. 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.

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