Intensive Botanical and Biological Control of Storage Insect-Pest
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Intensive Botanical and Biological Control of Storage Insect-Pest

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Storage of grains and seeds is critical in agriculture for both starting a new life and ensuring food security. Various factors influence grain and seed quality during storage, including crop or variety, original seed quality, storage conditions, seed moisture content, insect pests, bacteria, and fungi.

Rice weevil: (*Sitophilus oryzae*)

Effect of synthetic pesticides on environment and ecology

Pesticides are thought to be a quick, easy, and economical way to control insect pests, but they have polluted practically every location they have been used, with residues discovered in soil, air, and water all over the world. Pesticides released into the environment can have long-term or short-term consequences on an ecosystem's natural functioning.

Regular and indiscriminate use of pesticides has harmed not just the environment and agriculture, but also our food chain, impacting animal and human health and development. Synthetic pesticides, in addition to killing economically significant insect pests, also kill helpful natural enemies and other creatures, hence exacerbating pest issues. Synthetic pesticides along with the insect pest of economic importance also kill beneficial natural enemies and other organisms; thereby enhance pest problems as they are important in pest control. Among various pesticides, insecticides are generally the most acutely toxic class. Residual effect of insecticides was reported on natural enemies in which the suppressive effect was pronounced on the parasitic wasps that attack the obscure scale (Melanaspis obscura), a common scale insect pest of oak. Different arsenic derivates present in paddy soil were detected which appear to check the growth of rice. Persistence of pesticide in water, soil, air and food material poses a serious threat to living beings including humans.

Pesticides leached out from crop land to various water bodies through water drainage by rain or irrigation thereby constituting a problem for the supply of drinking water to the population. Some of the volatile pesticides are serious risk to atmospheric pollution which may cause various respiratory or allergic problems.

The effects of the different pesticides are directly reflected from soil properties and soil micro-flora through which these pesticides undergoes degradation, transport and other various process. Organic soil without the use of chemicals (pesticides) results in improved soil health and quality, and increased organic matter in the soil improves water holding capacity.

Use of Botanicals and plant extracts

Plant botanicals occupy a very small niche in the world of pesticides, but the increasing environmental concerns had led to a surge in use of environmentally sustainable and friendly “green “alternatives.

Essential oils are generally composed of complex mixtures of monoterpenes, biogenetically related phenols, and sesquiterpenes. Presently, the use of plant based bio pesticides are gaining popularity due to recent commercialization techniques and initiatives taken by the Government.

Plant extracts, essential oils have shown insecticidal activity against field crop pests and household insect pests. Many of these oils have also shown high oviposition and growth inhibitory activity.

The neem oil and kernel powder gave effective grain protection against stored grain insect pests like *S. oryzae, T. castaneum*, *R. dominica,* and *C. chinensis* at the rate of 1 to 2% kernel powder or oil. Coconut oil has been found effective against C. chinensis, for a storage period of six months, when applied to green gram at 1%. The powders of *Rauvolfia serpentina*, *Acorus calamus,* and *Mesua ferrea* are used as a grain protectant against R. dominica. Similarly, volatile compound diallyl disulphid isolated from neem have shown potent toxic, fumigant and feeding deterrent activity against stored grain pests, *S. oryzae* and *T. castaneum.*

Sl No	Stored grain pest	Essential oil used	Chemical constituent	Lethal concentration (LC50, LD50, KC50, KD50, KT 50, LT90) mg/L	Action
1	*Tribolium casteanum*	Mustard oil	Allyl isothiocynite	LC50 – 3.74 to 4.66 LC90-4.89 to 7.87	Fumigant
2	*Callosobruchus maculatus*	*Artemesia sieberi*	Camphor Camphene 1,8 Cineole Beta Thujone Alpha Pinene	1.45 ppm	Fumigant
3	*Sitophilous oryzae*			3.86 ppm	Fumigant
4	*Tribolium casteanum*			16.76 ppm	Fumigant
5	*Callosobruchus chinensis*)	*Ocimum grattissimum*	Beta ocimene Eugenol	1µL/L(100% ortality) 1µL/L(100% ortality)(Eugenol)	Fumigant
6	*Sitophilous oryzae* air	*Vitex pseudo negundo*		LC50=31.96 µL/L	Fumigant
7	*Rhizopertha dominica*		Camphor, Linalool, 1, 8 cineole	1µ L/720ml(100% mortality)	Fumigant

Use of Bio-agents in combination with other control methods

Natural biological control, which places reliance on the predators and parasites that would normally be found in association with storage pests, may also offer some prospects. The recent advances in the biological control of stored-grain insects with entomopathogenic fungi (EF), the effect of formulated *vs* unformulated strains of EF and the effect of combinations of EF with other components, *i.e.* diatomaceous earths (DEs), chemical insecticides, natural products and natural enemies against stored product insects are reviewed. Very few formulations of EF strains have been developed and used, of which invert emulsion formulation (water-in-oil type) is considered the most important. A synergistic effect of EF is produced by combining them with DEs, chemical and natural products. Moreover, since the action of EF against insect pests in general, and stored-grain insects in particular, is compatible with the food safety and environmental regulations, a good perspective for these biocontrol agents is expected as alternatives to synthetic insecticides. Few combinations of EF have been presented below-

Entomopath-ogenic fungi	Host	Application	Remarks
Beauveria bassiana	*Sitophilus zeamais*	Three formulations of *B. bassiana* were applied to grain, then mixing them to be in a direct contact with the adult insects. Formulations were: dustable powder (DP), oil suspensions (OS) containing a mixture of mineral oil and maize oil and hydrogenated rapeseed oil pellet (HP).	OS formulation was the best one with the highest level of control on maize grains compared with other formulations. OS also preserved the viability of the introduced conidia.
Metarhizium anisopliae	*Rhyzopertha dominica*	Application of *M. anisopliae* in invert emulsion formulation with the following ingredients: Tween 20, mixture of coco-nut oil and soybean oil, glycerin, water-soluble wax, sterile distilled water and conidial suspension of *M. anisopliae* to the inner surfaces of grain containers before introduction of the grains and adult insects.	Treatment with formulated *M. anisopliae* caused 93.3% mortality to treated *R. dominica* adults compared with the unformulated form (56.7% mortality). The introduced conidia into the formulation remained viable for 30.8 months with a half-life time of 4.6 months
Beauveria bassiana	*Tenebrio molitor*	The efficacy of *B. bassiana* in invert emulsion formulation with the	The formulated *B. bassiana* caused higher mortality of T. molitor larvae compared

		following ingredients was tested: sterile de-ionized water, conidial suspension of *B. bassiana*, glycerin, water-soluble emulsifier, canola oil and Tween 20. The application was conducted applied by spraying 1.0 ml of the formulated and unformulated strains onto larvae of *T. molitor*.	with the aqueous conidial suspension. Also, when different concentrations of the formulated *B. bassiana* strains were applied, the LC50 (in conidia/ml) was >600£ lower than the LC50 of the unformulated conidia
Beauveria bassiana	*Tribolium castaneum*	*Tribolium castaneum* was treated under ambient air or under modified atmosphere (reduced O_2 to 5 ± 1% or increased CO_2 to 40% ± 2%) with *B. bassiana*.	Higher larval mortality was recorded when fungus applied in modified atmosphere (reduction of oxygen) than when fungus applied alone. Mortality of adults exposed to fungus was increased with the increase of CO_2 contrary to the O_2 reduction.

Future research could be oriented in the formulation of the most effective strains or isolates of EF in order to enhance their efficacy against insects and improve their shelf-life by preserving their viability for longer periods. Oil-based formulations are the most promising and most appropriate for the formulation of effective strains of EF because they are able to enhance the efficacy of the introduced EF conidia and can conserve their viability for longer time. Invert emulsion formulations with unsaturated oils of plant-origin are considered the best oil-based formulations since they contain enough water for germination of fungal conidia during application under hot and dry storage conditions. To the best of our knowledge, no commercial bio-pesticides based on EF bio-agents are registered for use against the stored-grain insects. Also, there is no integration of any effective strain (formulated or unformulated) of EF in the management of stored-product insects.