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Essential Oils - Future Prospects in Seed Insect Pest Management

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ABSTRACT

Storage insect pests and their infestation on crop seeds are of great concern in quality seed production programs. Damage caused by these insect pests is absolute and irrecoverable, since the pest feeding causes qualitative as well as quantitative losses, such as seed weight loss, loss of seed viability due to poor germination capacity of seeds, poor seedling vigour, invasion by secondary pathogens etc., leading to crop loss. Essential oils extracted from different aromatic and medicinal plants especially act as an insecticide against these storage pests and are considered as an eco-friendly pest management option. Hence, essential oil extracted from such plants can offer an effective solution for controlling storage pests with minimal health impacts and contradicting insect pest resurgence issues.

INTRODUCTION

Storage insect pests cause monetary losses annually due to their feeding damage as well as contamination due to their presence/webbing/frass/faecal matter in the stored commodities and seeds. Accumulation of storage insects on seeds under storage results in loss of quality and quantity of seeds, thereby making the seeds unfit for next season sowing. Damage to seeds by these insects results in loss of seed viability, poor seedling vigour, increased susceptibility to invasion of pathogens etc. Therefore, they must be systematically protected against insect infestation during production and storage combining both chemical and non-chemical methods through integrated pest management (IPM) methods. Therefore, essential oils seem to be a good alternative with the potential to replace synthetic insecticides and repellents with added advantage of its eco-friendly nature too.

Since, 20^{th} and 21^{st} century, conventional insecticides have played a major role in protecting seeds under storage from insect infestation and damage. However, much public concern has triggered about its long-term ill effects on humans and environment as well due to inappropriate use of inorganic insecticides. We have also observed that these older molecules potentially have negative impact on the ecosystems leading to acute or chronic toxicity symptoms in mammals or beneficial organisms. Taking into consideration these issues, there is an urgent need to develop safe alternatives with minimal harmful effects on the environment as well as to non-target organisms.

INSECTICIDAL PROPERTIES OF ESSENTIAL OIL

Insect repellents are those substances that deter insects. Plant derived essential oils are those natural complex secondary plant metabolites characterized by a strong odour which could be attractive or deterrent. There are approximately 17,500 aromatic plant species 3,000 essential oils recorded globally out of which 300 oils are commercially used for pharmaceuticals, cosmetics and perfume industries apart from pesticidal application (Bakkali *et al.,* 2008; Chang and Cheng, 2002). Some of the plant families like Apiaceae, Asteraceae, Labiatae, Poaceae, Piperaceae, Compositae, Lauraceae, Myrtaceae, Cupressaceae, Rutaceae and Zingiberaceae. These plant oils consist of complex mixtures of volatile compounds containing twenty to sixty individual compounds in varying concentrations. These interfere with basic metabolic, biochemical, physiological and behavioural functions of insects which can be manipulated appropriately for their control in storage products like seeds/grains.

Major volatile fraction of any plant derived essential oil constitutes will be contributed by mainly monoterpenes or sesquiterpenes and their oxygenated derivatives along with aliphatic aldehydes, alcohols and esters. While non-volatile residues comprise 1-10% of the oil and constitute fractions like hydrocarbons, fatty acids, sterols, carotenoids, waxes and flavonoids. Thus, essential oils act as fumigant toxins, feeding deterrents, repellent or oviposition deterrents and neurotoxic as well.

Chemical profiling of each essential oil will give us an idea about the major components (relatively high concentrations like 20-70%) as well as the minor components which may be in traces. The proportion of major components or minor compounds will contribute to the bio-pesticidal properties of essential oils in a synergistic or additive manner on insects. Several essential oils and its constituents have been studied for their different modes of action like repellent, antifeedant, ovicidal, and inhibiting developmental activities in insects. For example, 1,8-cineole in *Cinnamomum camphora*, carvacrol and thymol in *Origanum compactum*, phellandrene and limonene in *Anethum* graveolens leaf essential oil, linalol in *Coriandrum* *sativum*, and menthol and menthone of *Mentha piperita* are some of the common examples of major components profiled through GC-MS (Chaubey, 2019). The fragrance and chemical composition of essential oils can vary according to the conditions like soil, climate, altitude and irrigation, stage of harvest (before or after flowering), time of harvest, plant part harvested etc.

MODE OF ACTION

Gamma-aminobutyric acid (GABA) receptor is known to be the primary inhibitory neurotransmitter of the central nervous system of insects on which EOs act upon. These oil components inhibit acetylcholinesterase (AChE), which hydrolyses acetylcholine, disrupting signal transmission in the central nervous system. Laboratory studies on effect of eugenol and *Ocimum tenuiflorum* essential oil in *S. oryzae* have shown that maximum percentage of AChE inhibition was observed after two hours, while both EOs inhibit approximately 40% of AChE only after 4 h of contact resulting in neurotoxic effects in *S. oryzae* leading to death of the pest. Octopamine acts as a neurohormone and neuromodulator in insects affecting various biological processes like muscle contractions of locomotory organs due to blockage of octopamine receptor binding sites etc., attributing to the sudden death of storage insects like *S. granarius* when in contact with EOs.

FUTURE PROSPECTS

Essential oil-based bio-pesticides have proven effective against storage insect pests but the major limitation being high volatility under different temperature and pressure conditions. In order to overcome these limitations, technology has advanced wherein nan-encapsulation is one of the techniques that can help solve this problem. Nano-encapsulation basically involves encapsulating EOs in carrier materials in the range of 1-100 nm, like nan-emulsions, lipid nanomaterials, polymeric nanoparticles, and clay nanomaterials. When the two phases are mixed, i.e either water in oil or oil in water a nano-emulsion is produced. In order to stabilize this oil-water mixtures, surfactants are used to reduce the surface tension between water and oil thus enabling proper miscibility. Eucalyptus nano-emulsion caused 100% mortality in *Sitophilus oryzae* (adult) at a concentration of 1.5 $\mu L/cm^2$ as against 80% mortality rates for eucalyptus oil of same dosage (Adak *et al.,* 2020). Polymeric nanoparticles are made using biodegradable polymers or synthetic polymers or their blends like chitosan, pectin, cellulose, PEG, alginate, cyclodextrin, starch, polycaprolactone etc. In the case of nanoclays like montmorillonite, the nanoparticles have ion exchange capacity, by which they change their nature from hydrophobic to hydrophilic or vice versa thus utilized for encapsulating EOs as insecticides. This formulation resulted in *S. zeamais* mortality rates of 100% in the first days and 75% after 30 days, proving the effectiveness of clays in the gradual release of Eo's ((Nguemtchouin *et al.,* 2013).

CONCLUSION

Insect mortality is only one of the immediate effects in pest control with insecticidal plants. In addition to above, these plants also affect insect feeding, oviposition, inhibiting growth and development resulting in decrease in the emergence of adults and cause insect mortality only. The slow mode of action of these essential oils is usually focussed as one of the limitations of essential oil in insect pest management but if deployed with an appropriate delivery system, essential oils will surely serve as one of the best weapons against development of insecticide resistance as well as management of these agents in an eco-friendly manner.

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