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Essential Oils as Grain Protectants in Pea Seeds and Effect on Seed Germination

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INTRODUCTION

Since long time, there have been efforts to protect harvested production against pests. The ancient Romans used false hellebore (*Veratrum album*) as a rodenticide, the Chinese is credited with discovering the insecticidal properties of Derris species, whereas pyrethrum was used as an insecticide in Persia and China [1]. In many parts of the world, locally available plants are currently in wide use to protect stored products against damage caused by insect infestation [2]. Essential oils are produced in 17500 aromatic plants belonging mostly to a few families, including the Myrtaceae, Lauraceae, Lamiaceae and Asteraceae. The synthesis and accumulation of essential oils are associated with the presence of complex secretory structures such as glandular trichomes (Lamiaceae), secretory cavities (Myrtaceae, Rutaceae) and resin ducts (Asteraceae, Apiaceae), etc. Many botanicals such as plant essential oils and there chemical constituents are reported for their developmental inhibitory activities against insect-pests [3].

The available literature to control stored grain pests has been reviewed under various heads as:

Essential oils as grain protectants

The protection of grains and seeds in storage is an ancient practice in which dry soil and wood ash were mixed with grains causing lethal dehydration of insect and application of some certain plant materials with grains to serve as fumigants. The effectiveness of plant materials including essential oils in checking the multiplication of insects-pests in stored grain was first reported by insecticidal activity of Acorus rhizomes. The active ingredient present to the extent of 15-20% in the rhizome oil of *Acorus* sp. was recognized as a one and it has been found effective against various pests [4].

Reported that oil of peels of different citrus fruit applied to cowpea seeds caused failure of production of adults (*C. maculatus*) up to 87 days and the emergence was minimum even after 312 days of treatment established insecticidal properties of limonene, a constituent of citrus oil for the control of insect pest of stored products. Researchers reported the insecticidal properties of Eucalyptus oil and suggested that its insecticidal effect can be improved by addition of chavicine or piperine reported that vapors of *Acoras calamus* oil reduced fecundity and caused degeneration in the follicles of vitellarium in females of *Tribolium casteneum*, *Sitiphilus oryzae*, *Callosobruchus chinensis*, *Trogoderma granarium* and *Anthremus flavipes* [5] reported that the exposure of oil vapors of *Acoras calamus* to *Trogoderma granarium* for 6 or 12 days resulted in immediate degeneration of most mature follicles of ovarian tissue reported that oils of *Mentha spicata* adversely affected the embryonic development of eggs and vapors killed the adult beetles of *Callosobruchus chinensis*.

Observed that a 1:1 mixture of the essential oils of *Cymbopogon nardus* (L.) and *Vitex negundo* L. was more toxic than the individual oils. Also, the 1:1 mixture of a-phellandrene and p-cymene was more effective than the individual terpenes. Sighamony et al. [6] reported that pure asarone is a stronger repellent than its four derivatives. Oil of clove was toxic to *S. oryzae* and *Rhyzopertha dominica*. Ahmed and Eapen [7] reported that adults of *R. dominica* and *Callosobruchus* spp. were more susceptible to essential oils or their components than those of other insect species. Studied the toxicity of *Acorus calamus* rhizome oil vapors against the immature stages of *Sitophilus granarius*, *Sitophilus oryzae*.

Studied the repellency of the oils of turmeric, neem and sweet flag against *Rhizopertha dominica* for eight weeks. All the three oils showed significant repellency during the first

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two weeks, thereafter, their repellency decreased more rapidly. *R. dominica* adults made significantly fewer and smaller feeding punctures in the filter paper discs (7 cm diameter) treated with test materials @ 100, 500 and 1000 µg/cm² than those in the control. The oil when topically applied was highly toxic to the *L. serricorne* with 100% mortality at 30 µg/insect and also to *C. maculatus* and *S. oryzae*, with mortality of 98.3% and 61.7%, respectively, at 50 µg/insect. When applied at a dosage of 1000 ppm to the "wheat" (*Triticum aestivum*) or cow peas (*Vigna unguiculata*), the oil gave 100% protection from the infestation of *S. oryzae* and *C. maculatus*, respectively.

Reported essential oils and their constituents exerted insecticidal effects or reduce and disrupt insect growth at several life stages found that essential oils extracted from different chemotypes of "thyme" (*Tymus vulgaris*) did not have the same toxicity against the bruchid, *Acanthoscelides obtectus*. Observed that the exposure to vapours of a synthetic pure β-asarone of *Acorus calamus* oil was effective against the adults of *Sitophilus zeamais* as an exposure to the vapours of *Acorus calamus* oil.

Schmidt and Streloke [8] studied "sweet flag" (*Acorus calamus*) oil and B-asarone, against (*Prostephanus truncates*) infesting maize grains and found that oil treatment reduced the feeding by 50%, within 21 days. A decrease in the feeding was observed in maize treated with B-asarone after 21-42 days at 30°C but not at 25°C. The admixture of rhizome powder also reduced the feedings up to 83%. Reported toxic activity of some monoterpenoids: p-cymene, or-pinene, camphor, linalool, terpineol, cuminaldebyde, cinnamaldehyde, anethole, carvacrol, thymol, estragole and eugenol against *Acantboscelides obtectus* (Say), a bruchid pest of kidney bean (*Phaseolus vulgaris* L.). A fumigant toxic effect and a reproductive inhibition were observed at different concentrations for 24 h and 48 h for adults. This inhibition involved female fecundity, oviposition and the development of neonate and intracotyledonal larvae. All monoterpenes revealed pronounced vapor toxicity and significantly inhibited beetle reproduction. Reported garlic oil toxicity against the eggs, larvae and adults of *Tribolium castaneum* and adults of *Sitophilus zeumais*. *Tribolium custaneum* egg mortality increased with garlic oil concentration complete kill of eggs was achieved at 4.4 mg/cm. The eggs were the most susceptible stage followed by adults, 10 day old larvae and older larvae. *T. castaneum* adults were more susceptible to garlic oil than *S. zeamais* adults.

Shaaya et al. [9] reported that essential oils have shown a similar joint action with CO_2 atmospheres. Enhanced toxicity of essential oil (a Lamiaceae plant) was observed in the presence of CO_2 to *T. castaneum* (larvae, pupae and adults), "Indian meal moith" *Plodia interpunctella* (larvae and pupae), "lesser grain borer" *Rhizopertha dominica*, "rice weevil" *Sitpphilis oryzae* and "saw toothed grain beetle" *Oryzaephilus surinamensis* (adults). Reported that peel oils of *Citrus* spp. and *Eucalyptus citriodora* at 10 and 20 ml/l were more toxic in the presence of two different controlled atmospheres (15% CO_2+1% O_2+84% N_2 and 12% CO_2+5% O_2+83% N_2) to the psocid, *Liposcelis bostrychophila*. Lee [10] reported fumigant toxicities of lavender and ylang-ylang essential oils against a chlorpyrifos-methyl resistant strain and an insecticide-susceptible strain of the saw-toothed grain beetle, *Oryzaephilus surinamensis* L. The resistant strain showed 1.3- and 1.6-fold higher tolerance against lavender and ylang-ylang fumigation toxicity, respectively. LT50 values at 15 ml/l of air had 2.9- and 1.4-fold higher for lavender and ylang-ylang fumigation toxicity, respectively, than susceptible strain.

Reported fumigant toxicity, ovicidal and oviposition-deterrent potential of essential oil of Indian dill, *Anethum sowa* and its three major fractions against the grain beetle (*Callosobruchus maculates*) on chickpea and found that two fractions produced 100% mortality of adult beetles at 3.0 ml/l dosage whereas the essential oil was the least effective. Neither the essential oil nor its fractions had any significant effect on chickpea seed germination. Papachristos and Stamopoulos [11] studied the effect of essential oils of *L. hybrida*, *R. officinalis* and *E. globulus* against larvae and pupae of *A. obtectus* at 4-36°C and reported that the insects were more susceptible at 10 and 180°C than at other temperatures. Paranagama et al. [12] valuated effect of the essential oils of "lemongrass" (*Cymbopogon citratus*), "lemongrass" *Cymbopogon nardus* and "cinnamon" (*Cinnamomum zeylanicum*) against "Angoumois grain moth" (*Sitotroga cerealella*) and found that percentage grain damage was lower in *C. citratus* and *C. nardus* and reported that the percentage seed germination differed non significantly with the control and caused reduced seed germination in paddy seeds treated with *C. citratus*. Observed that phosphine-resistant strains of *T. castaneum* did not show any cross-resistance to 1, 8-cineole, a major monoterpenoid found in *Eucalyptus* spp.

Chaubey [13] studied "zinger" *Zingiber officinale* and "cubeb" *Piper cubeba* essential oils for repellent, insecticidal, anti-ovipositional, egg hatching, persistence of its insecticidal activities against pulse beetle, *Callosobruchus chinensis* and reported that essential oil vapors repelled bruchid adults significantly as oviposition was reduced. "zinger" *Zinziber officinale* and "cubeb" *P. cubeba* essential oils caused both fumigant and contact toxicity to "pulse beetle" *C. chinensis* adults. These two essential oils reduced oviposition in "pulse beetle" *C. chinensis* adults when treated with sub-lethal concentrations by fumigation and contact method. Jahanshir [14] studied the effects of four essential oils viz. "water mint" *Mentha aquatica*, "thyme" *Thymus daenensis*, "myrtle" *Myrtus communis* and "artemisia" *Artemisia hausskenechtii* against two flour weevils, "flour beetle" *T. castaneum* and *T. confusum* and reported that mortality increased in both insects with increase in concentration and exposure time of essential oils. The essential oil of "water mint" *M. aquatica* exhibited significant fumigant toxicity against "flour beetle" *T. castaneum* and "consused flour beetel" *T. confusum* with LC50 of 2.32 and 2.94 µL/L air, respectively. However, over the same exposure time, LC50 of "myrtus" *M. communis*, "artemisia" *A. hausskenechtii* and "thyme" *T. daenensis* essential oils against *T. castaneum* and *T. confusum* were 29.88 and 38.07, 21.39 and 26.38 and 22.15 and 28.56 µl/l air, respectively.

Effect of essential oils on seed germination and seed vigor index

Observed that 2-4% of oil emulsion of "sweet flag" (*A. calamus*) had rapid knockdown action on "pulse beetle" (*C. chinensis*) and was safe for seed germination. Demonstrated that germination of wheat and gram seeds exposed to the vapours of essential oil of "mint" *M. piperita* @ 200 ml/l for 48 h was not affected. Ahmed and Eapen [7] Reported that oil of clove at 25 to 100 ppm concentration and acetone extracts of pepper against "rice weevil" *S. oryzae* and "lesser grain borer" *R. dominica* did not showed any adverse effect on seed viability of wheat grain.

Studied effect of plant essential oils viz. "Eucalyptus" (*Eucalyptus globulus*), "Camphor" (*Cinnamomum camphora*) and "Lemongrass" (*Cymbopogon citratus*) at different concentrations (0 to 20 ml/l) on seed germination and seedling growth of "congress grass" *Parthenium hysterophorus* and reported that all essential oils significantly reduced seed germination. Studied allelopathic effect of essential oil of "eucalyptus" (Eucalyptus globules) against two weeds "prostrate amaranth" (*Amaranthus blitoides*) and "doob grass" (*Cynodon dactylon*) at (0.5, 2, 3.5 and 5 ml/ml in laboratory and 0.25, 0.5, 0.75 and 1 v/v – in greenhouse) and found that germination percentage, germination rate, radicle length, plumule length, seedling height, primary root length and primary pedicle length, significantly decreased under both conditions. The highest inhibitory effect of essential oil was observed in '*A. blitoides*'. Eucalyptus oil concentration decreased seedling height in '*A. blitoides*'.

Vishavkarma and Mittal [15] studied the bioherbicidal potential of essential oil (25 to 250 µg/ml) of "horn cap eucalyptus" (*Eucalyptus tereticornis*) against "barn yard millet" (*Echinochloa crus* – galli L.) on percent germination, root length and shoot length development chlorophyll, protein and carbohydrate content and percent cellular respiration and found that *E. tereticornis* suppressed the growth and affects the physiology of the test plant at 100 and 250 µg/ml and further reported that oil affects seed germination and seedling development of weed.

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