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Synergistic integration of *Citrus aurantium* essential oil and gamma radiation: A strategy for optimizing radiation in effective control of *Sitophilus oryzae* and *Tribolium castaneum*

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INTRODUCTION & AIM

- Stored-grain insect pests, such as *Sitophilus oryzae* and *Tribolium castaneum*, cause significant post-harvest losses worldwide. Conventional control methods primarily rely on synthetic fumigants, which pose environmental and health risks and contribute to the development of pest resistance.
- Gamma radiation has emerged as a promising alternative, while plant-derived essential oils offer potential as eco-friendly bioinsecticides.
- This study aims to evaluate the efficacy of combining sublethal doses of Cobalt-60 gamma radiation with *Citrus aurantium* essential oil (CAEO) as a sustainable pest management approach, reducing the need for high-dose irradiation and synthetic chemicals.

METHOD

Insect species studied:
Sitophilus oryzae
Tribolium castaneum

Gamma irradiation was applied using a Cobalt-60 source at a dose rate of 3.983 kGy/h across 20 dose levels ranging from 100 Gy to 2000 Gy.

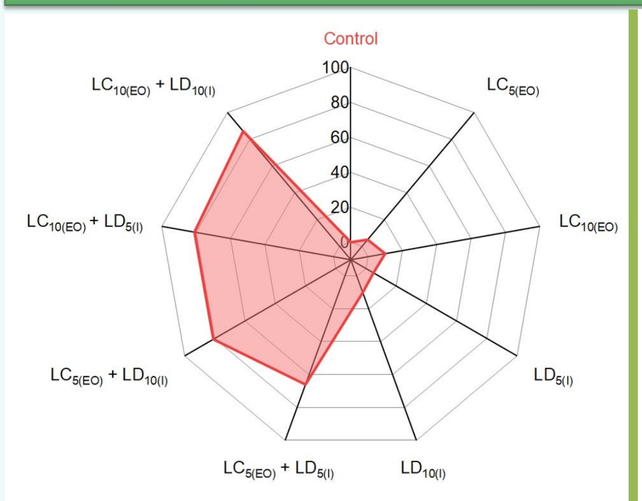
Fumigation with *Citrus aurantium* essential oil (CAEO) was conducted at five concentrations, ranging from 16.66 µL/L of air. to 100 µL/L of air.

Sublethal doses (LD_5 and LD_{10}) and concentrations (LC_5 and LC_{10}) were calculated by Probit analysis after 72 hours of treatment

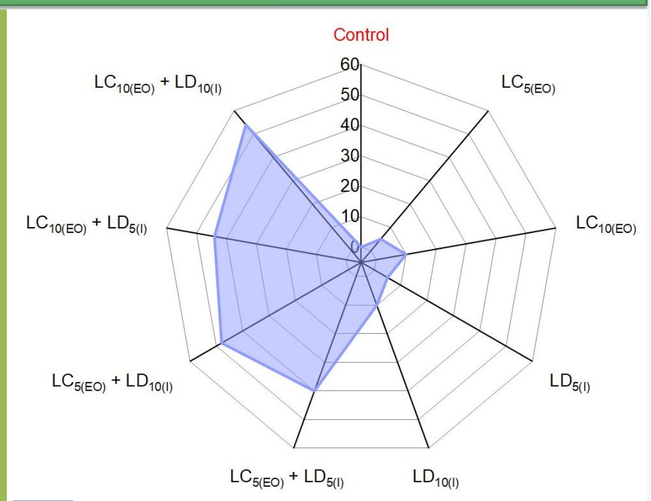
For *S. oryzae* and *T. castaneum*, radiation doses of LD_5 and LD_{10} were combined with CAEO concentrations of LC_5 and LC_{10} respectively.

Mortality was assessed 72 hours post-treatment. Synergistic interactions between gamma radiation and CAEO were evaluated using calculated synergism indices.

RESULTS & DISCUSSION



Sitophilus oryzae



Tribolium castaneum

Figure 1: Comparison of the effects of combined treatments with *Citrus aurantium* essential oil and gamma radiation on mortality of *Sitophilus oryzae* and *Tribolium castaneum*

	Sitophilus oryzae		*Tribolium castaneum*		
Concentration / Dose	LC_5 = 5.32 µL/L air	LC_{10} = 9.20 µL/Lair	Concentration / Dose	LC_5 = 3.87 µL/L air	LC_{10} = 9.41 µL/Lair
LD_5 = 260 Gy	0.488 (Synergism)	0.468 (Synergism)	LD_5 = 598 Gy	0.482 (Synergism)	0.530 (Synergism)
LD_{10} = 305 Gy	0.494 (Synergism)	0.473 (Synergism)	LD_{10} = 710 Gy	0.559 (Synergism)	0.567 (Synergism)

Figure 2: Synergistic effect of combined treatments related to *Sitophilus oryzae* and *Tribolium castaneum*

- The mortality percentage is higher in the integrated strategy by exerting a synergistic effect rather than single strategy.
- The doses and concentrations are lower in the integrated strategy than when they implemented as single treatments.
- Radiation doses used remained below the IAEA's 1000Gy threshold, indicating safety compliance and reduced irradiation requirement.

CONCLUSION

Combining sublethal gamma radiation with CAEO significantly enhanced mortality in both *S. oryzae* and *T. castaneum*, reducing the necessary radiation dose in single treatment by approximately four-fold and three-fold respectively. This integrated approach provides an effective, environmentally friendly alternative to synthetic fumigants for stored-grain pest control within safe radiation exposure limits.

FUTURE WORK

- Evaluate long-term reproductive inhibition and sublethal effects on insect physiology
- Explore additional plant essential oils and synergistic potential with gamma radiation
- Develop nano-formulations incorporating *Citrus aurantium* essential to enhance its stability and sustained release which enable prolonged and effective pesticidal activity over time

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