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Copper nanoparticles: Insecticidal action, resistance management and effect on endosymbiont abundance in olive fruit fly *Bactrocera oleae*

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The effectiveness of copper containing nanoparticles (Cu/CuO-NPs) against insecticide-resistant olive fruit flies (*Bactrocera oleae*) and their impact on the insect's reproductive and endosymbiotic parameters were evaluated. The insecticidal activity of both nano and bulk copper [Cu(OH)₂] was comparable or greater than that of the reference insecticide deltamethrin at recommended doses as revealed by feeding experiments. A significant synergistic effect between Cu-NPs or CuO-NPs and deltamethrin was observed in terms of adult mortality. Furthermore, the deltamethrin + Cu-NPs combination decreased the total number of offspring as compared with the untreated control. The above combination also significantly decreased the mean number of stings, pupae, female and total number offspring of the surviving female, compared to deltamethrin applied alone. The abundance of the *Candidatus Erwinia dacicola*- a *B. oleae* larvae bacterial gut endosymbiont- was adversely affected by bulk and nanosized copper. Concluding, Cu-NPs have a great potential to control insecticide-resistant *B. oleae* populations by reducing adult and larval survival and fecundity, and provide the means for reducing the environmental footprint of pesticides by minimizing their required doses.

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