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Biological effects of nano-metal oxides on saffron corm mite *Rhizoglyphus robini* (Astigmata: Acaridae) and their side effects on predator mite *Gaeolaelaps* sp.

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Abstract

The saffron corm mite, commonly found in all the cultivated saffron producing areas could decrease saffron economic value. Newly, Metal oxide Nanoparticles have been introduced as novel pesticides Due to the capability and versatility, they are important in reducing the use of pesticides. This study was conducted as an effective and environmentally-friendly method to control the growth of saffron corm mite. The lethal and sublethal effects of metal oxide nanoparticles (MNPs) including Copper Oxides (CuO), M*agnesium* O*xide* (MgO), Zinc Oxide (ZnO), Titanium dioxide (TiO_2), and Iron Oxide (Fe_3O_4) which their lethal concentrations ranged between 159.2 and 1036.4 mg L^{-1} were studied on *R. robini* adult females. The contact effect of the tested MNPs was evaluated using the corm dip bioassay method. Bioassays showed that the LC_{50} contact toxicity of the CuO treatment (229.1 mg L^{-1}) was higher than other MNPs. To assess the sublethal effects of the MNPs, adult females were exposed to the LC_{25} concentration of MNPs, and life-table parameters of the surviving bulb mite were investigated. The exposure to sublethal concentrations of the tested MNPs prolonged the egg duration, larval period, and nymphal period significantly when compared to the control mites (P<0.05). Compared to other MNPs or control mite, nano-MgO and nano-TiO_2 led to the longest duration of the total immature stages (11.32 and 11.32, respectively). The net reproductive rate (R_0), the intrinsic rate of increase (r), the finite rate of increase (λ), and the generation time (T) were significantly different between control and MNP treatments. The population exposed to ZnO, MgO, and TiO_2 had a much lower r value (0.164, 0.164, and 0.171 d^{-1}, respectively) compared to the control population (0.231 d^{-1}) and those exposed to Fe_3O_4- and CuO (0.180 and 0.176 d^{-1}, respectively). Also, discover simple and low-cost innovative mass rearing techniques and use the capacities of *Gaeolaelaps aculeifer* to control soil pests have highly importance. For mass production of this predatory soil mite, three growth environments were evaluated. Saffron corms and layered potatoes and the mixture of "cocopeat+perlite and saffron chaff" was used. The results showed that the *G. aculeifer* population was increased within 30 days, up to 27-fold gradually. This method gives saffron growers the choice to improve biological control of bulb mites in saffron fields. Our findings in evaluation of the sublethal effects of ZnO-NPs (313.9 mg L^{-1}) and CuO-NPs (229.1 mg L^{-1}) on the life table and predation rate of *G. aculeifer*, showed that the treatments significantly prolonged the duration of *G. aculeifer* immature stages. Relative to the control, exposure to ZnO-NPs increased the longevity of female adults by 3.7 days (P<0.05). However, we observed that CuO-NP and ZnO-NP had no significant effect on the GRR, R_0, r, and λ, but ZnO-NP caused a significant increase in the mean generation time (T) (P<0.05). In comparison to control predators, there was a significant reduction in the predation rate when *G. aculeifer* was offered prey previously exposed to ZnO-NPs and CuO-NPs. We concluded that ZnO-NP and CuO-NP are marginally compatible with the use of *G. aculeifer* in the integrated management programs against *R. robini*.

Keywords: Fecundity, Integrated pest management, Saffron, Nanopesticides, Toxicity, Bulb Mite