Research Article

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Effects of ZnO nanoparticles and Kaolin in combination with NeemAzal-T/S against *Bemisia tabaci* and its parasitoid *Eretmocerus mundus* on cotton

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ABSTRACT

The cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is an important pest of cotton which by transmitting plant pathogenic viruses cause damage and reduce lint quality. To reduce the use of chemical insecticides, effects of ZnO nanoparticles, Kaolin alone or in pairwise combination with NeemAzal-T/S against egg and second instar nymph of *B. tabaci* and pupae of its parasitoid *Eretmocerus mundus* Mercet were evaluated. The LC_{50} values of ZnO NPs, Kaolin and NeemAzal-T/S against eggs and nymphs of *B. tabaci* were 7.49 mg L^{-1}, 24.89 g L^{-1}, 6.83 mg L^{-1} AZA and 6.93 mg L^{-1}, 18.36 g L^{-1} and 6.00 mg L^{-1} AZA 3 days after treatment, respectively. The LC_{50} values of ZnO NPs, Kaolin and NeemAzal-T/S against *E. mundus* were 11.30 mg L^{-1}, 41.59 g L^{-1}, 36.90 mg L^{-1} AZA, respectively 3 days after treatment. In the laboratory conditions, ZnO + NeemAzal and Kaolin + NeemAzal exerted a higher level of control on eggs and nymphs of the pest than either alone, while they had a lower level of negative effects on the parasitoid pupae, too. In the field conditions and at 7 DAT, Kaolin + NeemAzal was the most effective treatment on eggs of the pest, causing a 67.43% reduction, while NeemAzal-T/S was the most effective treatment on nymph (86.52% reduction), which was not different with ZnO + NeemAzal and Kaolin + NeemAzal. NeemAzal and ZnO exerted the highest and lowest mortality on pupae of the parasitoid, respectively. Based on the field studies, ZnO NPs at 20 mg L^{-1}, Kaolin at 30 g L^{-1}, NeemAzal-T/S at 15 mg L^{-1} AZA and mixing equal volumes of NeemAzal-T/S (7.5 mg L^{-1} AZA)+ZnO NPs (10 mg L^{-1}) and NeemAzal-T/S (7.5 mg L^{-1} AZA)+ Kaolin (15 g L^{-1}) can be suitable candidates in IPM programs of *B. tabaci* field condition.

1. Introduction

Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae) is a serious pest of over 600 different plant species of vegetable and ornamental crops including cotton, eggplant, tomato, beans, soybean and broccoli in many countries [1, 2]. Both adults and nymphs of *B. tabaci* causes direct damage through ingestion of phloem sap or indirect damage by encouraging the growth of sooty mould and by transmitting of over 110 plant viruses [3]. Because of development resistance in *B. tabaci* populations to different classes of insecticides, and negative environmental impacts of chemical insecticides, alternative pest management strategies should be developed to control this pest [4, 5]. *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) is a primary ecto-endo parasitoid of whitefly nymphs [6], this parasitoid is usually unable to maintain whitefly populations below economic injury levels, therefore supplemental treatments are often need in field conditions [7, 8]. In recent years, the application of nanotechnology in insect pest management has been underlined [9]. Nanoparticles (NPs) are ultra-fine particles which have at least one dimension less than 100 nm. NPs are more reactive than their bulk counterpart because of their increased surface to volume ratio [10] and a number of physical properties

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