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Inhibition of *Fusarium oxysporum* growth in banana by silver nanoparticles: In vitro and in vivo assays

PROBLEM

Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *cubense* (Foc), is a destructive disease that threatens banana production worldwide. With limited effective chemical treatments and increasing pathogen resistance, there is a pressing need for innovative, sustainable alternatives to protect one of the most consumed fruits globally.

Fig 1. Symptoms of Fusarium wilt on banana plants.

GENERAL OBJECTIVE

To evaluate the antifungal potential of the different silver nanoparticles (AgNPs) against Ecuadorian strains of Foc race 1 using both in vitro and in vivo assays, analyzing their efficacy for combating banana disease.

PROPOSAL

Three formulations of AgNPs (Argovit-1220, Argovit-1221, and Argovit-C) were evaluated for their antifungal activity against four Foc race 1 strains isolated in Ecuador (EC15-E-GM1, EC19-LR-GM3, EC35-G-GM6, and EC40-M-GM2). In vitro assays were conducted using 96-well plates to assess fungal growth inhibition and calculate IC50 values. In parallel, in vivo experiments were performed under greenhouse conditions using Gros Michel. The AgNPs were applied either by foliar spraying or root drenching to evaluate disease suppression. Two inoculation techniques were used: root dipping and substrate drenching.

IN VITRO

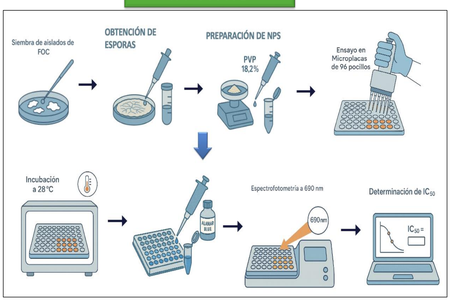

Fig 2. Protocol Overview: In Vitro Screening of AgNPs on Foc Strains.

IN VIVO

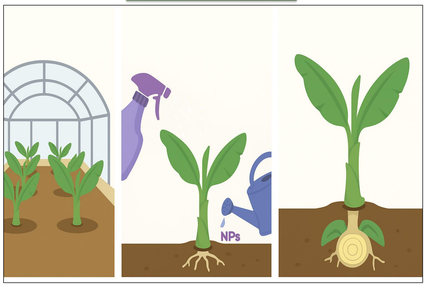

Fig 3. Protocol Overview: In Vivo Screening of AgNPs on Foc Strains.

RESULTS

- **In vitro**: All AgNPs exhibited strong antifungal activity, with over 95% inhibition achieved at 25 mg/L. Argovit-C showed the lowest IC_{50} values, indicating higher potency. The strain EC35-G-GM6 was the most resistant.
- **In vivo**: When applied via foliar spray or root drenching, the AgNPs significantly reduced Fusarium wilt symptoms. Disease inhibition ranged from 35% to over 83%, depending on the application method and nanoparticle formulation. The root dipping method followed by AgNP application was the most effective, particularly with Argovit-1220, which consistently showed the highest levels of disease suppression (up to 83%).

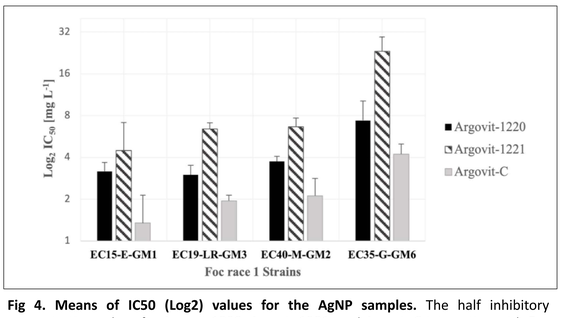

Fig 4. Means of IC50 (Log2) values for the AgNP samples. The half inhibitory concentration values for Argovit-1220, Argovit-1221, and Argovit-C interacting with Foc race 1 strain: EC15-E-GM1, EC19-LR-GM3, EC35-G-GM6, and EC40-M-GM2.

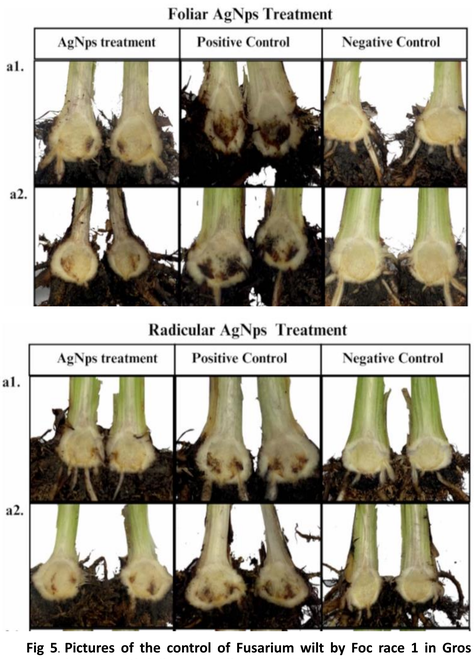

Fig 5. Pictures of the control of Fusarium wilt by Foc race 1 in Gros Michel plants with foliar and radicular AgNPs application.
a1. Argovit-1220 with root dipping inoculation, **a2**. Argovit-1220 with drench inoculation

CONCLUSIONS

- AgNPs demonstrated significant antifungal activity against *Fusarium oxysporum* race 1, both in vitro and under greenhouse conditions.
- AgNPs demonstrate high efficacy at low concentrations, offering a promising alternative to conventional fungicides, which are often ineffective or environmentally harmful.
- These findings support the use of nanotechnology as a promising tool for developing next-generation plant protection products.
- Future studies should focus on optimizing formulations for field conditions, understanding long-term environmental impacts.