Vol.1 Issue-6, February 2021

JUST AGRICULTURE
multidisciplinary e-Newsletter

Revolutionizing the use of copper nanoparticles in agriculture for plant disease management

Deepika Sood[1] and Sunita Chandel[2]

[1]PhD Scholar, Department of Plant Pathology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP

[2]Professor, Department of Plant Pathology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP

ARTICLE ID: 010

INTRODUCTION:

The fabrication of pesticides in cost-effective and eco-friendly ways is particularly important for agriculture. Plant pathogens like fungi, bacteria, viruses etc. are producing many economic and ecological problems worldwide, which must be controlled with potent strategies. It's been rightly stated that nanotechnology is the only magical spell, which has a potential to revolutionize the current food and agriculture industries. It can be achieved by the development of various nanotechnological strategies including the nano-based products to overcome the problems associated with food and agricultural loss. The remarkable antimicrobial potential of various metal nanoparticles may be applied for the development of novel nanoantimicrobials (antiviral, antibacterial, fungicidal, and pesticidal agents, etc.), which can be used as an effective tool for the management of plant diseases. Among the various metal nanoparticles, silver (Ag), copper (Cu), and zinc (Zn) nanoparticles are preferentially used as antimicrobial agents. Out of these, silver is expensive metal, and hence, the cost involved in the preparation of silver nanoparticle-based products would be higher. On the contrary, Cu is comparatively cheaper and ubiquitously available. Therefore, the use of copper nanoparticles (Cu NPs) in various agricultural applications is cost effective.

The green synthesis of copper nanoparticles (Cu NPs) from plant extracts which is a novel and fancy approach has finds its way in plant disease protection thus reducing the dependency on the copper fungicides which are used in abundance in mitigating losses due to many pathogens. Interestingly, plant extracts can serve as one of the most cost effective and eco-friendly material for synthesis of nanoparticles as the chemical methods used have a low productivity, non eco-friendly, capital intensive and toxic.

SYNTHESIS OF COPPER NANOPARTICLES:

Preparation of medicinal plant extract for Cu nanoparticles synthesis:

The fresh leaves of plant are to be collected and washed thoroughly using distilled water to remove impurities. The cleaned leaves are subsequently dried under sunshade to remove moisture completely, then powdered by using mechanical grinder and stored. Five (g) of powdered plant leaves are taken into a beaker/container along with 100 ml of distilled water and allowed to boil at 60 °C for 30 min under reflux condition. It is cooled down to room temperature. The prepared solution is filtered thereby powdered leafy materials filters out to get clear solution. The filtrate is stored at 4 °C for future works.

Synthesis of Cu nanoparticles from medicinal plant extract:

25 ml solution of leaf extract is introduced drop wise into 100 ml of 1 mM (0.001 mM) solution of copper sulphate under continuous stirring. After the complete addition of leaf extract, the mixture is kept for incubation for 24 h at room temperature. Within a particular time, the green colour of solution changes into straw yellow, which indicates the formation of copper nanoparticles. Then the solution is centrifuged for 15 min at 10,000 rpm and dispersed in double distilled water to remove any unwanted biological materials.

The application of Cu nanoparticles formulation is done as foliar sprays at effective concentrations viz. 5, 10 and 15 µl/ml.

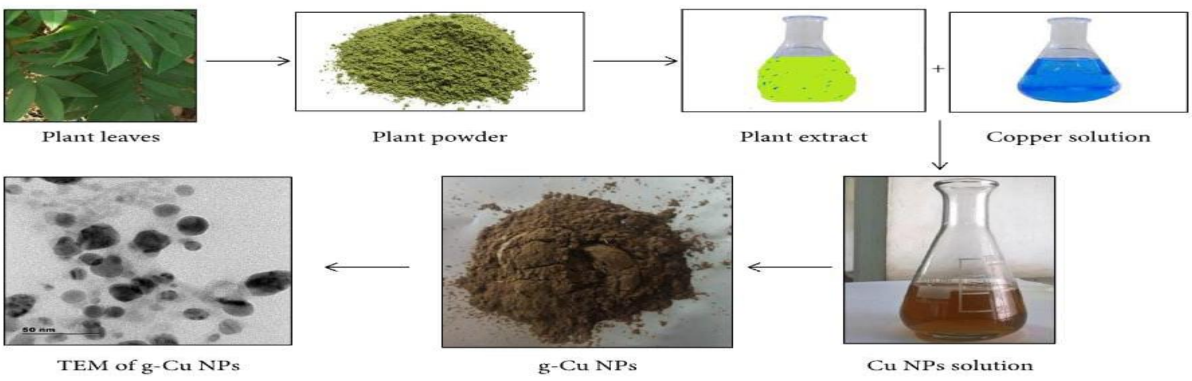

Fig. 1 The scheme of synthesis of g-Cu NPs (Ananda Murthy *et al.*, 2020)

MECHANISM INVOLVED IN ANTIMICROBIAL ACTION OF Cu NANOPARTICLES:

The mechanism of antimicrobial action is not well understood but a few reports are available on the mechanism concerning the antimicrobial action of Cu NPs. Cu NPs interact with the microbial cell wall because of its affinity toward the carboxyl group present on the microbial surface. Generation of reactive oxygen species (ROS), membrane damage, loss of enzyme activity, protein dysfunction, etc., are accountable for the antimicrobial action of nanoparticles. When Cu NPs come in contact with a bacterial cell, it releases Cu ions, which are absorbed on the cell wall leading to the generation of ROS and loss of membrane integrity. Similarly, Cu NPs are also responsible for the disruption of cellular metabolic pathways, formation of pits in a membrane, development of oxidative stress, which eventually cause cell death.

COMMONLY USED PLANT EXTRACTS FOR Cu NPs SYNTHESIS:

Many plant parts or whole plants have been used for the green synthesis of Cu NPs due to the presence of a large number of bioactive compounds in them. The extracts of plants have been efficiently applied for this purpose. Synthesis of Cu NPs has been successful with extracts of various parts of plant species that include *Punica granatum* peel, *Zingiber officinale* stem, *Citrus medica Linn.* (Idilimbu) juice, *Ziziphus spina-christi (L.)* Willd fruit, *Asparagus adscendens Roxb.* root and leaf, *Eclipta prostrata* leaf, *Ginkgo biloba Linn* leaf, *Plantago asiatica* leaf, *Thymus vulgaris* L, black tea leaf, *Terminalia catappa* leaf, *Azadirachta indica* leaf etc.

MANAGEMENT OF DISEASES:

The use of Cu in agriculture is the well-known application as a plant protector against diseases caused by fungi and bacteria. The nano-copper is used against *Xanthomonas axonopodis* pv. *punicae*, a causative agent of bacterial blight in pomegranate. It inhibits the growth of bacterium at 0.2 ppm only, i.e. >10,000 times lesser than it is generally suggested for Cu-oxychloride. Cu with chitosan complex nano-gels is reported to inhibit the growth of cereal plant pathogenic fungus *Fusarium graminearum* due to their synergistic effect. These nano-hydrogels can be considered as a new generation of Cu-based bio-pesticides because of their bio-compatibility. There is inhibitory effect of biogenically synthesized Cu NPs on the development of *F. oxysporum*, *Fusarium culmorum*, and *F. graminearum also*. The nano-based products such as nano-pesticides, nano-fungicides, nano-insecticides, etc., are already in the market, while many others are under the developing stage.

CONCLUSION:

The green copper nanoparticles (g-Cu NPs) are successfully synthesized by using medicinal plant extract. These green-synthesized Cu NPs exhibits high antifungal and antibacterial activity. Their mechanism of microbial growth inhibition involves the damage of cell membranes and the intracellular production of ROS. This article proposes a facile and cheap green-synthesis method for the production of Cu NPs with high antimicrobial activity. Thus, this nanomaterial could be useful for controlling pathogens that affect agricultural crops and forest species globally.

FUTURE PERSPECTIVES:

Cu is one of the most essential elements required by the plants. Cu NPs shows potential activity against pathogens and insect-pests of crop plants and, hence, can be used in the novel formulation such as Cu NP-based nanopesticides, nanoherbicides, and nanofertilizers, which will be required in lower quantity. It can also minimize the toxicity problem due to excessive use of pesticides generally experience with its injudicious use. Cu NP-based biosensors can be used for the management of pests and also in the detection of pathogens responsible for crop damage. Finally, the use of Cu NPs may revolutionize the field of food and agriculture industries.