М.А. Гендельманның 110 жылдығына арналған «Сейфуллин оқулары – 19» халықаралық ғылыми - практикалық конференциясының материалдары = Материалы международной научно-практической конференции «Сейфуллинские чтения – 19», посвященной 110-летию М.А. Гендельмана». - 2023.- Т. I, Ч. IV. – Р. 268-272.

UDC№63.630*232.13

THE EFFECTS OF NANOPARTICLE APPLICATIONS ON THE FOREST TREE SEEDLINGS

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Abstract: Nanotechnology is associated with different fields of science. Nano technology is used for 0.1-100 nm dimensions. The technology is to produce, characterize and functionalize biological and non-biological structures smaller than 100 nm. Nanoparticles are important when considering their environmental impact. The increase in the usage areas and applications of nanoparticles causes a significant increase in their interaction with the environment. They are also widely used in research on plants due to their role in establishing the connection between soil and environment. Therefore, it is important to know the transport mechanism and effects of NPs. Nanoparticles shoots, leaves and roots through which they can enter the plant. In addition, they can carry these substances in their metabolism and accumulate in some plant storage components. The effect of each nanoparticle on each plant may differ from species to species.The effects of nanoparticles can be negative as well as positive. It has even been stated in published studies that no effect was observed. In this paper, it is aimed to examine the results of the studies on the usability of nanoparticles as a supporting element in plant breeding and breeding techniques. Especially the effects on forest tree seedlings will be emphasized.

Keywords: seedling, morphology, nanoparticle, afforestation, breeding

INTRODUCTION

Nanosized materials find use in many fields with their strong physical and chemical properties (Rao et al., 2005; Gürmen and Ebin, 2008; Ayan et al. 2021). The dimensions of these materials are below 100 nanometers (Miller et al., 2004). According to the plant species, the effect of nanoparticles on the plant differs in nanoparticle concentration. However, it has different effects during plant growth periods (Nair et al., 2011; Ma et al., 2010). NPs produced from gold, selenium, titanium, zinc, iron, platinum, palladium in nanoparticles have properties such as anticancer, antimicrobial, antiviral and are used in a wide variety of fields (Kumar Mittal et al., 2013) (Figure 1). It has very wide usage area. Nanoparticles (NP) it adds an economic value (Tunca, 2015). It has found a wide application area especially in medicine, pharmacy, construction, cosmetics, optics and electronics sectors (Kaweeteerawat et al., 2015).

Soil plays an important role in studies with plants, as they provide the nutrients necessary for NP applications from the soil in studies on plants. How NP is transported on the plant and its effect on the plant are becoming more and more important (Du et al., 2011; Kundu et al., 2015). The use of nanoparticles in forestry has gained importance in recent years. Some studies have been done determine the effects of nanoparticles in forest tree seedling especially seed germination by using the seeds of Turkish pine (*Pinus brutia* Ten.) (Ayan et al., 2021), Anatolian black pine (*Pinus nigra*) (Çelikbaş, 2019a) and Scots pine (*Pinus sylvestris*) (Çelikbaş, 2019b) (Eskiömer, 2022).

Depending on the nanoparticle structure and plant anatomy, nanoparticles are absorbed by the plant root surface, taken by the roots and transported to the stem via the vascular system (Ma vd., 2010) (Figure 2).

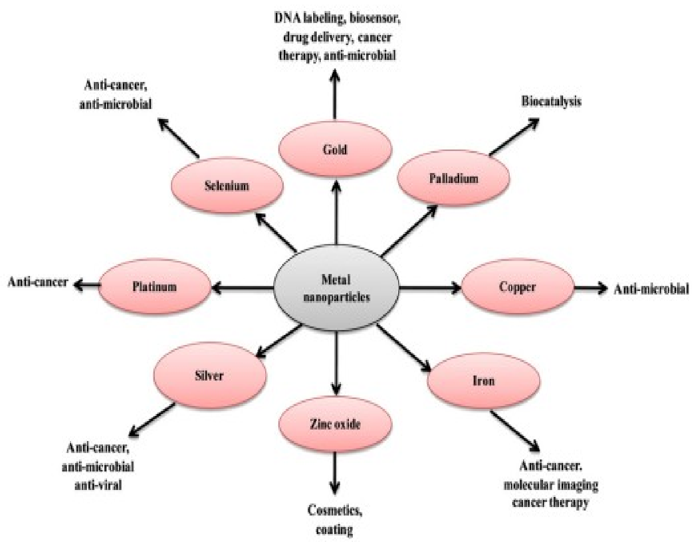

Figure 1. Types of metal nanoparticles and their applications in biotechnology (Kumar Mittal vd., 2013).

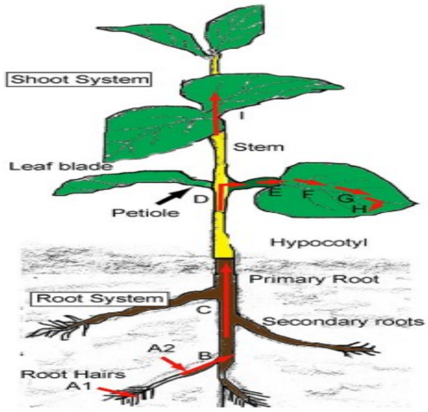

Figure 2. An outline and fundamental idea behind how plants absorb, move, and accumulate nanoparticles. Primary roots (A2) or lateral roots can take up nanoparticulate substances found in the natural world (A1 and then B). From the root (C), to the stem (D and I), and finally to the leaf, these nanoparticles are carried (E, F, G, H). Nanoparticles may be adsorbed on the surface of roots as well (Ma vd., 2010).

Through establishing complexes with aquaporins, ion channels, endocytosis, or organic substances, NPs enter plant cells. NPs engage in a lot of environmental interaction due to their small size. By combining with membrane transporters and root secretions to create complexes, NPs are also delivered to the plant. NPs are nonetheless also carried inside of cells in apoplastic or symplastic forms. According to the study's findings, NP structures that manage to get this far can be carried through phloem and xylem and build up in various tissues in plant beings (Cifuentes et al., 2010).

Reactive oxygen species can develop in nanoparticles as a result of them. In order to achieve good results in the resistance against abiotic and biotic stresses, especially in the field of agrinanotechnology, and to know their impacts on plant physiology, it is crucial to understand the effects on plants.

In particular, during the past 15 years, researchers have asked whether these materials, which are used in various industries and have an impact on the environment, have beneficial or detrimental consequences on the ecological system. Determining how nanoparticles affect the physiology of seed germination in forest tree seeds is crucial for safeguarding the sustainability of our country's forest resources.

RESULTS

It has been demonstrated in the studies that various nanoparticles can affect seed germination in a variety of ways. The findings of the results of the dissertation studies are summarized.

In the doctoral study carried out by Atik (2008); It was stated that natural substances made more diameter development in 2+0 aged oriental beech seedlings compared to control seedlings.

Kırdar and Allahverdiev (2003) in their research on the morphological characters of Polystimulin A6 application in eastern beech saplings; Polystimulin A6 was applied to the saplings in 4 different concentrations. As a result of the study; had the highest FB and CBD in the 200 ml/l extraction process. In addition, it was stated that higher values were obtained when the other morphological characteristics of the treated seedlings such as FKA, Root %, number of leaves were compared with the control seedlings.

Çelikbaş (2019a) Eight different nanoparticles were used, in which Anatolian black pine seeds were used as research material, in petri dishes, in the climate cabinet and in viols at room conditions. These; Silica, Fe_2O_3, Magnetite Fe_3O_4, ZnO, TiO_2, Au, CuO, Ag. As a result of this thesis; it has been observed that Ag, Fe_3O_4, Fe_2O_3, ZnO and Silica nanoparticles have a positive effect at high concentrations and low concentrations of CuO_2 and TiO_2 Np. In the experiments they set up on Pinus nigra seeds type viols, in NP applications; they found the highest root collar diameter development in Silica and TiO_2 NP applications.

Thesis studies applied in *Pinus nigra* and *Pinus slyvestris* species, they found that 1200 mg/l and 2000 mg/l doses had a positive effect on germination and growth (Çelikbaş, 2019a; 2019b). In a study conducted by Lin et al., (2007), it was observed that the application of 2000 mg/l ZnO NP to the corn plant had an encouraging effect on germination and root development. However, plant seedlings showed physiological responses to NPs during germination, but the effect of seed germination and root growth differed significantly between plants and NPs (Hao et al., 2016).

Muhammed (2022) stated that nanoparticles (NP) in bare-rooted 2+0 old Scots pine seedlings It was aimed to determine the degree of effect on morphological characters. Field trial in the study; four different Iron Oxide (Fe_3O_4), Copper Oxide (CuO), Zinc Oxide (ZnO) and Titanium Oxide (TiO_2) NP types, in three different doses and as controls measurements were carried out. NP solutions were prepared in the laboratory and applied to the root zone of the seedlings in the field before planting. In the study, all morphological measurements of the seedlings were carried out during the vegetation period. According to the control group in *Scots pine* seedlings in the field environment; NP applications morphological characters made a positive difference. The survival rate of the TiO_2 group seedlings was 95%, and the survival rate of the control seedlings was 61%. NP varieties and doses were measured on variables such as seedling height, root collar diameter, seedling fresh and dry weights, robustness index and hardiness index.

Fırat (2020) mentioned that It was carried out in the natural Turkish pine stand located in the transition region from the Central Anatolia Region to the Western Black Sea Region. In the region where continental climate effects are dominant; Silica, Fe_2O_3

(Iron (III) oxide), Fe_3O_4 (Magnetite), ZnO (Zinc Oxide), TiO_2 (Titanium Oxide), Au (Gold), CuO (Copper Oxide) and Ag (Silver) nanoparticles (NP) of five different doses (very high, high, medium, low, very low) germinated under natural conditions. The effects of Turkish pine seeds on seedling percentage and seedling growth were investigated. It was determined that all NP varieties and doses applied on the seedlings of the Turkish pine seedlings formed by planting 1+0 aged seeds, had a negative effect on seedling height, root collar diameter and seedling percentage.

It may be advised to apply nanoparticles to the grown seedlings in nurseries that send seedlings to semi-arid, arid afforestation areas based on the finding that nanoparticles improve the root diameter values, which are more significant for the survival rate of seedlings in lands with extreme conditions.

Based on the finding that nanoparticles improve root collar diameter values, which is more significant for the percentage of seedling survival in places with harsh conditions, it may be advised to apply nanoparticles to the grown seedlings in nurseries that send seedlings to semi-arid, arid afforestation areas.

CONCLUSIONS

The results obtained will shed light on new projects on the usability of NP applications in forestry in afforestation studies. In addition, the results obtained from the studies can be used to determine the positive and negative effects of NPs and application doses in terms of plant growth. Due to the characteristics of NPs that may aid in plant development, such as increasing water entry in plants, feeding from the seed coat, and accelerating germination (Savithramma et al., 2012), it is seen to be a prospective field for additional and in-depth research on forest trees, particularly for sapling production and afforestation studies. It is necessary to develop researches to determine the appropriate doses of different nanoparticles in metabolism on the basis of each species.

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