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Concept note

Scale-up cultivation of medicinal plants by agricultural nanotechnology and Vrikshayurveda

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ABSTRACT

The significance of the cultivation and conservation of plants and crops is increasing day by day due to the increasing population and requirements. So, agriculture is one of the ways that can be used for the scale-up of plants. Nowadays different agricultural techniques are developing for the sustainable development of plants. Along with crops, the cultivation of medicinal plants is also an area where we must focus because the demand for herbal products is gaining popularity. Traditional methods of cultivation are mentioned in different Ayurvedic classics. Vrikshayurveda is a special branch of Ayurveda which speaks about the importance of plants. If advanced techniques are in cooperation with traditional methods, it will be an advantage for the agricultural sector. Nanotechnology is one of the sciences which are gaining dominance in every field of the universe. It is the technology which alters the character of a material by changing it into a very minute nano level. Agriculture is one of the branches which utilizes the different methods of nano-techniques such as nano-priming, nano-fertilizers, nano-pesticides, nano-herbicides, nano-growth promoters and so on. Different methods given in this article are taken from various classical books mentioning the cultivation of plants in Ayurveda, and articles about the research in nanotechnology, agricultural techniques and practices. Different concepts related to various gunas (attributes) are mentioned in Ayurveda for drugs like sukshma (subtle) and tikshna (intense). These are helpful in developing biogenic nanoparticles using different herbal drugs for cultivation, diagnosis and treatment which will make no harm to both environment and humans.

INTRODUCTION

Nanotechnology is gaining dominance in every field of the universe. Modifying particle size at the nanoscale level, which differs greatly from the macro stage, is what nanotechnology entails. It incorporates numerous physics, biology, and chemistry concepts. Agriculture is one of the industries adopting various nanotechnology techniques. Agriculture production needs to expand as well because of the growing human population. Because the consumption of substances is rising, it is important to maintain a balanced production of substances as well. This applies to both food products and medicinal plants. Because modern marketing and trading practices depend more on herbal products, there is an overuse of herbal drugs that are destroying their natural habitat. Herbal medications are being overused, which causes their natural environment to be destroyed. As a result, we have a focus on the emerging field of medicinal plant cultivation. Plants are used as medicine in the science known as Ayurveda.

Every plant in our environment has specific medicinal capabilities, according to ayurveda (Sharma and Das, 2004). Plant cultivation is therefore a crucial field. Ayurveda is referred to as the science of life since it considers not only human life but also plant life. The unique branch of Ayurveda designated for plants is Vrkshayurveda. This branch specifically discusses plant cultivation, plant diseases, treatment, biofertilizers, and other related topics. Other practices can modernise by incorporating the idea of nanotechnology into the traditional methods of plant cultivation because nanotechnology is effective in seed growth, fertilisers, crop protection, preservation, and other fields. By employing nano-pesticides and nano-fertilizers, we can increase productivity. By using nano-zeolites and hydrogels, soil quality can be improved. Nanomaterials can be used to stimulate plant growth, and nanosensors can be used to intelligently monitor plants.

Vrikshayurveda is mentioned in the Vedas, Arthasastra, Brihatsamhita, Upavana Vinoda, Surapala Vrikshayurveda, Krishiparasara, and other writings. The vrikshayurveda by Surapal is a thorough work on plant cultivation, illnesses, and treatment. In plants, it clarifies the Tridosha idea. This book contains chapters on the art of enjoying gardening, choosing soil, classifying and propagating plants, sowing seeds, planting and caring for

plants, and watering plants. It also contains chapters on protecting trees, building gardens, determining where wells can be dug, nourishing solutions, treatment for plants, Tridosas and botanical wonders. The right interpretation and accessibility of Vrikshayurveda can help with intercropping, the use of biopesticides, organic fertilisers, tissue culture, and other methods to create an eco-friendly environment. Tissue culture, monoculture, hydroponics, and aeroponics are a few of the more recent techniques used to cultivate plants. The Vrikshayurvedic texts include numerous techniques for plant cultivation and preservation. Here, in order to describe nanotechnological operations, we are using seed germination methods, nourishing solutions, illnesses, and treatment of plants (Lallanji, 2000; Suresh et al., 2013).

This write-up is based on different classical texts mentioning the concept of cultivation of medicinal plants in Ayurveda. Books and articles that deal with the concept of nanotechnology and agricultural nanotechnology have been reviewed in the present manuscript.

SEED GERMINATION TECHNIQUES

Seeds made from dried fruits naturally ripen during the season, which is then dusted with milk and dried for five days. Then it was smoked with vidanga and mustard seeds (*Embelia ribes*). You can also use tila (*Sesamum indicum*), cow dung, and brihati powder (*Solanum indicum*). At the cut end, plants that resembled sugarcane were plastered with a mixture of honey-clarified butter, hog fat, and cow dung. Spread clarified butter and honey on the bulbous roots (Jugnu, 2004). These are all the techniques that are outlined in the classics for successful seed germination. When analysing current procedures, a seed goes through three phases of germination. The first is imbibition, where a seed takes water and its innate metabolism is set off. The following phase is the active or lag phase, during which water absorption is restricted but metabolism speeds up due to the creation of enzymes important for embryonic growth, such as phytase, endoxylanase, and amylase (Pereira et al., 2021). The final stage is seed germination, during which the seed rapidly absorbs water and the expansion of the embryo results in the creation of radicles. Seed priming is a conventional process that uses a water-based methodology to hydrate seeds before drying them out or using other physical ways. Therefore, seed priming will aid in accelerating germination, enhancing the vigour of the seedlings, and shielding the seeds from biotic and abiotic challenges. Moderate stress is induced by both soaking and drying, which causes some stress-related reactions in the seeds.

Seed nano priming is a technology in which nanoparticles or materials are used to create suspensions rather than the water medium in conventional seed priming. However, the difference is that, while in conventional seed priming, the substances will adsorb into the seed, in nano priming, it will create a coating on seeds and perform the actions. This uses a variety of nanomaterials, including metallic, biodegradable, and polymeric particles. Both an active nanoparticle and a nanocarrier system are present. Active nanoparticles are those with the capacity to influence biology on their own by acting as stimulants, anti-pathogens, or both. The technology enables the extended release of the chemical over time when an active ingredient (biological or synthetic), whether it is contained in the nanoparticle itself or not, is loaded onto a nanocarrier with sustained release properties. Some of the metals that are frequently used as active materials are iron, manganese, and zinc. In biological nanoparticles produced by using biological extracts from plants, fungi, or bacteria, high concentrations of phytochemical compounds, including phytomolecules rich in hydroxyl and carbonyl functional groups, such as phenolics, flavonoids, terpenoids, sugars, and proteins, can be discovered. These compounds are natural reducing agents for metals and can act as capping to stabilise the nanoparticles in colloidal fluids. Green synthesis is more cost-effective than chemical synthesis, increasing biocompatibility and reducing the toxicity of chemical agents. When concentrated properly, nanoparticles or nanocarriers can pierce the seed coat, creating more pores that facilitate the flow of oxygen and water. By examining the characteristics and potential applications of nanotechnology, it is possible to use the principles described in the Vrkshayurvedic classics for seed germination (Jugnu, 2004).

NOURISHING SOLUTIONS FOR PLANTS

Manure application is necessary for plant nutrition. Nowadays, organic farming is becoming more and more popular. Fungicides are known to efficiently treat soil-borne illnesses in general and damping off in particular; but, due to their widespread use, resistant plant pathogen strains have developed as well as natural predators and parasites have gone extinct. As a result, it is necessary to change the current situation and adopt fresh, new ideas. Here, principles from vrikshayurveda are addressed. To promote inflorescence and fruitification, mix ghee with cold milk, sesame, goat and sheep excrement, barley powder, and meat. Before being poured around plant roots, it has to soak in water for seven nights. If the fruits of trees are destroyed, the growth of blossoms and fruits can be induced by pouring cold water over them after they have been cooked with kulattha (*Dolichos biflorus*), maasha (*Phaseolus munga*), mudga (*Vigna radiata*), barley and tila (*Sesamum indicum*) (Majumdar, 1935).

An organic manure formulation called kunapa jala is the subject of numerous studies right now. the process of turning organic wastes into fermented liquid manures. The most important development, reportedly a first in global agri-history, was kunapa jala. One or more key nutrients, such as nitrogen, phosphorous, and potassium, which are all necessary for plant growth, are present in substantial amounts in kunapa jala, a natural organic product made from animal and plant materials. Kunapa literally means "smelling like a dead or rotting." Animal faeces were gathered and stored according to Surapala's protocol when they were available. Although dead boar wastes were mentioned first, Surapala expanded the source of wastes to include other animals, notably those with horns. Since practically any animal excrement could be used to make kunapa jala, farmers had additional alternatives for obtaining their raw materials. Boil the meat, fat, and marrow of deer, pig, fish, sheep, goats, and rhinoceroses in water to prepare kunapa jala. Then, transfer the mixture to an earthen pot and add compound milk, sesamum oil cake powders, honey-boiled masha, pulse decoctions, clarified

butter, and hot water. There is no specific quantity for any of these components, but the mixture becomes kunapa when the pot is left in a warm setting for about a fortnight. While compost made from bird manures, bone meal, and other sources of phosphorus and potassium assists in regulating root, bud, flower, and fruit formation, cell division, sugar formation in the sap, chlorophyll production, and photosynthesis, as well as increasing crop resistance to pests and diseases. Blood, cottonseed, fish meal, and emulsion are good sources of nitrogen. These days, panchagavya is becoming more and more popular with kunapa jala. Panchagavya is a concoction of five products made from cows. Ingredients include milk, ghee, curd, cow dung, and urine. The last two are derivative products, but the first three are direct products. All of these products are sold under the Gavya brand name. It is applied to the soil with irrigation, as a spray, and as a treatment for seeds. Fresh cow products, including cow dung (3 kg), cow urine (3 L), cow milk (2 L), curd (2 kg), and cow ghee (1 kg), were gathered for the production of panchagavya. Five ingredients were combined in the necessary amounts, well combined in a container, and fermented for seven days while being stirred twice daily. Effective microorganisms in panchagavya are a mixture of beneficial microbes that exist naturally, primarily lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria, and certain bacteria. Chemolethotrops and autotrophic nitrifiers found in panchagavya flourish on the leaves, increasing ammonia consumption and total nitrogen supply. The effectiveness of each treatment varied, but panchagavya and kunapa jala were shown to be the most successful in terms of enhanced output, effective photosynthetic activity, and better leaf nitrogen use (Kumar et al., 2020). By boosting macronutrients, micronutrients, and helpful microorganisms, Panchagavya enhances soil fertility, leading to enhanced soil health. It enhances the soil's ability to hold water while also enhancing plant growth and nutrient uptake. It has been demonstrated scientifically that earthworms, their vermicast, and bodily fluid (vermiwash) protect and stimulate plant growth.

Products that supply nutrients to crops in the nanoscale range are known as nano-fertilizers. Due to surface tension, fertilisers with a surface coating of nanoparticles hold the materials firmly. The term "nano-biofertilizer" refers to a hybrid product created by reducing organic fertiliser (biofertilizer) to nano size (1-100 nm) with the aid of a specific nanomaterial coating (Mahapatra et al., 2022). Materials including metals, lipids, polymers, emulsions, silicates, etc. are utilised to create nano-particles. This formula will aid in the gradual release of nutrients to plants and encourage healthy plant development. It enhances the soil's nutritional processes by fixing nitrogen, promoting growth hormones, and boosting resistance to pathogens that cause pests and diseases. A large area of cultivation can use a modest amount of fertiliser. Drugs and other substances produced in biofertilizers as nano-biofertilizers form are more beneficial and environment friendly also.

DISEASES AND TREATMENT OF PLANTS

The next stage of planting is to protect them against illnesses and, if necessary, to administer treatment. Similar to humans, plants are susceptible to two different types of diseases: internal and external. The tridoshas i.e. vata, pitta, and kapha of Ayurveda are what cause internal and external influences by insects, weather and other factors. Vata diseases cause a plant to become narrow and bowed, with knots on the trunk or leaves, and hard fruits that are lacking in juice and flavour. Kapha ailments appear when trees are overwatered with sweet, oily, sour, or cold substances in the winter and spring. Plants will take a very significant time to produce fruit, which will also be pale, small, tasteless, and premature. End of summer, Pitta is characterised by the disappearance of the clouds and an excessive inundation of bitter, sour, salty, and potent flavours on the trees, yellowing of the foliage, early fruit loss, dryness, and pallor of the fruits, flowers, and leaves. Trees' leaves dry out, turn yellow, become overly pale, and lose their natural perfume when they are exposed to heat or when insects eat away at their roots (Majumdar, 1935). Trees can be killed by a variety of things, including fire, wind, constant shade, bird congestion, excessive creeper development, and weed growth. With flesh, marrow, ghee, and kunapa jala, Vata disorders can be treated. Kapha diseases can be treated by removing the soil surrounding the plant and replacing it with fresh soil, as well as by using bitter, astringent decoctions of brihat panchamula (*Aegle marmelos, Gmelina arborea, Premna integrifolia, Stereospermum suaveolens* and *Oroxylum indicum*), coating roots with white mustard paste, and watering them with a sesame and ash mixture. Eating cold and sweet foods can treat Pitta problems. Watering using decoctions of milk, honey, yashtimadhu (*Glycyrrhiza glabra*), and madhuka (*Madhuka indica*). You can also use ghee, honey, and triphala (*Emblica officinalis, Terminalia chebula*, and *Terminalia bellerica*). For the bareness of trees, a hot decoction of kulattha, maasha, mudga, tila, and yava should be made.

Early detection of plant diseases and pathogens, disease resistance breeding programmes, site-targeted distribution of nano-formulated agrochemicals, and disease control are a few possible significant applications of nanotechnology in plant pathology. The nanoencapsulation of agrochemicals provides the effective concentration of the active component with excellent stability and site-targeted smart distribution with lower collateral harm and less toxicity (Nair and Sakthi, 2012). Herbicides, titanium oxides, and silver nanoparticles encapsulated in nanotechnology are used to combat phytopathogens. Nano-encapsulation is currently used to manufacture and use nano-pesticides. The process of nanoencapsulation involves sealing nanosized active component particles inside a thin-walled sac or shell. Insecticides, fungicides, and other substances can be encapsulated to create formulations that are effective at controlling pests (Shukla et al., 2013; Sahu et al., 2022).

CONCLUSION AND RECOMMENDATION

Together, the theories of three different sciences, i.e. agriculture, Ayurveda, and nanotechnology, assist in the development of fresh notions that are beneficial to all three fields. The quality of a drug will be more potent and active when it transforms from a large macro form to a nano one. Ayurvedic science is largely concerned with life. In this universe, each species is given equal weight. It discusses

the health and ailments of plants and animals in classics like Vrikshayurveda and Pasu Ayurveda. The continued existence of human life depends on plants. Therefore, safeguarding them is of utmost importance. In agriculture, plants are grown for a variety of uses, including food, medicine, textiles, and other goods. New techniques are being developed as a result of the sustainable development of plants and crops. Their primary interests are in the genetic modification of a plant to boost its resistance to biotic and abiotic stresses as well as the development of ecologically friendly practices. As a result, the development of these two sciences is indirectly facilitated by the expansion of nanotechnology through the invention of specialised techniques.

The future growth of nanotechnology can benefit from some ideas from these domains in a similar way. Twenty gunas are mentioned in Ayurveda, and these are primarily utilised to treat disorders and choose the right medications for treatment. Sukshma (capacity to penetrate anyplace), Vyavaayi (the component that aids in the spreading of things before they are digested), Teekshna (attribute responsible for sharpness or speed), Sara (that which gives momentum). These all properties can be made use of in nanotechnology.

Kapha is considered the substrate, pitta is that which institutes changes and vata is the controlling system. These three variables regulate how each substance's functions are carried out. Plants also have these tridoshas, and an imbalance in them causes illness. Plants contain tridoshas as well, and an imbalanced one can cause sickness. The sustainability of the plant is a significant issue because herbal pharmaceuticals are being used more frequently in a variety of industries, including food, cosmetics, and medicine. Therefore, plant cultivation and conservation should be prioritised. One field that has the potential to improve in this is nanotechnology.

However, the nanoparticles can stay in the soil and then pose a threat to human health. The use of nanotechnology in fertiliser and pesticide formulations must therefore be addressed very cautiously due to these worries, which calls for the necessity of rigorously analysing and examining the dangers associated with nano-formulations. Some investigations support the idea that biogenic nanoparticles will provide a remedy for this. We can consider the above-mentioned herbal medicines with the guna (quality) as a way to lower the risk, as well as medications and panchagavya-like preparations that can be used to expand the use of nanotechnology in agriculture without affecting population and the environment. Interdisciplinary approaches can be helpful in building up new platforms for exploring the different concepts of different sciences which will have future scope for further research.

CONFLICTS OF INTEREST

The author(s) declare(s) no conflicts of interest.

DECLARATION

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