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Review Article

Agricultural Insights for Development of Genetically Modified Foods, Horticultural Crops and Role of Nanotechnology

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Abstract

Agricultural productivity under stress conditions can be accomplished by modifying cellular metabolism and molecular transformations of genetically modified plans with the help of nano-material-mediated facilitations. Horticultural crops are the main source of nutritional compounds such as proteins, carbohydrates, vitamins, minerals, and organic acids. Osmotic stress combined with temperatures over 28°C caused a 30-45 percent blossom decline in several tomato varieties. Chili too is susceptible to drought stress, which can result in production losses of as much as 50 to 60 percent. Pigment and color retention are important determinants of vegetable and fruit quality and nutritional values. Genes involved in the enhancement of anthocyanin synthesis and accumulation during postharvest storage in red-fleshed kiwi. Targeted implementation of fruit-specific promoters with distinct up and low regulated epigenetic biomarkers might be useful in the expression of genes and reduces the side effects developed by constitutive promoters. Chitosan is one kind of these nanomaterials over-coated on post-harvested mangoes to secure its edible portion from rotting, increase its vitamin C contents, maintain its freshness, and increase shelf-life. The use of nanomaterials in the food industry reduces the cost of electricity applied in refrigeration for preservation purposes alongside maintaining the original vigor and vitality of the fruits like tomatoes.

Keywords: Horticultural crops, organic acids, agricultural productivity, fruit-specific promoters, plant epigenetic.

INTRODUCTION

In addition to ornamental purposes, horticultural crops are also the main source of nutritional compounds such as proteins, carbohydrates, vitamins, minerals, and organic acids. While harvesting and carrying there is a risk of damaging the product. This may result in a loss of productivity. So, it is necessary to avoid this type of postharvest loss by preventing various drastically physiological and environmental factors. One of the advanced and reliable approaches to enhancing the yield is the incorporation of agrochemical agents through nanotechnology and unique carriage strategies. Additionally, it also checks the over-usage of pesticides [1-3].

Several diagnostic, remedial and management approaches have been developed through advanced technology tools for the sustainable cultivation of agronomic crops. These contribute towards better quality and enhanced quantity of the product. A few examples of such techniques are nano-formulations involve the incorporation of useful agrochemicals in fertilizers and pesticides to increase gross yield; Nano-devices for the detection and investigation of pathological agents within a population and their complete remediation through genetic engineering

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procedures and post-harvest administration; Nano-sensors are used to provide safety indications against sensitive and residual agrochemicals. Moreover, precision agricultural strategies also encompass improving crop productivity by reducing the risks of soil, water, and nutrients lost due to emissions and leaching and avoiding other environmental calamities. Nano-particle mediated gene editing and DNA transfer in plants have got a tremendous place in modern farming technology as it assists in developing pest-resistant varieties of plants and long-term food preservation. Higher biomass to fuel production is another important milestone achieved via nanotechnology [4-7].

Amendment in agricultural productivity under stress conditions can be accomplished by modifying cellular metabolism and molecular transformations of genetically modified plans with the help of nano-material-mediated facilitations. The application of nano-particles in agricultural practices got a special role in modern age farming due to their tiny size, distinctive photosensitive properties and low surface area to volume ratio, and unique physio-chemical attributes. These vary in size from 2 nm to 100 nm within one or several dimensions in the form of nano-sheets, nano-tubes, nano-powders, nano-fibers, nano-crystals, or nano-clusters. Abrupt usage of fertilizers to increase crop productivity has caused immense damage to the environment. This problem, now, can be encountered by the addition of nanomaterials within fertilizers. Nano-coating of fertilizers improves the rate of dissolution and enhances the absorption through the roots of plants. Hence rapid and sustainable usage of nanomaterial's intervened fertilizers not only reduces the risks of environmental degradation but also saves farmers from expenses of their crop management [8-11].

To meet the nutritional demands of an extensively growing population all around the world several effective agricultural approaches have transfigured the global food supply to a great level, known as Green Revolution, but it also has put numerous detrimental, involuntary impacts on the environment and ecosystem, underlining the necessity of further sustainable farming strategies. Excessive and inadvertent treatment of fertilizers and pesticides to achieve higher harvests resulted in an elevation of minerals and toxic chemicals in groundwater and surface water which in due course imposes drastic impacts on the quality of drinking water and soil profile. As a result, several eco-unfriendly and alarming situations have been ascended such as eutrophication, killing of useful insects and wildlife, and the degraded soil may need expensive reclamation measures like increased irrigation, energy, and nutrients to restore the productivity of the soil [12-14].

Horticultural crops, Vegetables and Fruits

Amino acids (proteins) are a great source of useful metabolites and energy. 20 types of amino acids are considered necessary for the normal development and growth of human beings. All these amino acids are obtained from the food contents derived from the plants. To get additional contents of amino acids from crop plants, traditional breeding and mutagenic methods have participated a leading role. Recent research on some model plants such as Arabidopsis gives a detailed understanding of the metabolic pathways, intermediate compounds, and enzymes involved in biosynthesis, degradation, and regulation of amino acids. These investigatory measures have provided feasibility in applying genetic engineering techniques for bringing improvements in the levels of amino acids in crop plants. However, this approach is ruled out in the case of some vital amino acids like Trp., Phe, Lys, Val., Leu, due to highly regulated negative feedback loops and targeted degradation of amino acids by catabolic reactions, for example, degradation of lysine in the tricarboxylic acid cycle [15, 16].

Osmotic stress combined with temperatures over 28°C caused a 30-45 percent blossom decline in several tomato varieties. Chili too is susceptible to drought stress, which can result in production losses of as much as 50 to 60 percent. Leading to a decline in oxygen in the root zone, most vegetables are vulnerable to excess moisture stress. Under flooded circumstances, tomato plants produce intrinsic ethylene gas, resulting in the downward growth of leaves. Likewise, onion is also susceptible to over-irrigation during its bulb formation stage. It usually causes a 30-40% yield loss. The impact of these strains would be worsened in a climate change scenario. The response of plants to stressful situations is dependent on the stage in development as well as the duration and harshness of the strains, and they are the leading source of yield losses for more than half of all vegetation globally [16, 17].

Pigment and color retention are important determinants of vegetable and fruit quality and nutritional values as addressed in several publications. The scientists investigated the temporal and spatial regulations of anthocyanin synthesis by tracking its genetic codes in taproots of radish. It is manifested that morphological characters are significantly influenced by five different genes. Genes involved in the enhancement of anthocyanin synthesis and accumulation during postharvest storage have been identified in red-fleshed kiwi. Genetic polymorphisms associated with the delayed production of anthocyanin and rapid degradation of the peel highlight the variations in color fading controlled by the light signals in pear cultivars [18-21].

MdMADS1, a MADS-Box gene, was found to have an involvement in anthocyanin accumulation in apple peel when ALA (a plant growth stimulant) was present. Increased pigmentation in peach epidermis cultivated at high altitudes and examined the influence of altitude on protein changes likely involved in ripening. Maturation of strawberries by altering abscisic acid signaling involves the regulation of FERONIA-like receptor kinase [22-24].

When temporal and spatial gene expression sequences are sought to manipulate certain plant organs or developmental phases, constitutive promoters' capacity to drive high levels of transgenic expression might be a limiting issue. The 35S promoter's constitutive production of transcription factors may restrict the proper growth of plants, resulting in phenotypic abnormalities. In all the other circumstances, the binding protein promoters might well be inactive in different plant tissue, making it inefficient for spatiotemporal transgenic expression control. Specific-tissue-targeted activators could be effective for inducing transgenic characteristics without disrupting the normal physiological processes of the plants. Numerous promoters specializing in multiple phases of the flowering period, maturation, and ripeness of fruits have been found, yet they can be utilized as genome editing techniques to increase fruit production, taste and flavor, and post-harvest storage stability. Targeted implementation of fruit-specific promoters with distinct up and low regulated epigenetic biomarkers might be useful in the expression of genes and reduces the side effects developed by constitutive promotors. Such investigations have been made for both climacteric and non-climacteric plant species [25-27].

The rate of germination, development, and growth index of plants depends upon the uptake of essential nutrients through a special period of the lifecycle. The optimum concentration of an essential nutrient for each plant type can be determined by the "Generalized Dose-Response Curve". Below the curve concentration, it is the sub-optimal range which considerably reduces the plant growth. However, when the curve is above the optimum range, it also constrains growth whether due to toxic effects or nutrient-induced deficiency. Here it is noteworthy to highlight that these dose-response curves not only affect the physiological processes of plants in quantitative aspects but also impose qualitative modifications instance, too much accumulation of NO_3 in leaves of spinach not only alters yield but also imparts negative health effects on the consumers. Hence, the nutrient competency window can be constricted and entitled "Nutrient Acceptability [1, 23, 27].

One of the inquisitive groups of plant hormones is Jasmonates. These are part of complicated but specific interactions among plants, pests, and biological predators of those pests. Scientific investigations have made a clear linking of Jasmonates with other hormones and metabolic pathways. These chemical compounds have been recognized to exhibit substantial biochemical and physiological roles in plants. In due course of their significance in the horticultural field, there is much demand for extensive research on them which may undoubtedly contribute to magnifying the production of the horticultural crop [12, 16, 18].

Application of Nanotechnology in Advancements of Horticultural Science

On surface coating with characteristic nanoparticles or injecting inside the pulp of fruits has got a tremendous position in recent nutritional amendments and preservation strategies. Quite a lot of such chemicals have been synthesized and integrated into distinct classes of fruits and vegetables to upturn the nutrient contents of fruits and their post-harvest stability and longevity. Chitosan is one kind of these nanomaterials over-coated on post-harvested mangoes to secure its edible portion from rotting, increase its vitamin C contents, maintain its freshness, and increase shelf-life. Similarly, observations have been made that chitosan coatings over pomegranate and sweet cherries protect them from microbial attacks, upregulate anthocyanin activities, prevent color changes and retain water contents [28-30].

Nanotechnology/ Nanoparticles	Application	Improvements	Characteristics
Nanoparticles	Pulp of fruits	Nutritional amendments	Increase shelf-life
Chitosan	Nanomaterials over-coated on post-harvested mangoes	Edible portion from rotting, increase its vitamin C contents, maintain its freshness, and increase shelf-life	Increase its vitamin C contents, maintain its freshness, and increase shelf-life
Chitosan treatment	Higher concentrations of chitosan seem to be effective in extending fruit yield	features in kiwi fruits	increase shelf-life
Chitosan	Chitosan coatings over pomegranate and sweet cherries	Protect them from microbial attacks, upregulate anthocyanin activities.	Prevent color changes and retain water contents

One of the most vulnerable fruits is bananas which spoil faster than other fruits. Spoilage of peaches is another serious issue that affects their economic worth. Edible chitosan can be used to delay ripening and increase long-term stability. Nevertheless, chitosan treatment led to a considerable reduction in oxidative stress, aging prevention, delaying fruit set, and contour and color preservation. Higher concentrations of chitosan seem to be effective in extending shelf-life, fruit yield, and other qualitative features in kiwi fruits. The preceding examples reveal how chitosan plays an active role in increasing the structural properties and longevity of post-harvest preserved fruits, as well as maintaining their quality. The use of nanomaterials in the food industry reduces the cost of electricity applied in refrigeration for preservation purposes alongside maintaining the original vigor and vitality of the fruits like tomatoes. Similarly, carrot slices were treated with edible chitosan, which slowed the senescence, lowered carbohydrate content, and elevated phenolics content. And the same with broccoli, chitosan treatment combined with moderate heat shock extended shelf life while maintaining sensorial qualities [31-33].

It has also been manipulated in post-harvest cantaloupe melon and cucumber to induce cold tolerance, increase shelf life, preserve fruit quality, and boost antioxidant activity. People nowadays are more worried regarding quality control, which is why chitosan does have the capability for use in a variety of ways to improve. Nano-fertilizers are used in horticulture to accelerate biomass production, blooming, and viability in flowers, resulting in higher yields and better excellent orchards. In salt stress circumstances, exogenous nano-Ca supplementation on blueberries leads to improved vegetative growth and chlorophyll content in leaves. Accordingly, spraying nano-boron on mango tree leaves increases overall production and chemical and physical properties of fruits, which is likely due to increased chlorophyll and essential nutrient elements such as nitrogen (N), phosphorus (P), potassium (K), manganese (Mn), magnesium (Mg), boron (B), zinc (Zn), and iron (Fe) within the foliage. Mango tree spraying with nano-zinc increases the size, quantity, and productivity of mangoes, as well as the concentrations of leaf chlorophyll and carotenoids, and the levels of numerous nutritional components such as K, N, and Zn [11, 34, 35].

CONCLUSION

Horticultural production, particularly the cultivation of vegetables and fruits, supplies essential elements for well-balanced nutrition. Low-fiber cuisines significantly contribute to several of the planet's more prevalent chronic nutrition-based illnesses. When compared to cereals and pulses crops, horticultural crops produce significantly more per unit area. Inter-crops are also used in horticultural crops over the first months of development.

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