

## Nanofertilizers in Fruits and Vegetables

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### INTRODUCTION

Imagine walking through a mango orchard in Rajasthan or a vegetable field in Udaipur. Farmers are working hard applying fertilizers, irrigating crops, and hoping for good yields. But much of the fertilizer they apply never reaches the plant. Instead, it is washed away by water, lost in the air, or locked in the soil. This not only wastes money but also harms the environment. Now imagine a fertilizer so efficient that even a few drops can feed a plant effectively. This is the promise of nanofertilizers.

Nanofertilizers represent one of the most exciting innovations in modern horticulture. They are helping fruit and vegetable farmers increase productivity, improve quality, and reduce fertilizer waste. Nanotechnology is changing agriculture quietly, but powerfully.

### 2. What Are Nanofertilizers?

Nanofertilizers are fertilizers made using nanotechnology, where nutrients are converted into extremely small particles typically less than 100 nanometers in size.

To understand the scale:

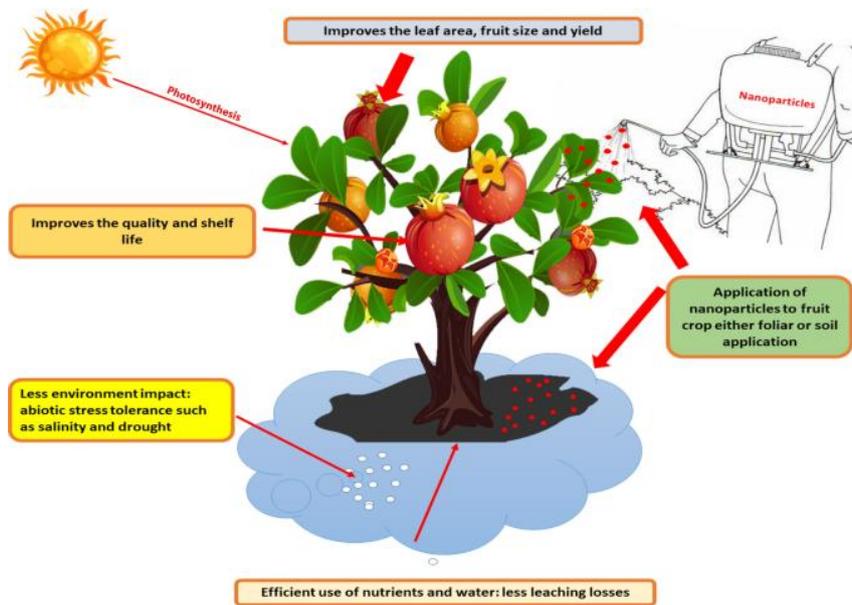
- One nanometer = one billionth of a meter
- Nanoparticles are 10,000 times smaller than a grain of sand

Because of this tiny size, nanofertilizers behave differently from conventional fertilizers.

They can:

- Enter plant tissues easily
- Release nutrients slowly
- Deliver nutrients precisely

Nanofertilizers provide a steady nutrient supply and improve plant growth and yield while reducing nutrient losses and environmental impact.



### 3. Why Are Nanofertilizers Needed in Fruits and Vegetables?

Fruits and vegetables are high-value crops.

They require:

- Precise nutrition
- High productivity
- Better quality
- Attractive appearance

### 4. How Do Nanofertilizers Work?

Because of their extremely small size, nanofertilizers have a much larger surface area compared to conventional fertilizers. This larger surface area allows faster absorption by plant tissues, higher nutrient use efficiency, and controlled release of nutrients over time. As a

result, nanofertilizers significantly improve nutrient uptake, enhance photosynthesis, promote better plant growth, and increase overall crop productivity due to their superior penetration ability. They also stimulate vegetative growth, improve flowering, and support better fruit development. In addition, nanofertilizers enhance pollination and plant fertility, which ultimately leads to higher yield and improved quality of fruits and vegetables.

### 5. Types of Nanofertilizers Used in Horticulture

Nanofertilizers can supply both major and micronutrients.

Major nutrient nanofertilizers	Micronutrient nanofertilizers
Nano nitrogen	Nano zinc
Nano phosphorus	Nano iron
Nano potassium	Nano boron
	Nano calcium

## 6. Major Benefits of Nanofertilizers in Fruits and Vegetables

### 6.1 Increased Yield

Nanofertilizers significantly increase crop productivity.

Example:

- Strawberry yield increased up to 43% using nanofertilizer spray.

Nano-boron and nano-zinc increase fruit number and yield in mango and pomegranate.

### 6.2 Improved Fruit Quality

Nanofertilizers improve important fruit quality parameters such as fruit size, fruit weight, sugar content, and shelf life. Their efficient nutrient delivery ensures that plants receive balanced nutrition at the right time, which promotes better fruit growth and development. In particular, Nano-NPK fertilizers play a significant role in increasing fruit weight and enhancing pulp percentage in fruit crops. This results in better-quality fruits with improved sweetness, longer storage life, and higher market value.

### 6.3 Better Nutrient Use Efficiency

Nanofertilizers increase nutrient use efficiency by about 20%.

This means:

- Less fertilizer required
- Lower cost

### 6.4 Environmental Protection

Nanofertilizers help reduce nutrient leaching, environmental pollution, and soil degradation. Due to their slow and controlled nutrient release, they supply nutrients to plants more efficiently over a longer period, minimizing nutrient losses through leaching and runoff. This improves nutrient use efficiency and reduces the need for excessive fertilizer application. As a result, nanofertilizers lower environmental impact and contribute to sustainable soil health and eco-friendly crop production.

### 6.5 Improved Stress Tolerance

Nanofertilizers help crops tolerate various environmental stresses such as heat, drought, and salinity. They improve the plant's internal defense system by enhancing antioxidant activity, which protects plant cells from damage caused by stress conditions. This strengthens the plant's ability to survive and perform better even under unfavorable environments. As a result,

nanoparticles improve stress tolerance in fruit crops, helping maintain growth, yield, and fruit quality under climate stress conditions.

## 7. Role of Nanofertilizers in Fruit Crops

Nanofertilizers are highly beneficial in fruit crops.

### Mango

Nano zinc plays an important role in improving fruit crop performance by increasing fruit weight, fruit number, and overall yield. It also enhances chlorophyll content in leaves, which improves photosynthesis and energy production in plants. As a result, plants grow more vigorously, produce more fruits, and achieve higher productivity along with better fruit quality.

### Strawberry

In strawberry, nanofertilizers increase fruit yield, promote better root growth, and enhance flower number. This improves nutrient uptake, plant growth, and overall productivity.

### Pomegranate

In pomegranate, the application of nano boron improves sugar content, enhances fruit quality, and increases overall yield. It supports better flowering, pollination, and fruit development, resulting in sweeter fruits with improved market value and higher productivity.



### Date palm

In date palm, the use of nanofertilizers improves fruit size, enhances fruit quality, and increases overall yield. They promote better nutrient uptake and fruit development, resulting in larger, healthier fruits and higher productivity.

## 8. Role of Nanofertilizers in Vegetable Crops

Vegetables respond very well to nanofertilizers.

### Tomato

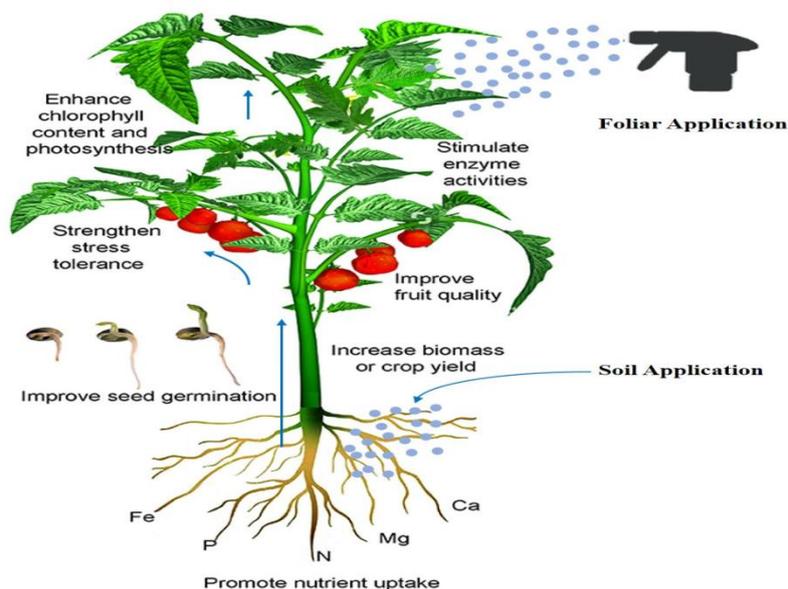
In tomato, nano zinc improves plant growth, increases yield, and enhances nutrient uptake. It promotes better chlorophyll formation and metabolic activity, resulting in healthier plants and higher productivity.

### Lettuce

In lettuce, nanofertilizers improve nutrient content, increase yield, and enhance overall quality. They promote better nutrient absorption and plant growth, resulting in healthier leaves and higher productivity.

### Cucumber

In cucumber, nano zinc improves nutrient use efficiency and promotes better plant growth. It enhances nutrient absorption and physiological activity, resulting in healthier plants and improved productivity.



### 9. Methods of Application

Nanofertilizers can be applied in several ways:

#### 1. Foliar spray

Most common method

Benefits:

- Fast absorption
- Efficient

#### 2. Soil application

Provides slow release nutrition

#### 3. Seed treatment

Improves germination

### 10. Mechanism of Action

Nanofertilizers improve plant growth through:

- Better nutrient absorption
- Increased photosynthesis
- Improved enzyme activity
- Better root development

They improve nutrient uptake and metabolic functions in plants.

**Table 1: Major Nanofertilizers and Their Role in Fruits and Vegetables**

Nanofertilizer	Nutrient supplied	Crop	Major benefit
Nano nitrogen	Nitrogen	Vegetables	Faster growth
Nano zinc	Zinc	Mango, vegetables	Increased yield
Nano boron	Boron	Pomegranate	Better fruit quality
Nano iron	Iron	Leafy vegetables	Improved chlorophyll
Nano calcium	Calcium	Fruits	Improved firmness
Nano phosphorus	Phosphorus	Vegetables	Root development

### 11. Advantages of Nanofertilizers

Major advantages of nanofertilizers include higher nutrient use efficiency, increased crop yield, and improved produce quality. They reduce the overall requirement of conventional fertilizers by delivering nutrients more effectively, which makes them cost-effective for farmers. In addition, their controlled release and

efficient utilization minimize nutrient losses and environmental pollution, making them safer for the environment and supporting sustainable agricultural production.

### 12. Limitations of Nanofertilizers

Despite advantages, there are some challenges:

- High initial cost
- Limited awareness

- Need for proper dosage
- Limited availability

### 13. Future of Nanofertilizers in Horticulture

Nanofertilizers are emerging as the future of fruit and vegetable production. They help increase crop productivity, improve produce quality, reduce environmental pollution, and support long-term food security. Due to their efficient and controlled nutrient delivery, they enhance nutrient use efficiency while minimizing losses. As a result, nanotechnology is becoming an important and powerful tool for improving the productivity and quality of horticultural crops in a sustainable way.

### CONCLUSION

Nanofertilizers represent a major breakthrough in horticulture by providing higher yields, improving produce quality, and supporting sustainable crop production. Their efficient nutrient delivery helps farmers achieve better results with lower fertilizer use. For fruit and vegetable farmers, nanofertilizers offer hope for higher income, reduced production costs, and a more secure future. In the coming years, nanofertilizers are expected to play a key role in promoting sustainable agriculture and meeting the growing food demand.