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Comparative Effect of *Azotobacter*, *Azospirillum*, and *Rhizobium* in Horticultural Crops

*Anil Kumar Salvi
RNT College of Agriculture, Kapasan (MPUAT, Udaipur), Rajasthan, India
*Corresponding Author's email: anilsalvi152@gmail.com

Horticultural crops such as vegetables, fruits, flowers, and plantation crops require a continuous supply of essential nutrients—especially nitrogen—for healthy growth and high yield. Chemical fertilizers alone cannot meet this demand sustainably. Therefore, biofertilizers like Azotobacter, Azospirillum, and Rhizobium play an important role in improving soil fertility, plant growth, and overall crop productivity. These beneficial microorganisms fix atmospheric nitrogen, produce growth-promoting substances, and increase nutrient availability. Although all three are nitrogen-fixing microbes, their mode of action, host specificity, and overall impact on horticultural crops differ.

This article explains the comparative effect of these organisms on horticultural crops and highlights how they contribute individually and collectively to sustainable cultivation.

Azotobacter: Free-Living Nitrogen Fixer

Nature and Characteristics

- *Azotobacter* is a **free-living, aerobic nitrogen-fixing bacterium**.
- It does **not require a host plant** to fix nitrogen.
- It survives in the rhizosphere of many horticultural crops.

Role in Horticulture

1. **Nitrogen Fixation:** Fixes 20–40 kg N/ha annually, which supports growth of vegetables (tomato, brinjal, cabbage), flowers (marigold), and fruit crops (banana).
2. **Growth-Promoting Hormones:** Produces **IAA, GA, cytokinins**, which enhance seed germination, root length, and vegetative growth.
3. **Disease Resistance:** Produces antibiotics and siderophores that suppress soil-borne pathogens.
4. **Stress Tolerance:** Improves drought and salinity tolerance in crops like onion, garlic, and chili.

Advantages

- Suitable for a wide range of horticultural crops.
- Works even without a symbiotic relationship.

Azospirillum: Associative Nitrogen Fixer

Nature and Characteristics

- *Azospirillum* is an **associative nitrogen-fixing bacterium** that attaches to plant roots but does not form nodules.
- Prefers crops with fibrous root systems.

Role in Horticulture

1. **Moderate Nitrogen Fixation:** Fixes 10–20 kg N/ha, especially useful in crops like **vegetables (carrot, radish), grasses, and spices**.
2. **Root Development:** Produces hormone-like substances that improve root volume, root surface area, and nutrient uptake.

3. **Increased Yield:** Enhances growth and yield in crops like tomato, spinach, coriander, turmeric, and ginger.
4. **Improved Nutrient Use Efficiency:** Helps plants absorb more phosphorus, potassium, and micronutrients, thus reducing fertilizer requirement.

Advantages

- Particularly beneficial for **vegetables with thick or fibrous roots**.
- Enhances overall vegetative development.

Rhizobium: Symbiotic Nitrogen Fixer

Nature and Characteristics

- *Rhizobium* forms a **true symbiotic association** with leguminous plants and develops nitrogen-fixing root nodules.
- Very crop-specific; different species are needed for different legumes.

Role in Horticulture

1. **High Nitrogen Fixation Capacity:** Fixes **50–150 kg N/ha**, making it the most effective biofertilizer among the three.
2. **Improves Soil Fertility:** After legume cropping, leftover nitrogen benefits subsequent horticultural crops like onion, tomato, and cauliflower.
3. **Enhances Growth and Yield:** Increases yield of legumes such as **peas, beans, groundnut, cowpea, and French bean**—commonly grown in vegetable-based systems.
4. **Better Protein Content:** Nitrogen fixation improves nutritional quality (protein content) of legume vegetables.

Advantages

- Very high nitrogen contribution.
- Essential for all legume-based horticultural systems.

Comparative Effect of Azotobacter, Azospirillum, and Rhizobium

Feature / Effect	*Azotobacter*	*Azospirillum*	*Rhizobium*
Type	Free-living	Associative	Symbiotic
Host Requirement	None	Partially dependent	Legumes only
N Fixation	20–40 kg/ha	10–20 kg/ha	50–150 kg/ha
Hormone Production	Very high	High	Moderate
Suitable Crops	Vegetables, fruits, flowers	Vegetables, spices	Legume vegetables
Growth Effect	Better seedling vigor	Strong root growth	High biomass and protein
Use in Horticulture	Universal	Mostly fibrous-root crops	Legume crops

Integrated Use in Horticultural Crops

1. **Vegetables:**

- Tomato, brinjal, chili → *Azotobacter* + *Azospirillum* improve growth and fruiting.
- Pea, beans → *Rhizobium* essential for high yield.

2. **Fruits:**

- Banana, citrus, grapes → *Azotobacter* improves nitrogen supply and plant vigor.

3. **Spices and Tuber Crops:**

- Ginger, turmeric, garlic, onion → *Azospirillum* accelerates root growth and nutrient uptake.

4. **Floriculture:**

- Marigold, rose, chrysanthemum → *Azotobacter* enhances flower size and number.