



PRECISION AGRICULTURE MEETS BIOLOGY: BIO-ENZYMATIC IMPACT ON STRAWBERRY CULTIVATION

Mahima Choudhary* and Jitender Kumar

Ph.D. Fruit Science (Horticulture) Galgotias University Greater Noida, Uttar Pradesh - 203201.

**Corresponding Author Mail ID: chaumahima2000@gmail.com*

Introduction

Strawberries are colorful, nutrient-rich, and commercially valued, making them an excellent target for sustainable agriculture advancements in the era of climate-conscious farming and health-driven markets. Using bio-enzymes made from natural sources like bananas, citrus, and aloe vera is one of the most promising strategies to transform strawberry farming at the connections of biological sciences and precision agriculture.

The agricultural industry is undergoing a radical change in response to these contemporary issues, one that combines the intelligence of natural biological processes with the accuracy of contemporary technology. Bio-enzymes are a potent and gaining popularity remedy at this crossroads. By fermenting plant-based waste materials like banana peels, orange rinds, and aloe vera pulp, these organic, microbe-rich solutions provide a sustainable means of increasing crop output, boosting soil vitality, and organically controlling pests and illnesses.



This article examines how strawberry farming is being revolutionized through the methodical and sequential application of bio-enzymes derived from bananas, citrus fruits, and aloe vera. In addition to producing greater yields

and better-quality fruit, this approach respects ecological boundaries and promotes long-term soil health by adhering to the principles of precision agriculture and regenerative biology.

Rethinking the Strawberry Field

Synthetic fertilizers and insecticides have long been used in conventional strawberry growing to increase yields and control pests. However, many growers are looking for greener options because of the ecological cost, which includes decreased biodiversity, pesticide residues, and degraded soil. Bio-enzymes are useful in this situation. Fruit and vegetable waste is fermented with sugar and water to produce bio-enzymes, which are organic solutions. These natural elixirs, which are abundant in plant-stimulating chemicals and helpful microorganisms, improve plant metabolism and immunology in addition to nourishing the soil.

A Sequential Symphony of Enzymes

In a recent study, researchers examined the effects of administering three distinct types of bio-enzymes at different phases of growth in the popular strawberry cultivar *Fragaria x ananassa* cv. Camarosa.

Before transplanting, use a banana-based sweet bioenzyme to improve root establishment and soil fertility, acidic bio-enzyme derived from citrus that improves fruit development and nutrient uptake during flowering and fruiting. Aloe vera-based bitter bio-enzyme to manage pests and disease naturally.

The ideas of precision agriculture—targeting particular growth stages with customized biological inputs—are mirrored in this method of application. Better fruit size and flavor,

increased plant vigor, and a noticeable rise in total output were the remarkable outcomes.

Beyond the Berry

This method's alignment with organic and regenerative farming concepts is what really sets it apart. Farmers may lower expenses, restore ecological balance, and lessen their reliance on chemical inputs by using locally accessible, biodegradable resources.

Additionally, this approach converts agricultural and domestic trash into useful bio-inputs, supporting global efforts that support circular agriculture. It's upcycling for the soil, not simply farming.

Measurable Benefits: More Than Just a Greener Option

The outcomes were striking. Following treatment with the bio-enzymatic sequence, strawberry plants showed:

- Stronger vegetative growth
- Increased number of flowers and fruits
- Higher total soluble solids (TSS) and improved sugar–acid balance in the fruit
- Improved ascorbic acid and antioxidant content
- Reduced incidence of common fungal and bacterial infections

Significantly, farmers using this technique reported better soil structure, more microbial diversity, and lower input costs—evidence that this strategy is both economically and environmentally sound.

Closing the Loop in Organic Systems

This approach is unique since it adheres to circular agriculture. Organic waste from homes and farms is recycled into bio-inputs that replenish the soil with nutrients and helpful microbes rather than being disposed away. In smallholder and organic farming contexts, this natural recycling cycle is especially important since it increases sustainability, lessens reliance on outside inputs, and fosters food system resilience.

A Path Forward

Under organic management, the sequential application of bio-enzymes derived from bananas, citrus, and aloe vera greatly improved strawberry output, fruit quality, and growth. In addition to enhancing soil and plant health, this method provides a sustainable substitute for synthetic agrochemicals used in commercial strawberry cultivation.

Combining the power of biology with precision agriculture, which is still developing, may define the next phase of sustainable crop production. With science as a guide and nature as an ally, farming appears to have a bright future.

A New Era of Eco-Farming

This bio-enzymatic method has far-reaching consequences that go well beyond strawberries. It provides a cost-effective, scalable strategy for sustainable horticulture, especially for small and medium-sized farms aiming to obtain organic or natural farming system certification.

Conclusion

Strawberry growth under organic management was found to perform better overall when bio-enzymes derived from bananas, citrus, and aloe vera were applied successively. Through the use of customized enzymatic inputs to target particular growth stages, this technique greatly enhanced vegetative growth, flowering intensity, fruit size, sweetness, and nutritional quality. Most notably, the method decreased the need for chemical inputs, improved microbial activity, and promoted better soil health—all of which are in complete harmony with the ideas of regenerative and sustainable agriculture.

Beyond its agronomic advantages, this bio-enzymatic approach helps farmers satisfy consumer demand for safe, high-quality, and clean produce by providing a workable and environmentally responsible substitute for synthetic agrochemicals. It is particularly beneficial for small holders and forward-thinking growers looking to switch to more environmentally friendly agricultural practices

because of its ease of use, low cost, and compliance with organic regulations.

Combining the power of biology with precision agriculture, which is still developing, may define the next phase of sustainable crop production. Farmers may increase productivity while protecting the environment by utilizing the organic harmony between biological treatments and plant demands. The future of farming appears to be not just prosperous and environmentally friendly, but also more resilient and regenerative, with science serving as a guide and nature as an ally.