Indigenous Liquid Bio fertilizer (Kunapa Jal) Formulations in Traditional Indian Farming

Dhwani Vataliya[1], Kinjal Bhatt[2]

[1, 2,] Department of Biochemistry and biotechnology, St. Xavier's college, Ahmedabad

ABSTRACT

However, the increasing accumulation of temple flower waste has become a serious issue now as its unsatisfactory decomposition affects soil health and cause pollution. Dealing with the organic waste in sustainable way is thus obligatory. Conversion of floral waste to liquid bio fertilizer has gained some interest due to its eco-friendly, assured effects and easily applicability as compared to chemical fertilizer. Floral waste–based liquid bio fertilizer is played a significant role in sustainable cropping system. Such liquid bio fertilizer not only enhances the soil nutrients, chemical and biological components but also sustains crop productivity for sustainable agriculture and less use of chemical fertilizer that may adversely affect the soil health. The industrially formulated liquid bio fertilizer usually contains microbial inoculants, such as nitrogen-fixing bacteria (Rhizobium, Azotobacter, and Pseudomonas), phosphate-solubilising bacteria (Mycorrhiza, Pseudomonas, Bacillus), potassium-solubilising microorganisms (Azotobacter), and natural protectants (Jaggery, Camphor), etc. These inoculants facilitate for biological process of N2 fixation, P assimilation, decomposition of organic matter etc. In soil and increases the level of organic carbon in soil and diversity of microbes, respectively. The Indian knowledge system can be utilised effectively to formulate these inoculation cultures in a low-cost, liquid state using natural inputs (panchgavya, cow dung, Jaggery), based on a fermentation system in plastic containers and earthen pots. The floral waste-based products in addition to fertilizer can be used in several other forms like plant growth evaluation, bio-bricks, lip balm, candles, natural colour, crayons etc. works as low cost and integrated utilization of floral waste could be beneficial.

KEYWORDS

Temple flower waste, liquid bio fertilizer, low-cost fermentation, Indian knowledge system, earthen pots, plastic containers, pot study, bio-bricks

I. INTRODUCTION

Solid waste is a serious problem worldwide, and its disposal is a major concern (Sharma, 2021). Waste like food scraps, agricultural waste, non-edible oils, paper/wood products, and industrial waste which are enriched in carbon source pose significant challenges in landfills due to their anaerobic decomposition. India is approaching a critical challenge in waste management, particularly in the disposal of rapidly increasing amount of solid waste. Waste management practices are often initiated only when the severity of the problem exceeds the convenience or feasibility of disposal methods. This approach has contributed to the accumulation of waste and the emergence of environmental and public health concerns (Bennurmath et al., 2021). An increasing demand in the population to 7.8 billion has placed increasing demand on the crops. The United Nations Food and agriculture facing challenges of feeding the population they estimate demand on crops will increase to 60% by the year

2030 (Allouzi et al., 2022). For the agricultural crops nutritional supple and maintenance is needed for the crops for this widely use of chemical fertilizer has been increased. Chemical fertilizers can efficiently and quickly increase the food production in the middle of the last century however, with the increasing the usage of chemical fertilizers, it can cause of many environmental and health issues, such as soil and food pollution due to heavy metals and radioactive substances, air pollution produced by NO, N2O, NO2 and other gasses, groundwater pollution caused by nitrates and also change the soil pH balance and structure (Zhao et al., 2024).

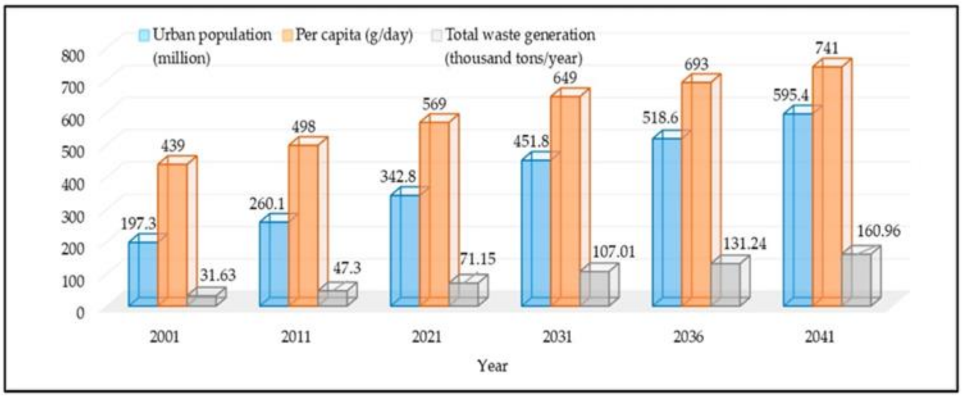

Figure: 1. Predicted urban population and its impact on waste generation (Adopted from Shahab & Anjum, 2022)

The graph shows that from 2001 to 2041, urban population, per capita waste generation, and total waste generation steadily increased. Urban population rose from 197.3 to 595.4 million, while waste generation increased from 31.63 to 160.96 thousand tons/year, indicating that urbanization significantly increases waste production (Shahab & Anjum, 2022). The increasing trend of urban waste generation highlights the urgent need for sustainable waste management strategies, where organic waste can be converted into value-added products such as liquid bio fertilizer.

Bio fertilizers are suitable alternative to chemical fertilizers, which are environment friendly and promotes the growth of crops. Bio fertilizers are rich in living microorganisms which can be produce seed germination microorganisms like PGPR (plant growth promoting rhizobacteria) which increases plant growth and increasing the quality of plant and soil. In 1895, the preparation of bio fertilizers using "nitragi" which contains nitrogen-fixing rhizobium strains. After this in the 1950 began the preparation of bio fertilizers using phosphorus-dissolving bacteria from the soil. Now a time to prepare bio fertilizers uses various fungi, algae and bacteria which promoting plant growth (Zheng et al., 2024). Bio fertilizers are eco-friendly formulations containing beneficial living microorganisms such as bacteria, fungi, and algae that enhance soil fertility and promote plant growth by increasing nutrient availability. These microorganisms improve plant development through biological nitrogen fixation, phosphate solubilisation, potassium mobilization, production of growth-promoting substances, and suppression of harmful pathogens. Unlike chemical fertilizers, bio fertilizers do not directly supply nutrients but help plants absorb nutrients naturally from the soil environment. Their application improves soil structure, microbial activity, water

Holding capacity, and long-term agricultural sustainability. Bio fertilizers are considered an important component of modern sustainable agriculture because they reduce dependence on chemical fertilizers, lower environmental pollution, and increase crop productivity in an economical and natural manner (Allouzi et al., 2022).

Different organic wastes can be utilized as low-cost raw materials for the production of liquid bio fertilizer because they contain carbohydrates, minerals, nitrogen, and other nutrients that support the growth of beneficial microorganisms. Fruit and vegetable wastes, flower waste, molasses, dairy wastewater, agro-residues, fishery wastewater, and food processing by-products can be converted into liquid bio fertilizer through microbial fermentation. In this process, the wastes are chopped or crushed, mixed with water, and inoculated with efficient microbial cultures such as nitrogen-fixing, phosphate-solubilizing, or plant growth-promoting bacteria (Atchaya & Kannahi, 2021). The mixture is then fermented under controlled conditions for several days or weeks, during which microorganisms degrade the organic matter and release nutrients into soluble form. After fermentation, the liquid is filtered and used as bio fertilizer. This approach helps in waste management, reduces environmental pollution, lowers production costs, and produces nutrient-rich, sustainable fertilizer for crop growth.

Bio fertilizers are important in agriculture because they improve soil fertility and promote plant growth through beneficial microorganisms. They help in nitrogen fixation, phosphate solubilisation, and nutrient availability to crops. Bio fertilizers enhance crop yield, maintain soil health, reduce the use of chemical fertilizers, and support sustainable eco-friendly farming practices (Sumathy & Devi, 2017).

Table 1. Comparison of different fertilizers (Adopted from Allouzi et al., 2022).

	Chemical Fertilizer	**Bio-fertilizer**	**Organic Fertilizer**
Source	From Synthetic chemical compounds	From living beneficial microorganisms	From plants, or different waste materials
Effect on soil	Gives immediate and high effect	Gradual through microbial activity	Slow and steady release
Nutrient supply	Direct nutrient supply	Enhances nutrient fixation	Adds nutrients and organic matter
Environmental impact	Overuse may degrade soil	Improves soil fertility	Improves soil structure
Cost	Higher cost	Low to moderate	Low if locally available
Residual effect	Short term	Long-lasting biological effect	Long-lasting soil improvement
Forms	Pellets, tablets, granules, liquid, spikes	Solid, liquid, polymer entrapped and fluidized bed dry formulations	Meal, powder, pellets, slurry waste, worm casting and compost

II. REVIEW OF LITERATURE

A. Why flower waste?

Flower waste is one of the rapidly growing biodegradable waste streams worldwide. It is generated mainly from temples, mosques, gurudwaras, weddings, festivals, flower markets, hotels, households, and floriculture industries. Due to increasing population, urbanisation, religious activities, and commercial flower production, the quantity of discarded flowers in rising every year (Sharma, 2021)._Temple flower waste is the major concern at this time because temple flower waste are generated daily, which can be thrown directly into water bodies such as rivers, ponds, lakes and also on the land, which can create negative impacts on water and soil quality as well as the health of living species. Worldwide, 800 million tons of flower waste are generated annually, and 3.5-4.0 tonnes of floral waste are generated daily, which can be very harmful to the environment and pose health concerns (Heera Lal Atal 2022). Flower waste is rich in several useful components, which is why it's often reused in composting, bio-products, and natural dyes. Flower waste contains several biodegradable components that enable it to break down easily by microorganisms. The key components that facilitate degradation are simple carbohydrates, cellulose and hemicellulose, pectin, proteins and amino acids, lipids, etc.

B. Current status of flower waste

Globally, floriculture is expanding continuously due to demand for decorative flowers, perfumes, cosmetics, medicines, and gifting purposes. This growth has led to an increase in post-harvest losses and discarded flowers during transportation, storage, and retail sales. Large amounts of unsold flowers are thrown away daily in flower markets and the event industries. India is among the leading flower-producing countries, and flowers are deeply connected with cultural and religious practices. Huge quantities of flowers are offered daily at places of worship and during ceremonies. After use, these flowers are often discarded as waste. Reports indicate that millions of tonnes of floral waste are generated annually, with a significant amount dumped into rivers and open land areas.

C. Major sources of flower waste in India

Religious places, flower markets, marriage halls and event venues, hotels and restaurants, household worship materials, floriculture farms.

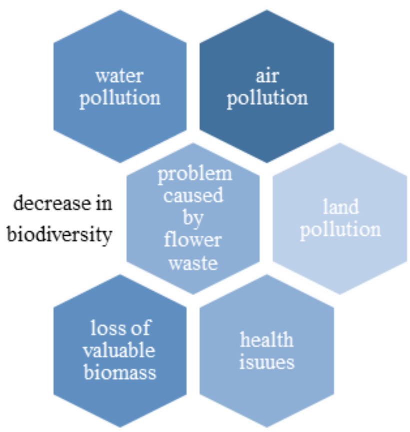

Figure: 2. Problem caused by flower waste (Gupta et al., 2023)

D. Classification of bio fertilizer from flower waste

Table 2. Classification of bio fertilizer

Based on the microorganisms	Bacterial bio fertilizers: Includes rhizobium, azotobacter, azospirillum, phosphate solubilizes etc. Improves soil fertility.	Fungal bio fertilizer: Mainly mycorrhiza fungi, which enhancing nutrient uptake and drought tolerance also forms symbiotic associations with plant roots.	Actnomycetes-based bio fertilizers: Although less common, these soil microorganisms excel at organic matter decomposition, liberating plant-available nutrients.	(Chaudhary et al., 2022) (Verma et al., 2022,) (SV agro solution, 2026) (Kan Biosys 2025)
Based on nutrient supply	Nitrogen fixers: By transforming atmospheric nitrogen into bioavailable forms, microbes like rhizobium, azotobacter, and azospirillum reduce the necessity for exogenous chemical n-fixers in crop production.	Phosphate solubilizes: Some microbes release organic acids that convert the insoluble form of phosphorous into soluble forms, which provide to roots easily.	Potassium mobilizers: Frateuria aurantia and bacillus mucilaginous break down silicate minerals to release potassium, which enhancing yield and plant strength.	(Chaudhary et al., 2022) (Verma et al., 2022,) (SV agro solution, 2026) (Kan Biosys 2025)
Based on mode of action	Symbiotic bio fertilizers: They establish symbiotic associations with plants; for instance, rhizobium induces nodule formation on legume roots to fix nitrogen directly for the host.	Non-symbiotic/free-living bio fertilizers: Free-living in soil, microbes like azotobacter and clostridium perform nitrogen fixation without requiring symbiosis with host plants.	Associative symbiotic bio fertilizers: Azospirillum forms loose associations with cereals and grasses, stimulating root growth and nutrient adsorption.	(Chaudhary et al., 2022) (Verma et al., 2022,) (SV agro solution, 2026) (Kan Biosys 2025)

Knowledge of these classifications empowers farmers to choose bio fertilizers suited to specific soil health profiles, crop requirements, and production deals, optimizing efficiency, nutrient balance, and plant resilience.

E. Fermentation

"Fermentation is the biological breakdown of complex organic materials into simpler substances through the action of microorganisms such as bacteria, fungi, and yeast". It is a natural metabolic process in which microorganisms utilize organic compounds as a source of energy and convert them into useful end products under aerobic or anaerobic conditions. In general, fermentation involves the decomposition of carbohydrates such as sugars, starches, and cellulose present in organic waste materials into simpler compounds including organic acids, alcohols, gases, enzymes, and nutrient-rich metabolites (Vocabulary.com, 2026).

In the case of flower waste, petals, leaves, stems, and other floral residues contain carbohydrates, fibres, proteins, minerals, and bioactive compounds that serve as substrates for microbial growth. During fermentation, selected beneficial microorganisms multiply rapidly and secrete enzymes that degrade the complex organic matter into smaller molecules. These biochemical reactions release nutrients such as nitrogen, phosphorus, potassium, amino acids, vitamins, and growth-promoting substances in forms that are more easily available to plants. Depending on the microorganisms involved and the fermentation conditions, products such as lactic acid, acetic acid, ethanol, carbon dioxide, and microbial biomass may be formed (Coyle, 2023).

F. Liquid state fermentation of flower waste using low-cost fermentation systems

Temple flower waste can be effectively utilized for the production of liquid bio fertilizer through the fermentation process. Large quantities of flowers offered in temples are discarded daily, creating environmental pollution when dumped in open areas, rivers, or landfills. Since floral residues are rich in organic matter, carbohydrates, minerals, and natural bioactive compounds, they serve as an excellent substrate for microbial fermentation. By converting this waste into liquid bio fertilizer, temple flower waste can be transformed into a valuable agricultural input while reducing waste disposal problems.

For the fermentation process, containers such as plastic vessels, plastic drums, buckets, and glass jars are commonly used to hold the flower waste mixture along with water, microbial inoculum, and supplementary nutrients such as Jiggery or molasses. Among these systems, previous studies have reported that plastic containers are more suitable for liquid-state fermentation compared to glass jars and other materials. Plastic containers are lightweight, inexpensive, durable, and easy to handle, making them practical for both small-scale and large-scale production (Bulk Agrochem, n.d.).

One of the major advantages of plastic containers is their non-porous nature, which helps retain moisture and limits excessive air exchange with the surrounding environment. This creates favourable low-oxygen or semi-anaerobic conditions that support the growth of many beneficial fermentative microorganisms. In addition, the inner surface of plastic containers can promote biofilm formation, where microbial communities attach and multiply efficiently. Biofilms improve microbial stability, enhance enzyme production, and accelerate the breakdown of organic compounds present in flower waste. As a result, nutrient release and fermentation efficiency may increase (Kumari et al., 2023).

During fermentation, microorganisms decompose floral sugars, cellulose, and other biodegradable compounds into simpler nutrients, organic acids, vitamins, and plant growth-promoting substances. These metabolites enrich the final liquid product and improve its value as a bio fertilizer. The fermented liquid can then be filtered and applied to soil or plants to enhance nutrient availability, stimulate microbial activity, and support plant growth. Therefore, using plastic containers for temple flower waste fermentation offers a simple, economical, and efficient approach for producing liquid bio fertilizer while promoting sustainable waste management (Mahakalkara et al., 2023).

G. Carrier materials and organic inputs

Table 3. Different carrier materials and its role

Carrier materials	Role	Citation
Cow dung	increasing microorganisms contain enzymes and naturally occurring microbes which speed up the fermentation process and increase the shelf life of bio fertilizer	(bulk agrochem, n.d) (kumari et al., 2023)
Jaggery water	energy source for the microorganisms and increases the rate of fermentation	(Mahakalkara et al., 2023)
Panchagavya	provides good moisture and conservation properties for the stored microorganisms	(Gorasiya et al., 2022)
Glycerol, PVP(polyvinylpyrrolidone), DMSO (dimethyl sulfoxide)	these agents are acts as protective agents that help in increasing bio-inoculants and protect microbes, also giving longer shelf life to the bio-fertiliser and stress tolerance during storage and transport	(Kumari et al., 2023)

H. Applications of bio fertilizers

- The improvement of the cultivated plant production: using bio-fertilizer has inspired the scientists, and they think microbes improve the plants growth ability by increasing the nutrients contained in the plant in direct or indirect ways. The bacteria that promote plant growth can adjust the hormones of the plant, improving the plant's growth. Through several years' experiments, it has also been proven that the bacteria PGPR can improve the growth of plants as well as the productivity of soil (Chughtai et al., 2019).

- Role of bio fertilizer in photosynthesis: The higher photosynthesis rate causes the plant to have better growth, because when the plant reaches its mature stage, approximately 90% of its body mass is reach from fixing the carbon dioxide at the photosynthesis process. The major part of the plant is foliage which contain chlorophyll so any factor that affects leaves can affect the plant (Chughtai et al., 2019). The number of leaves can have a major role in the plant's development. If the number of leaves increasing the root growth can be improved, the transport of water from the soil can be increased, and the amount of accumulated nutrients (Chughtai et al., 2019).

- Cost-effective: bio fertilizers have been proven to increase the growth of plants as well as soil fertility without having detrimental effects on sustainable systems. The sustainability of soil fertility can be ensured with the help of biological fertilizers using cost-effective renewable resources (Chughtai et al., 2019).

- Foliar application: liquid bio fertilizer can be applied directly to the plant leaves, but this method requires care for sensitive plants (Borah et al., 2023).

- Soil drenching: it is directly applied to the soil, not on the foliage. The application of liquid bio fertilizer will stimulate the root growth and vegetative growth. (Borah et al, 2023).

- Irrigation: irrigation with water of liquid bio fertilizer can be used in large-scale application of bio fertilizer (Borah et al, 2023).

- Seed treatment: Liquid bio fertilizer can be used to treat the seed before sowing with the help of microorganisms, which can enhance the growth of the plant so that more production can be gained (Borah et al, 2023).

- Bio-bricks production: in the production of bio-bricks consumed in decomposing waste or fertility, such as combining with the soil, such as fertilizer (Sugandhi et al., 2025), (Manette et al., 2015).

I. Applications of flower

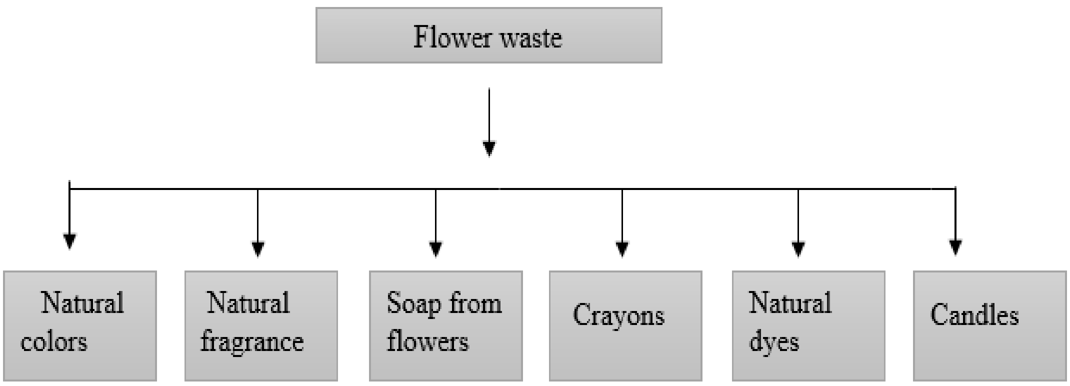

Figure:3 Different applications of flowers

REFERENCE

[1] Atal, H. L. (2022). Sustainable management of floral waste to produce bioenergy and valuable products. Journal of Indian Association for Environmental Management, 42(2), 26–34.

[2] Bennurmath, P., Bhatt, D. S., Gurung, A., Singh, A., & Bhatt, S. T. (2021). Novel green approaches towards utilization of flower waste: A review. Environment Conservation Journal, 22(3), 225–230. https://doi.org/10.36953/ECJ.2021.22327

[3] Borah, A., & Das, H. (2023). Liquid bio-fertilizers: A replacement tool for chemical fertilizer. Just Agriculture, 3(12). https://justagriculture.in/files/newsletter/2023/august/41.%20Liquid%20Bio-Fertilizers-%20A%20Replacement%20Tool%20for%20Chemical%20Fertilizer.pdf

[4] Bulk AgroChem. (2025). How to prepare biofertilizers. https://bulkagrochem.com/how-to-prepare-biofertilizer

[5] Chaudhary, P., Singh, S., Chaudhary, A., Sharma, A., & Kumar, G. (2022). Overview of biofertilizers in crop production and stress management for sustainable agriculture. Frontiers in Plant Science, 13, 930340. https://doi.org/10.3389/fpls.2022.930340

[6] Chughtai, S., Khan, S., Shoukat, M., Sardar, R., Iqbal, R. K., & Nasrullah. (2019). Application of bio-fertilizers in agriculture. Academia Journal of Agricultural Research, 7(9), 216–223. https://doi.org/10.15413/ajar.2019.0135

[7] Coyle, D. (2023, July 13). Fermentation: Benefits, safety, food list, and more. Healthline. https://www.healthline.com/nutrition/fermentation

[8] Gorasiya, T., & Faldu, N. (2022). Bioconversion of floral waste into biocompost by using microbial consortium from cow dung. Current Agriculture Research Journal, 10(3). https://doi.org/10.12944/CARJ.10.3.18

[9] Gupta, S. P., Khanna, S. K., & Gupta, A. D. (2026). Utilization of floral waste for eco-friendly value-added products: A circular economy approach. International Journal of Creative Research Thoughts, 14(3), IJCRT2603337.

[10] Joshi, H., Upadhyay, D., Bhattacharya, I., Thakur, A., Joshi, H., Bhowmick, P., & Andhare, P. (2022). Production of liquid biofertilizer and its effect on plant growth. Bulletin of Environment, Pharmacology and Life Sciences, Special Issue (3), 97–103.

[11] Kan Biosys. (2025, October 15). Types of biofertilizers explained: Uses, advantages, and farming tips. https://www.kanbiosys.com/types-of-biofertilizers-uses-advantages-farming-tips/

[12] Nguyen, T. H. N., Ng, L. C., & Riddech, N. (2018). The effects of bio-fertilizer and liquid organic fertilizer on the growth of vegetables in the pot experiment. Chiang Mai Journal of Science, 45(3), 1257–1273.

[13] Njike, M., Oyawa, W., & Nyomboi, T. (2015). Potential of quarry dust and cow dung as stabilisers for black cotton soil eco-blocks for housing. Civil and Environmental Research, 7(8), 117–124.

[14] Roots Analysis. (2025). Biofertilizers market size, trends and opportunities, 2035. https://www.rootsanalysis.com/reports/biofertilizers-market.html

[15] Shahab, S., & Anjum, M. (2022). Solid waste management scenario in India and illegal dump detection using deep learning: An AI approach towards sustainable waste management. Sustainability, 14(23), 15896. https://doi.org/10.3390/su142315896

[16] Sharma, N., Kumar, A., Syan, J., & Mukhopadhyay, S. (2025). Development and characterization of herbal colors for the Holi festival using natural ingredients. International Journal of Advanced Biochemistry Research, 9(6), 189–194. https://doi.org/10.33545/26174693.2025.v9.i6c.4508

[17] Sharma, R. K. (2021, June). Floral waste management & opportunities. Just Agriculture, 1(10), 1–2. https://www.justagriculture.in

[18] Sharma, R., & Patel, K. (2022). Bioconversion of floral waste into compost. Current Agriculture Research Journal, 10(2), 123–130.

[19] Sugandhi, N., Raaziqh, A., Ahmed, S. S., Hari, T., & Radhika. (2025). Sustainable innovation: Cow dung as eco-friendly special bricks for rural construction. International Journal of Engineering Development and Research, 13(4), 931–936. http://www.ijedr.org/

[20] SV Agro Solutions. (2026, February 20). Types of biofertilizers every farmer should know. https://www.svagrosolutions.com/article-details/types-of-biofertilizers

[21] Verma, L., & Kumar, V. (2024). Use of biofertilizers in modern agriculture. Advances in Genetics and Biotechnology International Research, 40(4), 1191–1193. https://doi.org/10.35248/0970-1907.24.40.1191-1193

[22] Verma, P., & Pandey, K. (2022). Biofertilizer: An ultimate solution for the sustainable development of agriculture. Current Agriculture Research Journal, 10(3). https://doi.org/10.12944/CARJ.10.3.04

[23] Vocabulary.com. (n.d.). Fermentation. In Vocabulary.com Dictionary. Retrieved March 27, 2026, from https://www.vocabulary.com/dictionary/fermentation

[24] Zhao, G., Zhu, X., Zheng, G., et al. (2024). Development of biofertilizers for sustainable agriculture over four decades (1980–2022). Geography and Sustainability, 5, 19–28. https://doi.org/10.1016/j.geosus.2023.09.006