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Biofertilizers and biopesticides from waste: A path toward sustainable agriculture

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Abstract
The use of waste food materials and converting it into Biopesticides and Biofertilizer is the main aim of this project. First sample is Lemon peels which are waste food material; it can reuse as Biofertilizer and Biopesticide for plant and soil. Due to its acidic nature the insect and pests are not affect the plant. It also has beneficial Phytochemicals and Minerals which can helps in plant growth and improving quality of soil. Other sample is Sugarcane waste material from this we made liquid fertilizer by dipping waste into water and making growing media as well as fertilizer by sun drying and making powder from sugarcane waste sample. All of this byproduct contains many phytochemicals and minerals like Lipid, Protein, Carbohydrates, etc… Nitrogen, calcium, chloride, etc. by use of this Biofertilizer and Biopesticide the soil quality is improved properly.

Keywords: Biofertilizer, biopesticides, waste of food products, phytochemicals and minerals

Introduction

Sugarcane is the most valuable commercial crop in the world. Sugarcane, which is grown once a year in January and March, is India's primary source of sugar. It is the primary element controlling the price of producing sugar. Since the Vedic era, sugarcane has been grown throughout India. India is ranked forty-first globally. Cuttings, which are segments of stem with axillary buds, or true seeds can be used to propagate the sugarcane plant. Sucrose usually accumulates in the stalk throughout the ripening period, which is the final stage of the stalk's vegetative life. One tropical plant is sugarcane. Heavy soils with adequate drainage are advised for sugarcane farming, even though it flourishes on medium- and light-textured soils with constant irrigation. Numerous value-added products can be made from a variety of crop residues and sugarcane by-products, including bagasse, sugarcane tops, molasses, and vinasse. Animal feed, composites, chelating agents, alkaloids, different enzymes, organic acids, amino acids, pigments, bioethanol, biodiesel, biobutanol, 2, 3-butanediol, biohydrogen, bioelectricity, and biopolymer are just some of them (Durgesh Nandhini and T.S. Krishnamoorthy et. al., 2017) [12].

In citrus cultivation, India led the world in both area and acid lime production from 2016 to 2017. In terms of both area and acid lime production in 2019–20, Gujarat and Andhra Pradesh were the top two states (Fernando Rivera-Cabrera *et al*. 2010) [13]. all citrus fruits share the flavedo, albedo, and carpel segments. Throughout 2017 and 2018, the different vegetative features of the lime tree seedlings were observed in relation to their developmental stages. Fruit, seed, leaf, flower, and tree.

A natural product called biofertilizer contains live bacteria that are grown from the soil or roots. They additionally help in the activation of plant growth hormones, which enhances nutrient absorption and boosts resilience to drought and moisture stress. Although farmers utilize chemical fertilizers as an extra source of nutrients, their application is insufficient (Isman et. al., 2011) [18]. Even with balanced application of only chemical fertilizer, a high yield level could not be maintained over time due to damage in the physical and biological habitats of the soil (Badar Rabia *et al*. 2015) [14].

Biofertilizers are made from food and kitchen waste from homes, restaurants, caterers, and retail establishments, as well as similar waste from food processing facilities. Biofertilizers are made from the roots or cultivated soil and contain live microorganisms, which means they have no negative effects on the ecosystem or soil health. Synthetic fertilizers have been used carelessly, contaminating the soil, killing beneficial insects and microorganisms, contaminating water basins, making crops more susceptible to disease, and lowering soil fertility (M. Kannahi *et al*. 2015) [15].

Long-term manorial studies conducted in various locations have demonstrated the superiority of an integrated nutrient supply system over chemical fertilizer alone in sustaining agricultural productivity (M. Kannahi et. al., 2015) [15].

Continuous application of biofertilizers improves soil health without damaging the environment. But nitrate leaks from chemical fertilizers contaminate ground and surface water, harming human health and the ecosystem. One of the main causes of the enormous rise in food production worldwide has been the usage of artificial fertilizers. Nowadays, there is a trend to look into the potential of replacing chemical fertilizers with more affordable and ecologically friendly organic ones (Tanushree Mondal *et al*. 2017) [16].

Crop protection products, or CPPs, are used globally in agriculture and agricultural product trade to increase yields, protect plants from disease, and prevent damaging harvests. However, the kinds and amounts of CPP utilized are not governed by any international law. The availability of agricultural products containing CPP on the German market is a natural outcome of the domestic and international trade in fruits, vegetables, and flowers. Unusable and inedible components of these goods make up a percentage of biological waste (J. Taube et. al., 2002) [17].

The need for environmentally friendly solutions to be used in integrated pest management (IPM) programs has grown significantly in recent years. In addition to biological management, botanical pesticides may be helpful in controlling the main pest species of many agricultural systems, especially in places where the use of synthetic substances is prohibited (Zehnder *et al*., 2007, Bernardi *et al*., 2013).

Materials & Methods
Materials require
- **Collecting bags:** A thick plastic bags for collecting samples.
- **Scissor:** For cut the samples in small pieces.
- **Container:** To dry material in sunlight.
- **Mixture:** For making powder of sample.
- **Distilled Water:** For diluting sample.
- **Note book:** For collecting data of tests.

Methods
- **Sugarcane powder**

Take a sample of sugarcane from the Bagasse (It's by product of sugarcane industries). Remove the infected sample (if required) sundry it for minimum 7 days with full day sunlight to remove complete moisture from the sample. Cut the samples into small pieces for making powder of it. Again, sundry the cutted samples for 1 or 2 days. Then make a powder form of sample with the help of the mixture grinder. Sieve the sample perfectly to remove big particles from the sample and for collecting uniform texture of sample. Wash the sample 4 to 5 times cause of acidic nature of Sugarcane (Razia et. al., 2020) [22].

- **Sugarcane Liquid**

Take a sample of sugarcane waste material from the Bagasse (It's by product of sugarcane industries). Remove the infected sample (if required). Take a 500gm sample of bagasse and deep it into 5 ltr. Water in big container for 15 days. Filter the sample once or twice and dilute in same amount of distilled water (Razia et. al., 2020) [22].

- **Biopesticide from Lemon**

Take 200gm of lemon waste (peels) from the kitchen or any other source. Wash it with water and remove the infected area of waste. Dip the sample into 1 ltr. of distilled water. Stir the mixture daily and observe the difference. After 15 days peel extract is ready. Remove the peels from water and filter the mixture with the help of filter paper. Extract was dilute in same amount of water and it's ready for use (Suri et. al., 2022) [23].

Test of Phytochemicals
1. **Lipid:** Mix the sample with equal parts ethanol and water, then shake. If lipids are present a cloudy white emulsion will form (Rajkumar, et. al., 2022) [8].

2. **Carbohydrates (Molisch's test):** Extract filtrates were treated with 2 drops of alcoholic α-naphthol solution in a test tube separately and 2 ml of concentrated sulphuric acid was added carefully along the sides of the test tubes. The formation of a violet ring at the junction may indicate the presence of carbohydrates (Balamurugan, et. al., 2019) [2].

3. **Protein (Xanthoprotein analysis):** The extract was treated with a few drops of concentrated HNO3 formation of yellow indicates the presence of protein (Patel, Pinal, et. al., 2014) [11].

4. **Tannin analysis:** 2 ml leaf extract was added to 1% lead acetate a yellowish precipitate indicates the presence of tannins (Ujah, et. al., 2021) [1].

5. **Phenolic compound (Phiobatannins analysis):** Deposition of red ppt. when aqueous of each plant sample is boiled with 1% Aqueous HCl was taken as evidence for presence of Phenolic compound (Shaikh, et. al., 2020) [3].

6. **Flavonoids (Alkaline reagent test):** Extract was treated with 10% NaOH solution; for estimation of intense yellow colour indicates presence of Flavonoid (Agidew, et. al., 2022) [4].

7. **Saponins:** To 2 ml of each extract, 6 ml of distilled water was added and shaken vigorously; the formation of bubbles or persistent foam indicates the presence of saponins (Kumar, Ashok, et. al., 2012) [10].

8. **Carotenoids:** 1 g of each specimen sample was extracted with 10 ml of chloroform in a test tube with vigorous shaking. The resulting mixture was filtered and 85 % sulphuric acid was added. A blue color at the interface showed the presence of carotenoids (Hashmi, et. al., 2021) [6].

9. **Coumarins analysis:** 3 mg of 10% NaOH was added to 2 ml of aqueous extract formation of yellow color indicates coumarins (Maharaj, et. al., 2022) [2].

10. **Terpenoids**: Take 1 ml of each solvent and add 0.5 ml of chloroform followed by a few drops of concentrated sulphuric acid. The formation of a reddish-brown precipitate indicates the presence of terpenoids in the extract (Egbuna, et. al., 2018) [5].

11. **Phytosterol (Salkowski's analysis):** The extract was treated with chloroform and filtrate. The filtrate was treated with a few drops of concentrated H2SO4 and shakes, allowing standing, the appearance of golden red indicates the positive test (RK Karangiya et. al., 2019).

Test of Minerals
1. **Calcium:** Slowly add ammonium hydroxide or sodium hydroxide to the liquid sample to neutralize any acids and raise the pH to slightly alkaline (around pH 9-10). This is done to ensure calcium ions are in their ionic form. After adjusting the pH, add a few drops of ammonium oxalate solution to the sample. If calcium ions are present, a white precipitate of calcium oxalate will form (Burstrom et. al.,1968).

2. **Chloride:** Place 2-3 ml of the liquid sample into a clean test tube. Add a few drops of dilute nitric acid (HNO_3) to the sample. This helps to eliminate any interference from other ions such as carbonates or sulphates. Add a few drops of silver nitrate ($AgNO_3$) solution to the test tube. A white precipitate indicates the presence of chloride ions (Marschner et. al., 2012).

3. **Phosphorus:** Ammonium molybdate and antimony potassium titrate react in an acid medium with dilute solutions of phosphorus to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The colour is proportional to the phosphorus concentration (Mc Eleney et. al., 2022) [24].

4. **Sulphur:** A drop of a solution containing sodium azide and iodine is placed on the material to be tested. Rapid evolution of nitrogen gas from the decomposition of the azide indicates the presence of sulphur (Heritage et. al., 2017) [25].

5. **Iodine:** Take 1 ml of a given sample in a clean, dry test tube. Take control of 1 ml of distilled water in another tube. Add about 2-3 drops of Lugol's solution to both the tubes and mix them in a vortex. Observe the appearance of colour in the test tubes. Heat the test tubes in the water bath until the colour disappears. Take the test tubes out for cooling Note down the appearance of colour seen in the test tubes (Soares et. al., 2017) [26].

6. **Bromine:** An unknown sample is treated with a small amount of elemental bromine in an organic solvent, being as dichloromethane or carbon tetrachloride. Presence of unsaturation and/or phenol or aniline in the sample is shown by disappearance of the deep brown coloration of bromine when it has reacted with the unknown sample (Fajal et. al., 2025) [27].

7. **Chlorine:** Take a test tube filled with deionized or distilled water. To this add, 5% dilute nitric acid. Using a dropper add a few drops of silver nitrate. If a cloudy white precipitate is formed, it indicates the presence of Chloride ions in water (Sodhi et. al., 2025) [28].

8. **Nitrogen: -**The Kjeldahl method consists of four primary steps: digestion, distillation, capturing of ammonia, and titration. Each step is essential for accurately determining the nitrogen content. The sample is heated with concentrated sulfuric acid (H_2SO_4), breaking down the organic material (Stansfield et. al., 2025) [29].

Test of pH in Sugarcane husk as a media
pH is measured by Digital Ph meter 335.

Water holding capacity
Drying the sugarcane husk in an oven until it's completely dry. Add 10 gm sugarcane husk in funnel. After Add 20 ml water in sample. Filter the mixture with filter paper. Saturate the sugarcane husk with water until it stops dripping. Measure the water which collected in measuring cylinder. (Bordoloi, *et al*., 2019) [21].

Result

- **Phytochemical test of samples**

Tests	Lemon waste Water	Sugarcane waste Powder	Sugarcane waste Liquid
Lipid	++	+++	+
Carbohydrates	+	++	+++
Protein	+++	+	+
Steroids	+++	++	-
Tannin	++	+	-
Phenolic	+++	+	-
Flavonoids	+++	++	+
Saponin	-	-	-
Carotenoids	-	-	-
Coumarine	+++	++	+
Terpanoids	+++	+	++
Phytostetol	+++	++	+

(+ less amount present ++ Moderate amount is present +++ Highly present)

1. **Lipid:** Sugarcane waste powder has a high lipid content, lime waste pesticide has a moderate lipid content, and sugarcane waste liquid has a lower lipid content.

2. **Carbohydrate**: According to the analysis, there is a significant concentration of carbohydrates in sugarcane waste liquid, a reasonable quantity in sugarcane waste powder, and a lower amount in lime waste pesticide.

3. **Protein:** According to the protein test, lime waste pesticide has a high protein content, sugarcane waste powder has a moderate protein content, and sugarcane waste liquid has a lower protein content.

4. **Steroid:** Based on data analysis, steroids are shown to be abundant in lime waste pesticide, moderately present in sugarcane waste powder, and nonexistent in sugarcane waste liquid.

5. **Tannin:** According to the tannin test, there is a large concentration of tannin in lime waste pesticide, a lower concentration in sugarcane waste powder, and no tannin at all in sugarcane waste liquid.

6. **Phenolic**: According to the results of a phenolic test, phenolic compounds are most abundant in pesticides made from lime waste, less prevalent in powdered sugarcane waste, and nonexistent in liquid sugarcane waste.

7. **Flavonoids:** As per the tests of Flavonoids; it is highly present in Lime waste pesticides; in moderate amount of flavonoid is present in Sugarcane waste Powder and in less amount of flavonoid present in Sugarcane waste liquid is observed.

8. **Saponin:** According to the saponin test, none of the samples contain saponin.

9. **Carotenoid:** The carotenoid test indicates that it is not present in any of the samples.

10. **Coumarine:** According to the Coumarine test, it is found in high concentration in lime waste pesticide, in moderate amounts in sugarcane waste powder, and in smaller amounts in sugarcane waste liquid.

11. **Terpanoid**: According to tests, Terpanoid is found in large concentrations in lime waste pesticide, in moderate amounts in sugarcane waste liquid, and in smaller amounts in sugarcane waste powder.

12. **Phytosterol:** From the data analysis of the phytosterol test, it is found in high concentration in lime waste pesticide, in moderate amounts in sugarcane waste powder, and in a lesser quantity in sugarcane waste liquid.

- **Minerals test of Samples**

Tests	Lemon waste Water	Sugarcane waste Powder	Sugarcane waste Liquid
Calcium	++	+	+++
Chloride	+	++	+++
Phosphorous	+	++	+++
Sulphur	+	-	-
Iodine	+++	++	+
Bromine	+	-	-
Clorine	-	-	-
Nitrogen	+++	+	++

(+ less amount present ++ Moderate amount is present +++ Highly present)

1. **Calcium:** According to a calcium test, sugarcane waste liquid material contains a high concentration of calcium, while lemon waste water contains a moderate amount and sugarcane waste powder contains a lower amount.

2. **Chloride:** a report to a test, there is a significant concentration of chloride in sugarcane waste liquid material, a moderate amount in sugarcane waste powder, and a lower quantity in lime waste water.

3. **Phosphorus:** In accordance to a phosphorus test, phosphorus is found in high concentration in sugarcane waste liquid material, in moderate amounts in sugarcane waste powder, and in smaller amounts in lime waste water.

4. **Sulphur:** According to a test, sulphur is not found in sugarcane waste liquid or powder, and it is hardly ever found in lime waste water.

5. **Iodine:** As per an iodine test, iodine is found in high concentration in lime waste water, in moderate amounts in sugarcane waste powder, and in fewer quantities in sugarcane waste liquid.

6. **Bromine:** Based on a test, bromine is not found in sugarcane waste liquid or powder and is hardly ever found in lime waste water.

7. **Chlorine:** In response of the test, none of the samples contain chlorine.

8. **Nitrogen:** Pursuant to the nitrogen test, lime waste water has a high concentration of nitrogen, sugarcane waste liquid has a moderate quantity, and sugarcane waste powder has a lower amount.

Conclusion
This Waste-derived biopesticides and biofertilizers very effective low cost and eco-friendly compere to chemical fertilizers, making them more helpful to the soil and improving its quality over time. As a result, biofertilizers are affordable, sustainable, and environmentally beneficial; still, they cannot completely replace chemical fertilizers. Organic farming and Integrated Nutrient Management both heavily depend on the usage of biofertilizer. In today's agricultural practices, these technologies are becoming increasingly important. In the upcoming years, biofertilizers will play a bigger role due to the shifting landscape of agricultural practices and the environmental risks connected to chemical fertilizers.

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