

Original Research Article

Biotechnology in Agriculture- Bio- Decomposers, Compost, Kitchen Garden

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Abstract: We all observe World Environment Day on June 5th every year. The issue of recycling cuts across many subjects. The entire process starts under the domain of agriculture. The real process involved comes under the domain of biotechnology. Once the product like a bio-decomposer is out, its use again comes under the umbrella of agriculture & horticulture. Consumption of the output falls under nutrition & its impact is felt in public health. To see the effectiveness of the process, the methods of research are adhered to. The article discusses the vagaries of the monsoon & discusses the importance of bio-decomposers to address these vagaries both at household & community level. The concept of kitchen garden, its cost effectiveness, process of formation of bio-decomposers and biotechnology involvement are described through the literature review mentioned in the article. The crux of the article is the case study of preparing a bio-decomposer, using the bio-decomposer for the plants or vegetables thus enriching them. Finally, the process of formation of soil by using the bio-decomposer on the used tea leaves & used flowers. On the top of it, using only dry cow dung & dry leaves as manures is the key.

Keywords: Bio- decomposers, kitchen garden, fermentation.

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INTRODUCTION

The IMD (Indian Meteorological Department) remarked positively on the forecast of the monsoon conditions of 2023 stating a probable timely arrival of the monsoons in India. Earlier, in 2023 the IMD had stated that despite the developing El Nino conditions, India would get a normal rainfall [14].

The 2023 monsoons hit Kerala on 8th June 2023 i.e. 7 days later than its normal progression date. By June 25-26, the monsoons had advanced over Mumbai and

Delhi after a delay of 14 days in Mumbai and 2 days earlier in Delhi. By June 23, it hit Uttar Pradesh. This pattern of arrival indicates that the south western monsoons have knocked the Indian shores late this year. Moreover, due to the cyclone Biparjoy, the distribution of rainfall remained very uneven with the North western India experiencing 37% surplus rainfall while the central parts and the southern peninsula experienced 35% and 45% deficient rainfall [15-17, 19].

Even though the rains have helped bring the heat down, but they have increased the prices of

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vegetables and fruits. For example, the heat waved initially impacted the tomato crop leading to a dry and wilted crop field. The unseasonal rains of May caused by the cyclone further damaged the crop. Heavy rains reduce photosynthetic activity, alter metabolism and affect the enzymatic activity of plants [21].

During May, the farmers had to dump their harvested tomatoes as they couldn't get the justified price of their production. The farmers spend Rs. 65000 per acre to grow tomatoes and the yield is between 700 and 1000 crates. The production cost per crate is Rs.45. The farmers can not add more value to the crop instead of selling it raw. Most farmers can't afford to dehydrate and can the tomatoes or store them for a few days or weeks. The rains have also impacted apples, pears, peaches and plums. The rains have disrupted the supply chain. Major impact is observed mainly when the major producer states facing are adversely affected by extreme weather or crop damage [18, 20].

Even though supply chain hoarding is a major issue, prices of essential vegetables still shoot up in such conditions. Delayed rains have also delayed the sowing of Kharif crops like paddy, pulses, oilseeds, cotton, and sugarcane [19].

In such conditions, other technologies and methods must be adopted for reduce our OOOPE i.e. Out of Pocket Expenditure at household. One of the wise ways to do so is the development of Kitchen gardens. These gardens require a significant amount of time,

effort, energy and financial investment but the returns are very significant and sustainable in terms of fulfilling the food security and nutritional concerns at the household level. People can consume fresh produce without a profound use of chemicals [7-9].

Waste decomposers produced by the government and companies are a great help for such gardens as they can help the families apply the concept of one's waste -other's raw material (zero waste concept) . People can produce highly nutritious compost by the household based biodegradable waste like tea leaves, fruit and vegetable peels that they scrape out during cooking and eating. Left- over food can be given to either cows or be used for compost production [1].

Such waste or organic decomposers can also be used by actual farmers in their fields for the decomposition for 'Paraali' and agricultural waste to produce manure and compost [23].

This paper focuses on the production, use and importance of waste decomposers. It also highlights the importance of kitchen gardens and how they can play a role in cost reduction. How and why waste reduction is important is also an important topic to be covered in this paper [7].

The current work reviewed 23 pieces out of which there are 7 research papers, 18 articles and 1 chapter from a book. The details are given in the Table 1.

Table 1: Literature review details of the current article

YEAR	CONTENT	FINDINGS	RECOMMENDATIONS	FUTURE APPLICATIONS
2014 [2]	Plant Growth Promoting Bacteria from Cow Dung Based Biodynamic Preparations	<ol style="list-style-type: none"> 1) There are basically 3 biodynamic preparations for plant growth promoting bacteria each containing different concentrations of yeasts, lactobacilli and actinomycetes. 2) Each preparation is organic in nature but has different origins and composition 3) Panchgavya, BD500 and CPP are the three preparations. Each impacts different crops in different ways. 4) All use fermentation in one of their ways to enhance yields 	<ol style="list-style-type: none"> 1) Apart from cows, other animals should also be considered for the source of preparations 2) Use should be increased so that the subsidy provided on fertilisers can be reduced by reducing demand. 3) Diversity in the preparations as well as the availability in the form of capsules should be increased 	<p>Making these biodynamic preparations available for the commoners for better yields so that toxic chemicals can be avoided</p> <p>Exploring other kinds of animal wastes as well as microbes is necessary for diversity</p>
2014 [4]	Method for preparing organic fertilizer by fermenting cattle manure	<ol style="list-style-type: none"> 1) Explains the Chinese agricultural technology of producing organic fertilisers from cow dung through fermentation 2) Cow dung has good amount of water content hence fermentation is preferred and is done in 2 phases 3) Compositions vary and may involve dung, sawdust, pluck 	<ol style="list-style-type: none"> 1) Alternatives of cow dung should be explored 2) For better uptake of nutrients, method of cow dung fertiliser must be improved through sharing of technologies 	<p>Exploring better machinery for faster production and availability will be essential</p> <p>Protection of animals will also be important</p>

YEAR	CONTENT	FINDINGS	RECOMMENDATIONS	FUTURE APPLICATIONS
		powder, plant ash, humic acid etc.		
2014 [7]	What are the economic costs and Benefits of Home vegetable gardens ?	<ol style="list-style-type: none"> 1) Kitchen gardens may or may not help in cost reduction 2) Home based activity hence, it is difficult to understand the overall economic dynamic as personal expenditures may vary 	<ol style="list-style-type: none"> 1) Proper choice of location should be done 2) Investments will be successful only if requirement is kept under consideration 	Urban Development ministry must make it a regulation for solid liquid waste management at the household level
2017 [8]	Economic analysis of Kitchen garden at farmers' doorsteps	<ol style="list-style-type: none"> 1) Increase nutrition and food security 2) Higher demands can be met through these 3) Help raise income 	<ol style="list-style-type: none"> 1) For nutritional security organic methods must be adopted 2) Shouldn't be seen only as way of earning 	Use of organic fertilisers and involving home based biodegradable waste
2018 [21]	Monthly report on Tomato	<ol style="list-style-type: none"> 1) Major tomato producing states are West Bengal, Maharashtra, Karnataka, Gujarat, UP etc 2) Grows in all the seasons 3) Transplanting periods vary 	<ol style="list-style-type: none"> 1) Major producer states' farmers should be given more access to storage and conservation as it is a perishable item 2) Genetic technologies need to be explored for better survival of the crop 	<p>Cold storages must be accessible to poor farmers more.</p> <p>Genetic engineering needs to explore the perishability rates of this crop.</p>
2019 [6]	Importance and advantages of Kitchen garden in urban areas	<ol style="list-style-type: none"> 1) Kitchen gardens are growing in urban areas 2) Helps reduce OPE and mental stress 3) Purification of aura and air 	<ol style="list-style-type: none"> 1) Persistence is required as it is a time taking investment 2) Definitely helps in cost reduction as some needs are met through the garden but shouldn't be seen as the major saver because a lot depends on a successful harvest. 	<p>Better quality seeds, standard and elaborate ways of gardening must be explored.</p> <p>Each garden must try to have a solar panel and rain water harvesting. These 2 things should be made a regulation.</p>
2021 [1]	Role of decomposers in agricultural waste management	<ol style="list-style-type: none"> 1) Agri waste important to manage 2) 3 types waste- livestock manure, postharvest, agro-industrial 3) 3 types management processes- Landfills, anaerobic decomposition, Hydrolysis 	<ol style="list-style-type: none"> 1) Waste management should be taught at household level too 2) Technologies for post harvest waste decomposition must be promoted and made compulsory 3) States that are suitable for the given crop must be focused on more through contract farming. 	The method of waste management that can be used at the household level must be made compulsory for eg: waste segregation
2020 [3]	Waste Decomposer and its uses	<ol style="list-style-type: none"> 1) Plant based decomposers cause a lot of pollution due to less uptake of fertilisers 2) Process of formation of bacteria based decomposer that can enrich the soil with nutrients and also increase the yield. 3) National Institute of Organic Farming introduced it. 	<ol style="list-style-type: none"> 1) Should be made available on subsidy 2) The bottle should be well labelled and descriptive 3) Spreading more knowledge about the product and increasing the companies for production is important for better quality 	Must be made compulsory to be used in such gardens and agri fields
2023 [23]	Compost	<ol style="list-style-type: none"> 1) Can be prepared on a small scale 2) With the ratio of 30:1 for carbon and nitrogen, most pathogens get killed 3) Vermi composting uses earthworms 	<ol style="list-style-type: none"> 1) Benefits must be explained to interested to gardeners 2) Should be introduced as not an option but an important component 	Same as previous that composting must be a necessary element for gardening through guidelines and corporations

YEAR	CONTENT	FINDINGS	RECOMMENDATIONS	FUTURE APPLICATIONS
		4) Guano is the excrement of birds, bats and seals.	3) To improve the soil quality, increasing soil biome is important	
2022 [9]	The cost effectiveness of Growing a garden	1) Positive returns on investment mostly 2) Better mental health 3) Done according to area	1) Beautification must not be considered as part of real time returns 2) Cost comparisons must be calculated individually as it is a part of mixed income	Same as previous similar article
2022 [12]	Waste decomposer – Immanent for plants	1) Advantages of waste decomposer 2) Can be used for forming biopesticide 3) Can be used for drip irrigation	1) Irrigation methods must be improved. 2) Tubewells must be prohibited.	Same as previous similar article
2023 [11]	Compost	1) Can be prepared on a small scale 2) With the ratio of 30:1 for carbon and nitrogen, most pathogens get killed 3) Vermicomposting uses earthworms 4) Guano is the excrement of birds, bats and seals.	1) Should be promoted and advertised in better way 2) With the exploration of other minerals, the need for weedicides can be reduced	Same as previous similar article
2023 [13]	Not just tomatoes: Why are vegetable prices seeing a rise?	1) Food inflation is increasing 2) Monsoons affect crop quality 3) Supply chain got disrupted 4) Post harvest Losses occurred	1) Hoarding should be questioned neutrally 2) For better survival access to better technologies to be made easier	Same as previous similar article
2023 [14]	IMD strikes optimistic note even as monsoon 2023 Misses its date with Kerala	1) 2023 monsoons got 7 days late 2) Monsoons normal despite El Nino conditions	Forecasts must be made earlier for horticulturists, farmers etc.	Traditional methods of afforestation, prohibiting tubewells etc. must be followed
2023 [15]	When will Monsoon 2023 arrive in Mumbai, the rest of Maharashtra and Goa?	1) Monsoon hit Mumbai by 25 – 26 June 2) Delayed rains in the west coast	SAME AS ABOVE	SAME AS ABOVE
2023 [16]	Monsoon hits Delhi,Mumbai on same day for first time in 62 years	1) Monsoons got delayed by 14 days 2) Were 2 days early in Delhi	SAME AS ABOVE	SAME AS ABOVE
2023 [17]	When will Monsoon arrive in Lucknow and the rest of Uttar Pradesh	1) Monsoons hit UP on June 23 2) Despite the cyclone hampered rains, delay occurred	SAME AS ABOVE	SAME AS ABOVE
2023 [18]	Thrown away due to Poor prices, To selling at Rs 150 per kg, why Tomato Prices are always wobbly	1) Due to heat waves the tomato crop did not sell well 2) Cyclone rains further damaged the crop 3) Due to shorter supply in Major producer states, prices hiked (also because of hoarding)	Cold storage facilities must be made accessible	Same as previous similar article
2023 [19]	Indian Monsoon reaches Kerala after longest delay in four years	1) Uneven rainfall distribution 2) Deficient rains	Same as other monsoon articles	Same as previous similar article
2023 [20]	Explainer: why tomato prices are surging in your city	1) Food inflation difficult to control	Same as the other tomato crop articles	Strict action must be taken for hoarding Elaborate technologies must be adopted

YEAR	CONTENT	FINDINGS	RECOMMENDATIONS	FUTURE APPLICATIONS
		2) When major producer states face difficulties, prices shoot up		
2023 [5]	Methods to make Cow manure Organic fertiliser	1) Cow dung contains 10-20% crude protein, 1-3% crude fat, 20-30% nitrogen free extract and 15-30% crude fiber 2) Windrow compost turner used for fermentation and composting 3) Semi- wet material crusher and horizontal type mixer used for grinding and mixing raw materials 4) New type organic fertiliser granulator used for crushing and mixing of raw materials 5) Rotary drum screener used for screening process	Description of the components must be made easily available	Same as previous similar article
2023 [22]	Organic Farming	1) Composting is a natural process of rotting or decomposition 2) 3 methods of composting 3) Indore, Bangalore and Coimbatore method	Same as other compost articles	Efforts to be made on cutting down the cost of production

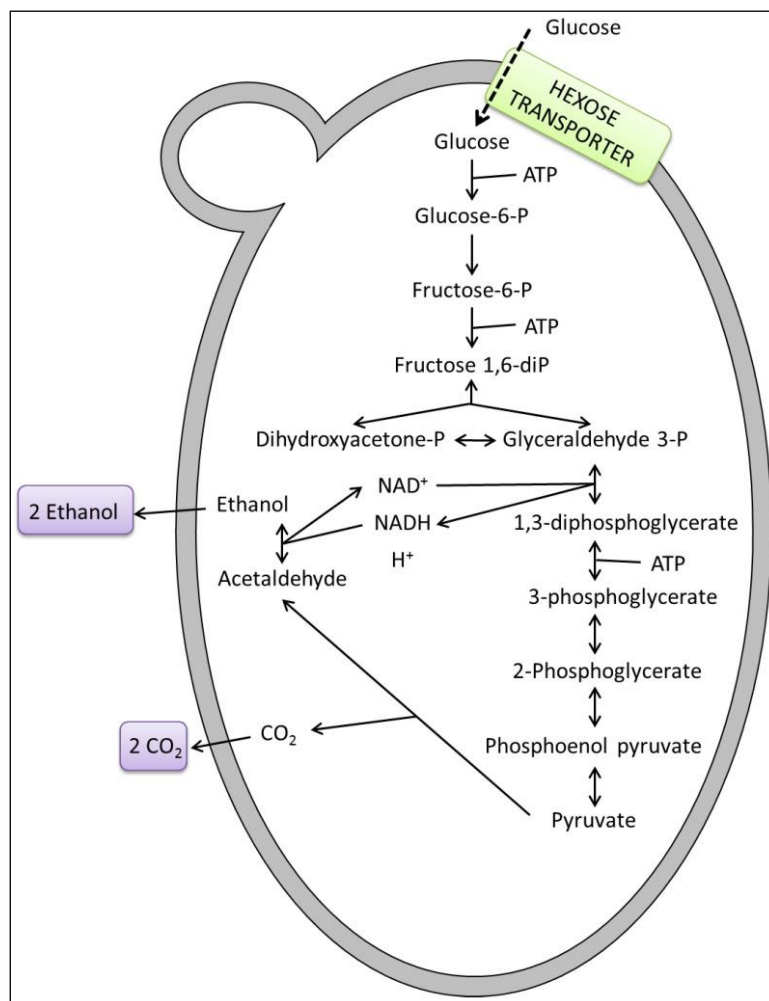


Figure 1: Process of Fermentation

RESEARCH METHODOLOGY

The following study follows the 'Case Study' method as the design of the study. The case study is an example of developing a kitchen garden using bio-decomposers to understand the working of decomposers and how they benefit the plants through composting. The Ministry of Housing & Urban Affairs (MOUHA) started the concept of composting in 1975 & the idea of composting at household level in 2014 through the Swachh Bharat Mission. The section below explains the details of the case study. It delves into the introduction and evolution of waste decomposers, their working and how the process was carried out [23].

The Process of making the Bio-decomposer

The name of process is simple and common. It is a process used daily in our lives without the proper realisation and awareness of the human minds at large. This process is called fermentation [10].

Fermentation has been used since long for the purpose of producing alcohol, bread and by-products. Scientifically speaking, fermentation is a process of metabolism where an organism converts carbohydrates like starch, sugar into alcohols or acids. This process was fully and properly carried out before it was understood from a scientific point of view. This process was first studied by the French chemist and microbiologist Louis Pasteur. Several strains of 'Saccharomyces Cerevisiae' have been most commonly used for this process. They are known for their fermentative capacity and technological characteristics. Yeasts also play a role in wastewater treatment and production of bio-fuels [10].

The process of fermentation involves the breakdown of Pyruvate (a product of glucose metabolism) into ethanol and carbon dioxide. During low or limited oxygen conditions, ethanol is produced from acetaldehyde and 2 moles of ATPs are generated. Ethanol gets accumulated and fermentation stops [10].

This process of fermentation is what is used in the making and multiplication of waste decomposers [10].

Agricultural waste contains various kinds of waste like sugarcane baggage, paddy, wheat straw, vegetable waste, jute fibres etc. Accumulation of agricultural waste causes a lot of environmental pollution. Retention of crop residue after harvest helps reduce soil erosion. Animals can't digest this residue. The process of burning of the residues lead to the emission of gases like Carbon Monoxide (CO), Carbon Dioxide (CO₂), Nitrous Oxide (NO) and Ammonia (NH₃). This causes air pollution and loss of organic content. To avoid such harmful consequences, biological decomposition is used as the main and efficient method. A variety of bio-decomposers like bacteria, fungi, protozoa help to degrade the cellulose by depolymerising cellulases that in turn hydrolyse lignocellulases. Most

commonly known decomposers are Humicola, Trichoderma and Penicillium aspergillus [1, 5, 23, 26].

The prices of soil based microbes are increasing. Because of this the prices of the decomposers are also on the rise [26].

Organic farming also involves the formation of 3 biodynamic preparations – Panchgavya, BD500 and Cow pat pit with high amounts of lactobacilli and yeasts. Actinomycetes are present only in CPP.

The bacteria can take up only 3 carbon sources i.e. dextrose, sucrose and trehalose. All strains produce Indole Acetic Acid and ammonia. These preparations were serially diluted tenfold and placed on Luria Bertani agar, de Man Rogosa Sharpe (MRS) agar, malt agar, with chloramphenicol for the enumeration of bacteria, lactobacilli, yeast and actinomycetes. Seven isolates, four from PG, two from BD500 and one from CPP were evaluated. They were characterised for gram reaction, endospore formation and biochemical attributes like nitrate reduction, casein hydrolysis, starch hydrolysis, H₂S production etc [2, 5].

The near full length of 16S rRNA gene sequences of the strains were custom sequenced on ABI 3730x1 Genetical Analyser at Xcelris Labs LTD [3].

Moving further, the focus now again shifts on the decomposers. These are basically a consortium of beneficial microbes like Azotobacter, Azospirillum, Rhizobium, Acetobacter) isolated by Krishan Chandra in 2004 from cow dung for enhancing crop production. The National Centre of Organic Farming, Ghaziabad, UP introduced these decomposers [4].

They control several soil borne, foliar diseases, insects and pests. Decomposers can be easily multiplied using jaggery at farms and home based gardens. They play a role in situ composting of crop residues, seed dressing, providing biocontrol agents etc. They are sold at lower prices with greater shelf life [5, 26].

The propagation of jaggery indicates the presence of cellulolytic, phosphate and potassium solubilising activity [5].

Since the launch of these waste decomposers, more than 10 lakh farmers have been able to revive their fields without suffering severe crop damage though pest infestations. The input cost has been reduced to zero and the income has been doubled. These waste decomposers can help in reducing the huge volume of organic waste by quick composting. Soil fertility will increase as the decomposers help in increasing the earthworm population [3, 25].

The following is the process of mass multiplication of waste decomposer. This process

follows the standardised protocol given by Krishan Chandra in 2015 [5].

- Mix 2 kg jaggery and mix it in a plastic drum with 200 L of water
- Pour one bottle of the decomposer (30 g) into the drum
- Mix with a wooden stick
- Cover the drum with a paper or cardboard
- After 7 days, the solution will turn creamy
- The decomposer solution can then be prepared again and again from the above solution by adding 20 L of initial solution along with 2 kg jaggery and 200 L water. It would be ready in 7 days.

After this solution is formed it will be added to smaller drum with dried cow dung, all the degradable organic waste and will be left to rot for 15 days until it turns into properly composted soil.

This soil will then be added to the plants/crops thus recycling the soil. The figures below show the prepared biodecomposer & the soil.

Given below are the figures of the biodecomposers & soil in the process of being prepared and the final product after going through the process. There are four figures two each for the biodecomposer & the soil.



Figure 1: Biodecomposer in the process with one kilogram of Jaggery



Figure 2: Prepared Biodecomposer after 7 days



Figure 3: Soil in the process



Figure 4: Prepared Soil after 3 months

Cost comparison

This section makes a comparison of cost of tomatoes from the kitchen garden & from the market during the months of July & August 2023. The lead author does a comparison of cost per day keeping 200 grams of consumption of tomato in a household of 5

people. The total cost includes the preparation of 200 litre of liquid bio-decomposer on the day of its preparation. One drum lasts for 30 days. The average size of a household in India as per Census 2011 is 5 currently. The input costs are given in the table given below [27].

Table 2: Input costs of preparing bio-decomposer (source- actual expenditure incurred by the lead author for her kitchen garden)

Material	Cost in ₹
1. Gunny Bag (3'2")	250 (one time cost)
2. Waste Decomposer	20 (one time cost)
3. One gunny bag full of soil	No cost as prepared from compost using used tea leaves & produced bio-fertilizer
4. Water (Full in a 200l drum)	5.50 (the water bill per year is ₹2000 per year)
5. Drum	300 (one time cost)
6. Jaggery (one kilogram)	60
7. Covering wood board for the drum	100 (one time cost)
8. Salary of gardner	100 (per day)
Total (8 line items- 4 are recurring & the other 4 are non-recurring)	835.50
Tomato production per day	200 grams

The same bio-decomposer is used for 10 other types of vegetables along with flower pots & decorative plants. Hence, if we add line items 2, 4, 6 & 8, we get ₹ 186 as recurring expenditure. This cost covers not only tomatoes but 20 other items that are in the kitchen garden on that day. By rounding up the cost to ₹ 200 as it also includes some costs of non-recurring expenditure, the cost involved in tomato is ₹ 10 per day.

During the time when the cost of tomatoes were ₹200 per kilogram, the cost of consumption per day was ₹ 40 considering per daily consumption to 200 grams of tomato. Currently in September 2023, when the price of tomato is normal at ₹60 per kilogram, the per day cost at each house hold stands at ₹12 per day.

In addition to that, the quality related indicators like nutrition, freshness, food mile, mental satisfaction, healthy environment, recycling for sustainability, motivation for self & others are priceless.

CONCLUSION

The article is basically an effort to understand the application of biotechnology through a case study in an urban life of a household. The lead author does this at home on her roof top & hopes the article motivates others to follow. The production of soil using used tea leaves & flowers is an experience that can only be felt. The use of liquid bio-decomposer made through use of waste decomposers by ICAR at home followed by the use of the same to enrich the vegetables is another experience [24].

On the top of it, consuming these vegetables from the roof top only fulfils the concept of 'food mile'. The simple premise of this concept is that 'less the distance travelled by the food from the time of its making to reach our plate, healthiest is the food nutritionally'. It is one factor used when testing the environmental impact of food, such as the carbon foot print of the food. Hence, when someone does this, you are reducing carbon imprints on the earth [25].

Declaration of the lead author

The lead author also certifies that she has expressed her personal opinion based upon her exposure & experiences.

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