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DEVELOPMENT OF MEDICINAL PLANT-BASED BIO-DECOMPOSER FOR PARALI DECOMPOSITION: A LABORATORY INCUBATORY STUDY

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ABSTRACT

A laboratory incubatory experiment was performed in order to develop a suitable Parali bio-decomposer using different medicinal plant products viz. Citrus lemon juice and Amla juice. Parali (crop residue) burning has emerged as a major environmental concern due to its adverse impact on soil fertility, microbial diversity, and atmospheric pollution. The present laboratory incubatory experiment was conducted to develop a suitable medicinal plant-based bio-decomposer for rapid decomposition of Parali using Citrus lemon juice and Amla juice in different concentrations. The decomposition efficiency was evaluated through physico-chemical analysis, micronutrient estimation, and microbial population studies. Five treatments with three replications each were maintained under controlled laboratory conditions. The results revealed that soils treated with medicinal plant based decomposers showed significantly higher organic carbon, available nitrogen, phosphorus, potassium, and microbial population in comparison to the control. Maximum bacterial and fungal population was observed in the Amla juice and Citrus lemon juice treated samples. Micronutrient concentrations such as Fe, Zn, Mn, and Al also increased considerably in treated soils. The findings indicated that medicinal plant products in combination with cow dung and jaggery solution can serve as efficient eco-friendly bio-decomposers for sustainable agricultural waste management.

KEYWORDS: Parali, Bio-decomposer, Soil fertility, Agricultural waste management.

INTRODUCTION

Agricultural crop residue management has become a major challenge in modern agriculture. Large quantities of *Parali* (stubble residues) generated after harvesting are often burnt in open fields, causing severe environmental pollution, loss of soil nutrients, and destruction of beneficial microorganisms. Stubble burning contributes to greenhouse gas emissions, particulate matter pollution and deterioration of soil health.

Biological decomposition using microbial and plant-based formulations offers a sustainable alternative to residue burning. Medicinal plant products possess organic acids, enzymes, antioxidants, and growth-promoting substances which stimulate microbial activity and accelerate decomposition processes. Citrus lemon (*Citrus limon*) contains citric acid and essential oils which help in rapid degradation of lignocellulosic material. Amla (*Phyllanthus emblica*) is rich in vitamin C and organic compounds that support microbial proliferation. Cow dung and jaggery solution provide

essential nutrients and carbon sources for microbial growth.

The present investigation was undertaken to evaluate the efficacy of medicinal plant-based decomposers for accelerated Parali decomposition under laboratory incubatory conditions.

AIM AND OBJECTIVES

1. To develop suitable medicinal plant-based bio-decomposer formulations for Parali decomposition.
2. To compare decomposition efficiency of different treatments with control.
3. To evaluate changes in physico-chemical parameters of decomposed soils.
4. To assess micronutrient enrichment in decomposed Parali containing soils.
5. To study microbial population dynamics after decomposition.

MATERIALS AND METHODS

The experiment was conducted at the laboratory facilities of Central Ayurveda Research Institute (CARI), Jhansi, India. The physico-chemical parameters viz. EC, pH, OC and available N,P and K were analysed at IGFRI, Jhansi using M.L. Jackson (1973) methods of Soil Chemical Analysis. Micronutrients Analysis was done using diethylenetriaminepentaacetic acid (DTPA) solution. The determination of micronutrients was done using ICP-OES(Inductively Coupled Plasma Optical Emission Spectroscopy (Elizabeth Kulikov©Agilent Technologies, Inc. 2016 Published September 1 2016 Publication number:5991-7250EN). Total bacteria and fungi population were determined using serial dilution technique and plate method as described by Allen (1957)using Thornton,s agar medium (Thornton, 1922) and fungal population count is done using Martin,s Rose Bengal Agar Media, respectively.

EXPERIMENTAL DESIGN

A laboratory incubatory experiment was established using plastic containers of 1.5 kg capacity. The experiment was conducted using 5 treatments (**Figure 1**) with 3 replications for each treatment. Thus, a total of 15 experimental units were included in the study and decomposition was observed after 45 days.

Treatment Combinations

1. Control (Parali-10 gm+Soil-1 kg+ sufficient water).
2. Parali-10 gm+ Soil-1 kg +Cow dung-250 gm + Citrus lemon juice-75 ml +Gur solution (50%) 50 ml+ sufficient water.
3. Parali-10 gm+ Soil-1 kg +Cow dung-250 gm + Citrus lemon juice-50 ml +Gur solution(50%)-250 ml + sufficient water.
4. Parali-10 gm+ Soil-1 kg +Cow dung-250 gm + Amla juice-100 ml +Gur solution (50%) -50 ml+ sufficient water.
5. Kultha powder + Soil-1 kg + sufficient water.

Figure 1: Photograph showing Parali decomposition by different decomposers (experimental treatment combinations).

OBSERVATIONS

The following parameters were analyzed after decomposition of Parali by different experimental treatment combinations.

Physico-chemical Parameters	Micronutrient Analysis	Microbial Population
Electrical Conductivity (EC)	Iron (Fe)	Bacterial Count
pH	Zinc (Zn)	Fungal Count
Organic Carbon (OC)	Manganese (Mn)	-
Available Nitrogen (N)	Aluminium (Al)	-
Available Phosphorus (P)	-	-
Available Potassium (K)	-	-

RESULTS AND DISCUSSION

The values of physico-chemical parameters were found to be high in the treated soils in comparison to the control (**Table 1**). Parali decomposition was found much earlier in case of medicinal plant products treatment in comparison to the Control.

Table 1: Average Physico Chemical Parameters of Decomposed Parali Containing Soils.

Treatments	EC (ds-m)	pH	OC (%)	Available N	Available P	Available K
T1 Control	0.755	7.72	1.325	137.984	21.65	462.18
T2 Lemon Juice 75 ml	1.734	7.87	2.55	169.344	82.17	2886.93
T3 Lemon Juice 50 ml	1.936	7.89	2.53	160.981	97.68	2527.40
T4 Amla Juice 100 ml	1.843	8.006	2.66	169.344	101.36	2492.00
T5 Kultha Powder	0.927	7.85	1.18	129.621	24.63	411.41
CD at 5%	NS	NS	0.89 (S)	27.9 (S)	25.2 (S)	318.5 (S)

NS = Non-significant; S = Significant at 5% level; OC = Organic Carbon Content

Table 1 indicated that treating the soil has greatly altered its chemistry and biology. Treatment 3 (lemon juice) has the highest electrical conductivity, followed closely by treatment 4 (amla juice); however, there was no statistically significant difference between treatments 3 and 4. All treatments were found to be either neutral or slightly alkaline with regard to their pH values and no statistically significant difference was detected among the treatments in terms of pH value. Treatment 4 had the highest organic carbon content (OC) at 2.66%; therefore, increasing the level of organic matter; whereas treatment 5 (kultha powder) exhibited the lowest OC. Treatments 2 and 4 contained the most nitrogen (N) available (169.344 kg/ha), indicating the addition of juice type had a beneficial effect on the concentration of nutrients in the soil. Treatment 4 exhibited the greatest amount of phosphorus (P) available (101.36 kg/ha), followed closely by treatment 3 (97.68 kg/ha); both treatments had a greater concentration of P than any of the other treatments. The available potassium (K) concentrations obtained from treatments 2 (2886.93 kg/ha), 3 (1257.82 kg/ha), and 4 (1248.16 kg/ha) were significantly higher than control. No statistically significant differences were noted with respect to K concentration among treatments 2, 3, and 4 (**Figure 2**). All levels of OC, N, P, and K were significantly different at the 5% level; however, EC and pH levels among treatments were similar. Treated soil using lemon and amla juices improved soil fertility more than the control group or kultha powder.

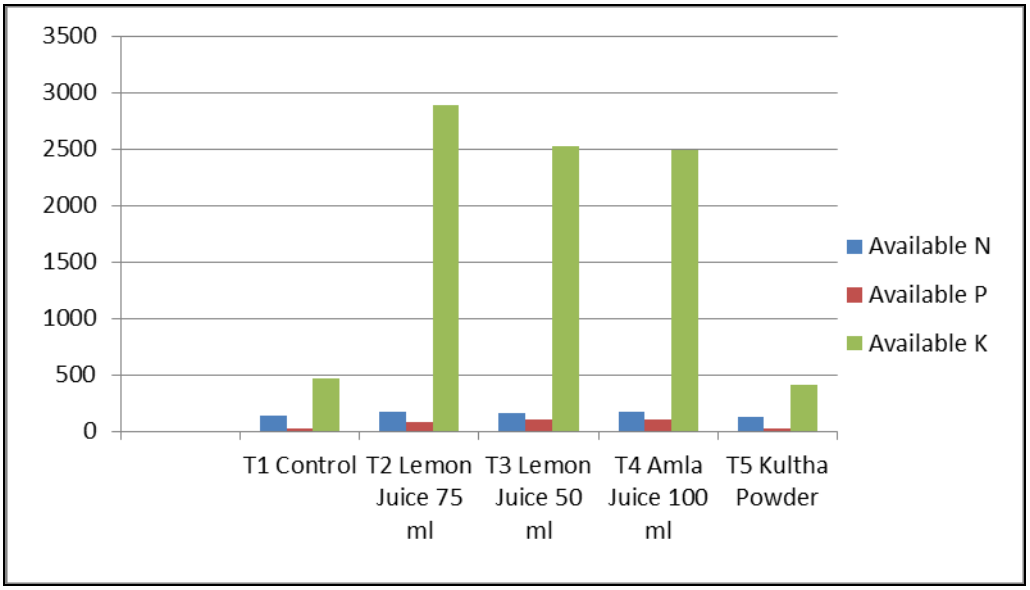

Figure 2: Comparative Graph Showing Available Nitrogen (N), Phosphorus (P), and Potassium (K) in Decomposed Parali Containing Soils

In order to assess the microbial population in the decomposed parali containing soil, microbial assay was done at the Microbiology Laboratory of the Institute. It can be observed from the analysis that both, the total bacterial population as well as fungi population were higher in the treated soil samples after the decomposition of the Parali in comparison to the Control (**Table 2**). Highest microbial population was observed in case of 75-ml lemon juice treated decomposed Parali containing soil.

Table 2: Microbial Population in Decomposed Parali Containing Soils.

Treatments	Bacterial Population (CFU/g)	Fungal Population (CFU/g)
T1 Control	3.6×10^6	3.0×10^3
T2 Lemon Juice 75 ml	4.5×10^6	3.4×10^3
T3 Lemon Juice 50 ml	4.3×10^6	4.6×10^3
T4 Amla Juice 100 ml	4.6×10^6	4.6×10^3
T5 Kultha Powder	4.1×10^6	3.5×10^3

In comparison to the control, all treatments increased the growth of bacteria and fungi, according to the microbial population study. T4 (Amla Juice 100 ml) had the largest bacterial population (4.6×10^2 CFU), closely followed by T2 (Lemon Juice 75 ml) and T3 (Lemon Juice 50 ml). Similarly, T3 and T4 showed the highest fungal population (4.6×10^3 CFU). Both bacterial and fungal microbial counts were lowest in the control treatment as depicted in **Figure 3**. These results show that in soils containing parali, treatments with lemon juice and amla juice increased microbial activity and breakdown efficiency.

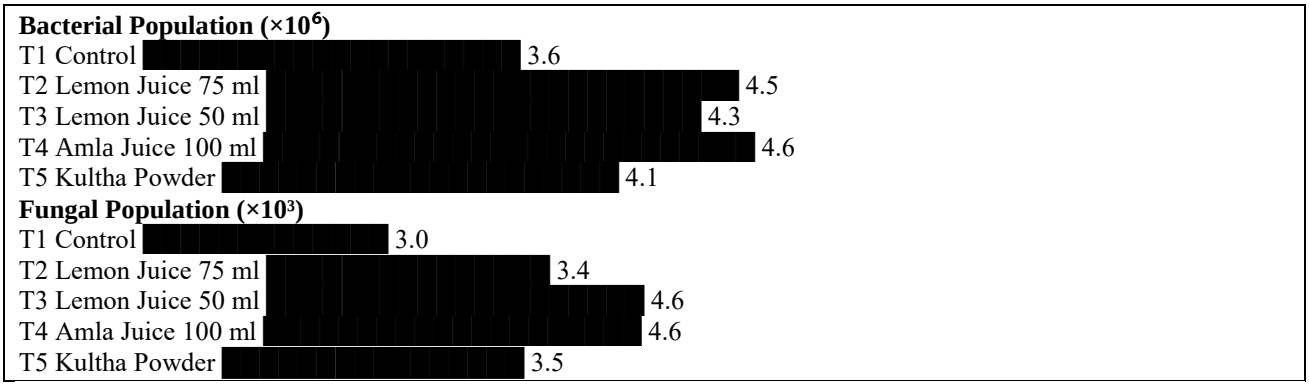

Figure 3: Comparative Graph Showing Bacterial and Fungal Population in Decomposed Parali Containing Soils.

The values of the micronutrients viz. Iron (Fe), Aluminium (Al), Zinc (Zn) and Manganese (Mn) were much higher in the Parali treated soil in comparison to the control (**Table 3**). From the values it can be said that culture can be developed from the Parali treated soil.

Table 3: Micronutrient Analysis of Decomposed Parali Containing Soils.

Treatments	Fe (ppm)	Zn (ppm)	Mn (ppm)	Al (ppm)
T1 Control	9412.713	53.83	216.41	17747.08
T2 Lemon Juice 75 ml	9559.373	61.57	259.79	19948.81
T3 Lemon Juice 50 ml	9428.406	57.60	265.51	17732.08
T4 Amla Juice 100 ml	9889.883	62.22	289.80	21208.11
T5 Kultha Powder	10627.036	55.28	303.00	17537.50
CD at 5%	**517.8 (S)**	**9.7 (S)**	**41.2 (S)**	**2578 (S)**

S = Significant at 5% level

The comparative micronutrient status of degraded Parali-containing soils under various treatments is shown in **Figure 4**. The findings show that the concentrations of Fe, Zn, Mn, and Al varied noticeably between treatments. T5 (Kultha Powder) had the highest Iron (Fe) content, whereas T4 (Amla Juice 100 ml) had relatively greater Zinc (Zn) and Aluminum (Al) contents. T5 also had the highest quantity of manganese (Mn). In comparison to the control, treatments including lemon and amla juice typically increased micronutrient availability. Overall, the graph shows that applying various bio-decomposer treatments had a major impact on the accumulation of micronutrients in the soil, which improved the fertility state of the soil.

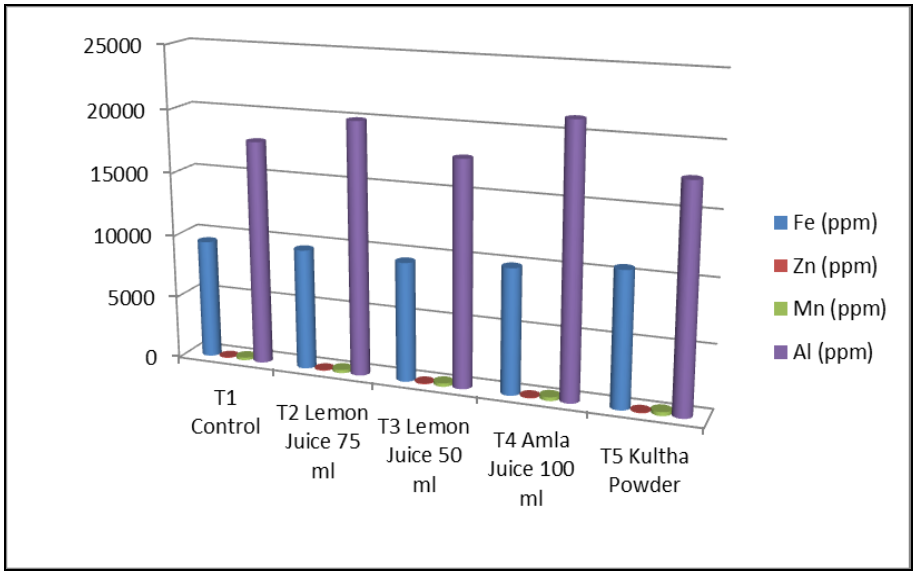

Figure 4: Comparative Graph Showing Micronutrient in Decomposed Parali Soils Bar Graph of Microbiological Assay.

DISCUSSION

The present investigation clearly demonstrated that medicinal plant-based decomposers significantly enhanced Parali decomposition and improved soil fertility parameters. The incorporation of Citrus lemon juice, Amla juice, cow dung, and jaggery solution created favorable conditions for microbial multiplication and decomposition of crop residues (Alexander M(1977)).

The organic carbon content was considerably higher in treated soils, indicating effective conversion of organic matter into humified material. Increased availability of nitrogen, phosphorus, and potassium suggests enhanced mineralization processes during decomposition (Indian Council of Agricultural Research (ICAR) (2012).

Among the treatments, the Amla juice-based formulation recorded the highest organic carbon, phosphorus, manganese, and fungal population, while the Citrus lemon juice treatment exhibited higher bacterial population and potassium availability.

Microbial assay results indicated substantial increases in bacterial and fungal populations in treated soils compared to control. Enhanced microbial activity accelerates lignocellulosic degradation and nutrient release(Subba Rao NS (1999)).

The increase in micronutrient concentrations such as iron, zinc, manganese, and aluminium further confirms the beneficial effect of medicinal plant-based decomposition. These micronutrients play vital roles in soil fertility and plant nutrition. The decomposition process was considerably faster in medicinal plant-treated samples than in untreated control soils. This suggests that medicinal plant products can serve as effective natural bio-enhancers for agricultural waste decomposition (Singh RP, Agrawal M (2008)).

CONCLUSION

The study demonstrated that medicinal plant-based formulations are effective bio-decomposers for rapid decomposition of Parali under laboratory conditions. Application of Citrus lemon juice and Amla juice in combination with cow dung and jaggery solution significantly improved soil nutrient status, microbial population, and micronutrient availability. Among the tested treatments, Amla juice and Citrus lemon juice-based formulations showed superior decomposition efficiency and enhanced microbial activity. The findings suggest that such eco-friendly bio-decomposer technologies may be useful for sustainable crop residue management and prevention of stubble burning. The developed formulations may further be evaluated under field conditions for large-scale agricultural applications.

Future Scope

1. Field evaluation of medicinal plant-based bio-decomposers.
2. Development of commercial bio-decomposer formulations.
3. Assessment of impact on subsequent crop productivity.

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