In Vivo Studies of Soil Conditioning and Growth Promotion Efeects of Kitchen Biowaste On Maize Grown Under Salinity Stress

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Abstract*— Among various composting methods, kitchen waste composting stands out as a practical, zero-cost approach that transforms food scraps into valuable nutrients for home gardens, promoting sustainable waste disposal and soil enrichment. The present study was designed to screen various microbes for their composting ability to degrade kitchen waste and evaluate the biofertilizer potential of this compost on the growth parameters of corn plant under salt stress. The comparative analysis of plant growth parameters based on height, leaf count, and root length revealed significant variation among the different compost treatments. The physicochemical analysis of the prepared compost revealed a temperature of 30.58°C ± 0.26°C and a pH of 9.24 ± 0.33. The compost contained 19.62 ± 1.44% carbon and 0.82 ± 0.02% nitrogen, with a C:N ratio of 24.10 ± 1.78. To assess its agricultural efficacy, the compost, supplemented with bacterial filtrates, was applied to soil (under salinity stress) cultivated with Zea mays (maize). The results indicated a notable enhancement in early plant development, with maize exhibiting an average height of 29.43 ± 0.43 cm, a leaf count of 6.29 ± 0.36, and a root length of 1.21 ± 0.05 cm. These findings highlight the potential of microbial-enriched kitchen waste compost in accelerating decomposition and improving its function as a soil conditioner, thereby contributing to enhanced soil fertility and crop productivity.

Key words*— compost, kitchen waste, soil conditioner, maize, microbes.

I. INTRODUCTION

The rapid growth in food production and consumption worldwide has resulted in a significant surge in food waste, especially from kitchen [1]. Reports from the Food and Agriculture Organization (FAO) indicate that nearly one-third of all food produced globally goes to waste, with vegetables making up a large share due to their short shelf life and high perishability [2]. Addressing this issue through sustainable waste management practices is crucial for reducing environmental impact and promoting efficient resource utilization [3]. Among various composting methods, kitchen waste composting stands out as a practical, zero-cost approach that transforms food scraps into valuable nutrients for home gardens, promoting sustainable waste disposal and soil enrichment [4].

Composting is a traditional, cost-effective approach to transforming organic waste into valuable nutrient-rich humus, which serves as both a soil enhancer and a natural fertilizer [5]. Kitchen waste is one of the major environmental issues of modern way of life. Increased human activity leads to increased waste [6]. Animal feeding, anaerobic digestion, composting and burning can be a solution to stabilize and reduce this biodegradable waste. Decomposition of these organic wastes to landfill sponsorships releases connections that produce unpleasant odours, contaminated soils, and aquatic ecosystems, thereby the risk of disease infection [7]. However, this biodegradable waste which contains high content of organic ingredients such as carbohydrates, proteins, lipids and organic acids can of course be converted into valuable organic matter by implementing microorganisms that can decompose convert them into usable compost making it a potential source of fertilization [8].

Compostable accoutrements host a different community of bacteria, fungi, molds, and other microorganisms [9]. During composting, these microbes laboriously break down organic matter, producing carbon dioxide, water, heat, and guck — a stable organic emulsion that enhances soil fertility and supports sustainable husbandry practices [10].

Compost inventories essential nutrients similar as nitrogen, potassium, and phosphorus, along with pivotal secondary and trace rudiments that promote factory growth [11]. likewise, it improves soil structure by enhancing drainage, aeration, and humidity retention, serving both flaxen and complexion- grounded soils. As an eco-friendly and cost-effective result for organic waste disposal,

composting plays a crucial part in sustainable husbandry [12]. Compared to mineral diseases, compost significantly increases soil organic carbon situations and enhances nutrient vacuity, making it an effective volition for maintaining soil health and productivity [13].

Kitchen waste composting plays a vital role in improving soil fertility by supplying key nutrients such as nitrogen, phosphorus, and potassium [14]. Through the decomposition of biodegradable materials like vegetable peels, eggshells, and other kitchen waste, this process generates nutrient-rich organic matter that enhances soil health and promotes sustainable agricultural practices [15]. Additionally, it helps reduce reliance on synthetic fertilizers, which can contribute to soil degradation and water contamination. By integrating composting into waste management and agricultural practices, sustainable farming methods can be promoted while minimizing environmental harm [16].

The present study was designed to screen various microbes for their composting ability to degrade kitchen waste and evaluate the biofertilizer potential of this compost on the growth parameters of corn plant under salt stress [17].

II. MATERIAL AND METHODS

2.1 Study site

The experiment was carried out at MIET, Meerut, located at 28° 54’29’’N latitude and 77° 78’00’’E longitude, with an elevation of 224 meters above sea levels. The area also supports numerous sugar industries, thriving on extensive sugarcane farming. Furthermore, a wide variety of fruits and vegetables are grown in the region. This study selected Zea mays (maize) as the test crop, a widely consumed leafy vegetable recognized for its nutritional significance [18].

2.2 Collection of kitchen waste

A variety of kitchen waste materials, including potato (Solanum tuberosum), cabbage (Brassica oleracea var. capitata), cucumber (Cucumis sativus), onion (Allium cepa), tomato (Solanum lycopersicum), and pea (Pisum sativum) peels and refuges, were utilized as primary inputs for the experiment [19]. This material was carefully collected in clean bags from a campus cafeteria, hostel mess mixed and shredded into smaller pieces to accelerate degradation [20]. To supplement nitrogen, dry leaves and twigs sourced from the campus garden were added as a bulking agent, facilitating aeration and enhancing the structural integrity of the composting material [21].

2.3 Selection of Microbial inoculants

Composting is an aerobic microbial and biochemical process that enables the breakdown of organic materials through hydrolysis, producing humus—a stable and sanitized final product [22]. Firmicutes, Proteobacteria, Bacteroidetes, and Actinobacteria actively contribute to the breakdown of organic matter during decomposition. Microbial additives can be selectively isolated based on their specific decomposition functions or cultivated in mixed cultures using soil, cow dung, and straw [23].

For microbial characterization, starch hydrolysis, oxidase activity testing, carbohydrate fermentation studies are important [24][25].

2.4 Compost preparation

The waste mixtures were composted in polythene bags measuring 1.5 m in height, 2 m in width, and 2 m in length, chosen to ensure adequate oxygen supply and facilitate the production of a significant amount of compost [27]. To accelerate decomposition, 40 grams of inoculum were incorporated into the raw composting materials [26].The temperature moisture content, weight loss, and pH levels were analysed weekly with laboratory instruments [28].

During the maturation phase, the compost were turned weekly to optimize oxygen availability and create favourable conditions for microbial growth. [29]. The composting process lasted approximately three months and was fully decomposed, yielding a dark, crumbly, nutrient-rich compost ideal for agricultural use [31][30].

2.5 Physico-chemical analysis of compost

The final compost's Nitrogen-Phosphorus-Potassium (NPK) composition was assessed at the end of the incubation period. [32]. For analytical preparation, the sample was prepared to determine the nitrogen, phosphorus, and potassium concentrations in the compost [33].

2.6 Microbial analyses of compost

Bacteria, actinomycetes, and fungi played a pivotal part in composting [30]. Compost and soil samples were collected and accessed, employing the plate count system according to methodology described in [34][35].

2.7 Preparation of soil for in vivo studies for compost evaluation

Air-dried, sieved, acid-washed sand soil underwent sterilization twice over two consecutive days, followed by thorough drying and mixing. In the greenhouse experiment, five seedlings were transplanted into plastic pots (25×25 cm^2), each containing 2 kg of steam-sterilized sand soil enriched with 20% kitchen compost. Each group consisted of 10 replicates, with five seedlings per pot grown at 25°C under soil water conditions near field capacity [36] [37]. The pots were categorized into five groups: G1 to G5 with G1 (control plants) [38]. Irrigation was administered twice weekly, with 200 mL of half-strength Hoagland nutrient solution [39].

2.8 Morphological and biochemical analysis of plant

After one month, plant growth parameters were assessed by measuring root depth, shoot length, and the fresh and dry weights of both shoots and roots [40]. Additionally, Chlorophyll concentrations (µg/ml) were determined according to [41].

2.9 Statistical analysis

A one-way analysis of variance (ANOVA) was performed to assess significant differences in mean values among treatments, with a significance threshold set at $P < 0.05$ [40].

III. RESULTS AND DISCUSSION

Here are the results of methodology used:

2.3 Selection of Microbial inoculants

The microbes are selected based on their capability to produce enzymes necessary for degradation. (Fig. 3.1) demonstrates the enzymatic capabilities and metabolic activities of microbial isolates. The biochemical tests conducted on microbial isolates revealed significant enzymatic and metabolic conditioning. In the cellulase, amylase and pectnase test, a clear hydrolysis zone was observed around the microbial growth on respective agar. The carbohydrate fermentation test displayed a conspicuous colour change from red to yellow in the broth medium, signifying acid production from carbohydrate metabolism. These results inclusively confirm that the microbial isolates retain strong capability to degrade complex organic composites and suggest implicit operations in organic waste declination.

2.4 Compost preparation

The progressive decomposition of kitchen waste over a 12-week composting period with inoculations performed at intervals of 0, 120,and 180 days.The composting process of kitchen waste was visually monitored over a 12-week period, with images captured at Week 1, 3, 5, 7, 9, and 12 to document the progressive physical changes in the organic material. [27]. The texture appeared more compacted and fragmented, with a noticeable reduction in recognizable food particles, suggesting increased microbial and enzymatic activity [26]. The compost mass darkened significantly and the structure became increasingly uniform. The transformation into humus-like material was evident, reflecting the active role of microbial consortia in organic matter mineralization and stabilization [36]. By Week 12, the original waste was no longer recognizable, indicating that the composting process had effectively transformed the kitchen waste into nutrient-rich organic matter [28].

2.5 Physico-chemical analysis of compost

The physico-chemical characteristics of compost samples (P001–N005) were assessed by monitoring temperature and pH variations at 2-week intervals throughout a 12-week composting period the temperature and pH as shown in fig below. This rise corresponds to the thermophilic phase of composting, during which microbial activity intensifies, leading to the breakdown of complex organic substrates [33]. During Week 9 and Week 12, temperatures stabilize between 29°C and 31°C. This cooling trend is characteristic of the transition from active decomposition to the maturation phase, where microbial activity slows down and the compost stabilizes. [33]. In terms of pH variation, all compost samples started with slightly acidic to neutral pH values in the range of 8.0 to 9.5 during the early composting phase (Week 2). Over time, there was a modest increase in pH across most samples, especially by Week 12, where values approached or slightly exceeded 10.0 in some cases (e.g., N005). This rise in pH may be attributed to the breakdown of nitrogenous compounds and the production of ammonia during organic matter degradation. However, the overall pH remained within the acceptable range for mature compost, supporting its suitability for agricultural use [32]. These results demonstrate that the composting process was effective in transforming kitchen waste into a stabilized organic product. The trends observed are consistent with established composting dynamics and reinforce the potential of kitchen waste composting as a viable method for organic waste

management and soil amendment production [30] [36]. The percentage of organic carbon showed a consistent decline from 24.3% in Week 1 to 15.2% by Week 12, indicating substantial degradation of organic matter. This decline is attributed to microbial respiration, during which carbon is utilized as an energy source and released as carbon dioxide [35]. In contrast, total nitrogen content increased initially from 0.76% in Week 1 to 0.88% by Week 3 and 5. A slight decrease followed in the subsequent weeks, stabilizing at 0.76% by Week 12, which may be due to ammonia volatilization and microbial immobilization. Despite this, the final nitrogen content remained comparable to initial levels, indicating a good nitrogen balance in the compost [31]. The C:N ratio serves as a crucial indicator of compost maturity. The ratio dropped significantly from 32.0 in Week 1 to 20.1 in Week 12, falling within the ideal range (<25:1) for mature compost. This steady decline confirms the reduction in carbon-rich materials relative to nitrogen, aligning with microbial succession and compost stabilization over time. [15]. The parameters confirm that the compost achieved maturity by Week 12, making it suitable for use as a soil conditioner and organic fertilizer [32].

2.6 Microbial analyses of compost

The comparative biochemical test results for microbial isolates are presented in Figure 3.6. These results demonstrate significant variability in the metabolic and enzymatic capabilities of the isolates. High prevalence of enzymatic activities such as cellulase, amylase, and protease production was observed among the isolates, indicating their potential role in the degradation of complex organic materials suggesting their importance in biomass conversion and starch metabolism, versatility in utilizing diverse carbon sources respectively. [34].

2.7 Preparation of soil for in vivo studies for compost evaluation

Physicochemical analysis of the prepared soil revealed a neutral pH (6.8–7.2), moderate organic matter content, and balanced macro-nutrient levels (NPK). These results confirm that the soil preparation protocol was effective in establishing a consistent and conducive medium for in vivo compost evaluation. [37].

2.8 Morphological and biochemical analysis of plant

The growth pattern of maize plants under different compost treatments was monitored for 35 days, as shown in Figure 3.8. The compost-treated pots (P1, P4, S4, S7, and N3) showed improved germination rates, faster shoot elongation, and better overall plant health compared to the untreated control. By Day 7, seedlings had emerged in most of the treated pots, with P1, P4, and S7 showing faster and healthier emergence compared to the control [40].By Day 15, significant differences in plant height and vigor were evident. Plants in P1 and P4 exhibited rapid shoot elongation and greener leaves, while S7 and N3 showed moderate but steady growth. In contrast, the control plants were smaller and displayed pale coloration, suggesting inadequate nutrient availability. S4-treated plants showed relatively slower growth than the other treated groups, indicating a possible lower nutrient content or slower release from the compost used. These treatments supported robust vegetative growth, likely due to higher organic matter and microbial activity. Control plants, by comparison, showed the poorest growth, with signs of nutrient stress still evident by Day 35. These results confirm that compost significantly enhances plant growth by improving soil fertility, moisture retention, and microbial activity highlighting their potential application in sustainable agriculture [41]. In terms of leaf count, N005-treated plants showed the highest number of leaves, suggesting robust shoot development and efficient nutrient assimilation, further reinforcing the positive effect of compost on foliar growth. Root length measurements revealed that N005 and N003 again outperformed other treatments, with root lengths approaching or slightly exceeding 1.5 cm. These results imply stronger root systems that likely facilitated better water and nutrient uptake, contributing to the overall improved shoot growth [40].

IV.CONCLUSION

Though microbial bioconversion of kitchen waste into bio-fertilizers is highly desirable in a circular economy, its actual production is still far from being realised. Technical barriers particularly involve the lack of proper technologies for waste segregation, collection, and transportation, especially in developing countries where waste management is generally neglected. The combination of microorganisms in kitchen waste improves and maintains the soil's chemical and physical properties. This study proved the potential benefits of bio-organic fertilizers (BIOs) in reducing salt stress in maize plants, improving crop growth. It introduced a novel

way to producing BIOs from agricultural waste, providing a sustainable and long-term alternative to chemical fertilizers. The data confirms that the quality and composition of compost play a critical role in promoting plant development, with treated plants outperforming the control in height, leaf production, and root expansion. On the whole, the findings highlight the metabolic diversity and adaptive capabilities of the microbial isolates, which may hold promise for industrial and environmental applications such as waste degradation, bioenergy production, and saline soil remediation.

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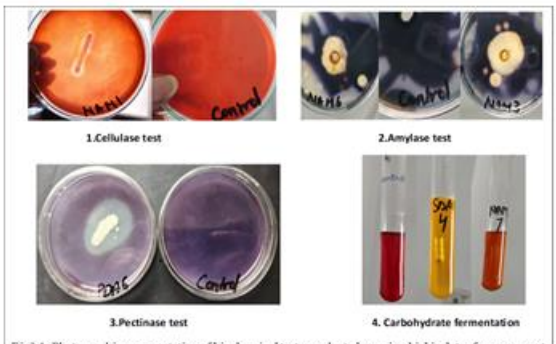

Fig3.1: Photographic representation of biochemical tests conducted on microbial isolates from compost samples. (1) Cellulase test showing hydrolysis zones on CMC agar, (2) Amylase test indicating starch degradation on starch agar plates, (3) Pectinase test on pectin agar with clear zones around colonies, and (4) Carbohydrate fermentation test showing color change in broth medium indicating acid production. Controls are included for comparison.

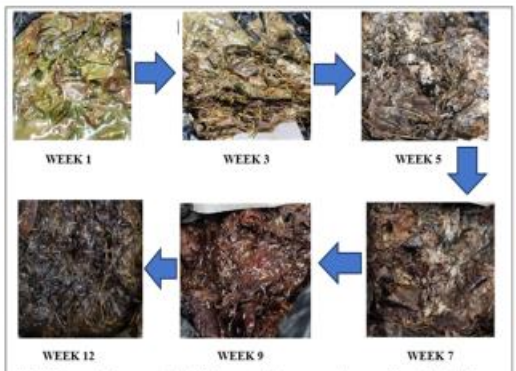

Fig 3.3: Progressive decomposition of kitchen waste during composting over a 12-week period. Images illustrate the physical changes in organic matter at Week 1, Week 3, Week 5, Week 7, Week 9, and Week 12, showing gradual breakdown and darkening of materials as compost matures.

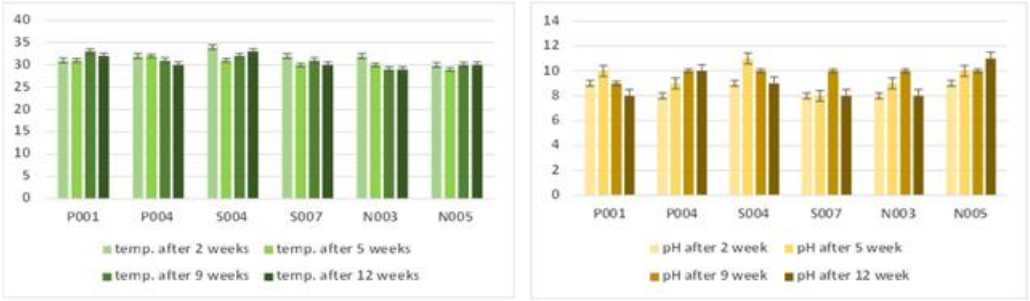

Fig3.4: Variation in temperature and pH of compost samples (P001–N005) measured at 2-week intervals over a 12-week composting period.

Fig3.5: Temporal variation in compost quality parameters during the composting process.

Changes in Organic Carbon (%), Total Nitrogen (%), and Carbon to Nitrogen (C: N) ratio were measured at regular intervals from Week 1 to Week 12. time.

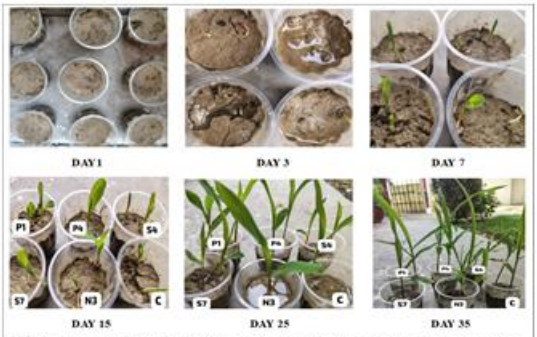

Fig3.8: Growth progression of maize plants under different compost treatments observed over a 35-day period. Images show plant development on Day 1, Day 3, Day 7, Day 15, Day 25, and Day 35. Each pot (P1, P4, S4, S7, N3, C) received compost from different sources to evaluate the effect of compost type on germination and plant growth.