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Research Article

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Effect of Liquid Bio Fertilizer from Kitchen Waste on Growth, Physiology of Green Gram (Cicer Arietinum L.) and Mung Bean (Vigna Radiata L.) Cultivars

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Abstract

The worldwide increasing human population caused problems to the food security and land for agriculture. Population growth also increase the pollution in environment especially waste generation from anthropogenic activities. Therefore, it is essential task for researchers and farmers to waste management and agricultural productivity improvement. The chemical fertilizers improve more crop productions but it damages both environmental ecology and human health with great severity. Therefore, researchers focus on bio-waste based technology for agricultural productivity and maintain soil fertility. Being a fundamental part of organic farming, biofertilizers are important for preserving soil fertility and sustainability because they fix atmospheric dinitrogen (N=N), mobilize fixed macro and micronutrients, or change insoluble P in the soil into forms that plants can use. sustaining soil structure and nutrient availability while increasing the uptake of N, P, K, and micronutrients. Presented study conducted for liquid bio fertilizer preparation from kitchen waste and its impacts on agricultural plants. Resultants the kitchen waste found the good sources of nutrients such as NPK and its application increased plant growth and physiology. Higher concentration of liquid fertilizer shows higher increment of plants growth and developments as compared to control plants. Nowadays, liquid biofertilizer technology has greater advantages than traditional carrier-based biofertilizer technology. Its help to waste management and crops yields. Therefore, various kitchen waste was used for this study. It will help waste management and soil fertility. The study may helpful for segregation of kitchen waste for good source of liquid fertilizer. Presented study will be helpful for sustainable waste management and economic growth. Study will also play a vital role for maintaining the soil health and pollution control technique.

Keywords: Kitchen Waste, Liquid Bio Fertilizer, Plant Growth and Development

1. Introduction

Population growth affect the food security worldwide. Population growth and the expansion of the agriculture sector are closely related. The higher population levels result in higher land use per unit of land as a function of population growth. However, land intensification has grown to be a significant and pressing issue as a result of an increase in both rural and urban population. This is the cause of the yearly cropping pattern's change from short to protracted fallow, as well as the extensive use of numerous cropping systems on extremely fragmented land [1]. The uneven population density between rural and urban areas is making this situation worse and contributing to food insecurity. Therefore, it is becoming more and more difficult to feed the current big population, which will only rise over time, due to the rapid growth of industrialization and urbanization.

When chemical fertilizers are applied recklessly, the air, water, and land are contaminated, putting the ecosystem in jeopardy [2]. Because they are not absorbed by plants, these hazardous materials accumulate in ground water, and some of them also add to the eutrophication of aquatic habitats claim that these substances negatively affect the fertility of the soil, its ability to hold water, its increased salinity, and the discrepancies in nutrients [3-4]. Despite the fact that chemical fertilizers must be used to keep up with the world's growing food demand, there are instances in which organic farming can lead to the successful growth of particular crops and niche markets [5].

Living microorganisms called biofertilizers penetrate the rhizosphere, or the interior of the plant, when applied to seeds, plants, or soil. This increases the host plant's availability to nutrients, which in turn promotes plant growth [6]. In order to speed up the microbial processes that increase the availability of nutrients that are easily absorbed by plants, biofertilizers are widely used. By fixing atmospheric nitrogen, soluble phosphates, and the creation of soil-derived chemicals that promote plant growth, they increase soil fertility state that the goal of these biofertilizers is to make use of the biological system of nutrient mobilization that occurs naturally [7-9]. The soil fertility and crop productivity are eventually significantly increased by this technique.

In order for plants to grow and develop, they require fourteen key mineral elements: micronutrients (Fe, B, Cl, Mn, Zn, Cu, Mo, and Ni) and macronutrients (N, P, K, Ca, Mg, and S) [10-11]. The majority of the elements are present in the soil, but because they are in forms that plants cannot assimilate, they cannot be absorbed by the plants. Certain elements are only taken up by plants in specific forms; for example, nitrogen is taken up by plants as either nitrate or ammonia. According to biofertilizers are categorized according to the types of microorganisms they include and the functional traits they have acquired by their interactions with plants in the rhizosphere. N-fixing, P-solubilizing, P-mobilizing, micronutrient solubilizer, and rhizobacteria that promote plant growth are the general categories of biofertilizers.

A substitute to carrier-based constructions is the use of liquid bio fertilizers [12]. Liquid bio fertilizers should have an inexpensive, widely accessible, non-toxic, and simple-to-use carrier material. The carrier also needs to be physically and chemically homogeneous, have a high water-holding capacity, and have the right pH to support microbial growth [13].Because liquid biofertilizers have a 1.5–2-year shelf life, they are more appealing than solid inoculants. They are easy to handle and operate, do not require sticky materials, are uncontaminated, compatible with contemporary technology, and can tolerate temperatures as high as 45 °C. Additives that promote the growth of microbial strains are simple to add and apply to soil and seedlings alike. The carrier material for liquid bio fertilizers should be cheap, plentifully available, non-toxic, and easy to use. Therefore, for management of food waste and vegetable waste and also maintain the soil health and agricultural productivity, the liquid fertilizer will be a vital tool with respect to economy and sustainable agriculture.

2. Material and Methods

2.1 Preparation of Liquid Fertilizers from Kitchen Waste

For preparation of liquid bio fertilizer taken a 10 litre glass container. First of all, fill the container with 1 kg biodegradable kitchen scraps and added 10 litre of water. After that container was covers and wait 3 to 5 days. The container is not tightly locked. Let it sit for 3 to 5 days and pour the water in a different container. Dilute it in a ratio of 25, 50,75 and 100 and use the mixture as a treatment. The composition of NPK from prepared liquid fertilizer was given in table 1.

pH	EC (µs/cm)	Total nitrogen (%)	Potassium (ppm)	Phosphorus (mg/kg)
5.07	6800	2.30	144	223

Table 1: Composition of NPK in Prepared Liquid Bio Fertilizer

2.2 Experimental Design and Treatments

This experiment was carried out we studied the effect of liquid bio fertilizers applied on Green Gram (Vigna radiata L.) and gram (Cicer aritinum L.) under different doses of liquid fertilizers (T1, T2, T2, T3, T4 and T5). Each experimental unit contained a pot with the height of 20 cm and 15 cm in diameter and 10 seeds were sown (8 Jan 2024) in each pot to ensure the emergence of the seedlings, then thinned plant in each pot. We maintained sufficient quantity of moisture in the pot by applying regular water. The sampling of plant was taken at juvenile stage (20 days after sowing) and vegetative state (40 days after sowing) by random sampling method.

Treatments	
T1	Control
T2	25 ml liquid fertilizer
T3	50 ml liquid fertilizer
T4	75 ml liquid fertilizer
T5	100 ml liquid fertilizer

2.3 Sampling and Plants Analysis

Plants were taken for growth and biochemical analysis at 20 and 40 DAS (days after sowing).

2.3.1 Growth and Biomass Analysis

The lengths of the roots and shoots were measured in centimeters plant-1 using a meter scale. The leaf area was measured graphically. For this purpose, plant leaves were laid out on graph paper, and the area covered by each leaf was measured and reported as cm2 plant-1. Following meticulous cleaning and drying, the plant sections were divided, weighed, and maintained in a hot air oven at 80°C until a consistent weight was reached for the purpose of measuring biomass.

2.3.2 Growth Indices

Biomass accumulation and allocation was measured using following formula described in [14].

Root: Shoot ratio (RSR) = RW / SW (g g^{-1})

Absolute growth rate (AGR) = $(H_2 – H_1) / (T_2 – T_1)$ (cm day^{-1})

Where, RW = root dry weight; SW = shoot dry weight; H = plant height; $(T_2 – T_1)$ = time interval.

2.4 Biochemical Analysis

2.4. 1 Total Chlorophyll and Carotenoids

After crushing a 0.1 g leaf sample, 10 mL of an 80% acetone (v/v) solution was added. The solution was stored at 4 C for the entire night in a test tube. The optical density (OD) of the solution was measured at 663 nm and 645 nm. The following formula was used to compute total chlorophyll and carotenoids, as reported.

2.4. 2 Ascorbic Acid

Method of used for the extraction and determination of ascorbic acid. To extract the sample, 500 mg of fresh leaf was homogenized in an ice bath with 20 mL of an extracting solution. The homogenate was centrifuged at 6000xg for 15 minutes. One mL of supernatant was mixed with 5 mL of a 2,6-dichlorophenol-indophenol (DCPIP) solution. The optical density (OD) of pink solution (Es) was determined at a wavelength of 520 nm. Then in same solution one drop of ascorbic acid was added, and OD (Et) was measured at the same wavelength. For the blank (Eo), 1 mL of the extracting solution and 5 mL of the DCPIP solution were mixed together, and the OD was measured. To prepare a calibration curve, a 1% aqueous ascorbic acid solution was used.

Ascorbic acid (mg g^{-1} fresh leaf) = [{Eo – (Es – Et)} x V] / (v x W x 1000)

Where, W = weight of leaf taken (g), V = total volume of the mixture (ml), v = supernatant taken for analysis (ml).

3. Results

Result of the study shows that the application of liquid bio fertilizer improves growth and biomass of selected cultivars. Based on obtain results study suggested that the Kitchen waste can be manage by utilization as bio fertilizer. It will helpful for crop productivity and waste management strategy. Result of selected study describe in details below.

3.1 Effect on Plant Morphological Characters

3.1.1 Plant Height

Results of the study shows that higher plant height was seen in treatment T5 (100 ml LF) as compared to control plant (T1). Mung bean (A) and green gram (B) both cultivars showed similar trend with treatments (Fig. 1). Higher plant height was seen at 40 DAS than 20 DAS. The higher value of plant height in green gram cultivar was found 18.5 cm at 40 DAS. While cultivar mung bean showed 20.5 cm at 40 DAS. The use of liquid biofertilizers can significantly impact plant height, often promoting better growth. Biofertilizers contain beneficial microorganisms that enhance nutrient availability and uptake, improve soil health, and stimulate plant growth (Singh et al., 2019, Chaudhary et al., 2020). Here are some factors and findings related to the effect of liquid biofertilizers on plant height. Plant height as well as root and shoot length is increases after the applied of the liquid bio fertilizer with higher to lower concentration chronologically T5>T4>T3>T2>and T1.

3.1.2 Number of Leaf and Roots

Number of leaves and roots per plant was also higher in 100ml treated liquid bio fertilizer in all selected cultivars (Fig. 1). The number of leaves and roots increments can be a significant indicator of its overall health and vigor, especially when evaluating the impact of applied liquid bio fertilizer. Bio fertilizers can enhance nutrient availability, promote better root development, and improve overall plant growth, which often results in an increased number of leaves [15]. A study also conducted by found that higher growth of plant due to fertilizer application. Study define that microbial activity in enhanced plant growth and production [16]. In presented study similar trends was also seen and found the liquid fertilizer increased number of root and leaf plant-1. The higher number of root was found in cultivar Mung bean than cultivar green gram. The number of roots a plant develops can provide significant insights into its overall health and nutrient uptake efficiency, especially when evaluating the impact of applied liquid bio fertilizer. Similarly, a study found that the liquid bio fertilizer increased plant growth and development as compared to organic bio fertilizers [17]. Liquid fertilizer may available easily to plant root and enhance nutrient availability and improve root growth and plant development, which often results in an increased number of leaf and roots. a study reported the fertilizers increased the availability of nutrients and primary root growth [18].

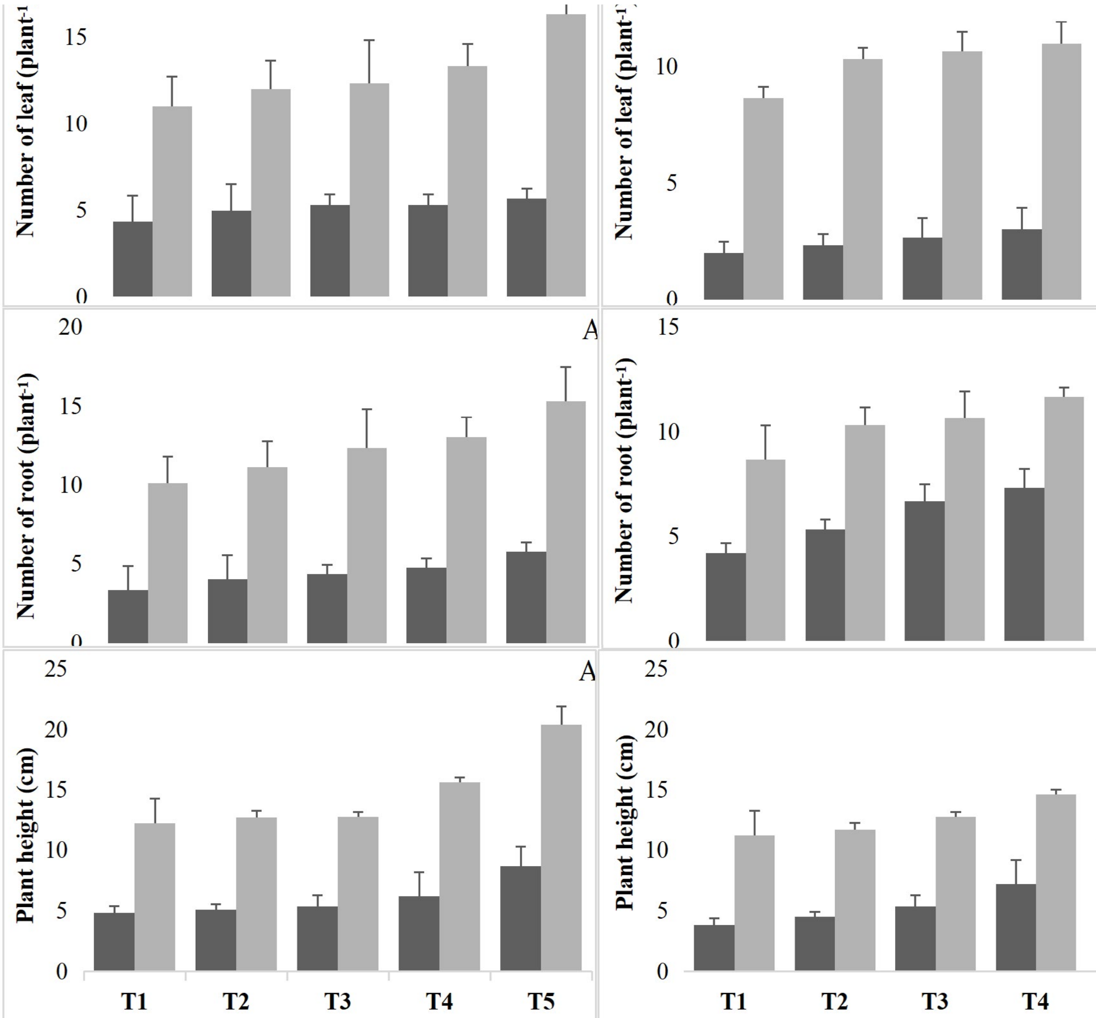

Figure 1: Effect Of Liquid Bio Fertilizer On Number Of Leaves (plant-1) Number Root (plant-1) And Total Plant Height (cm) of Selected Cultivars (A) Mung Bean (*Vigna Radiata L.*) and (B) Green Gram (*Cicer Aritinum L.*) (Mean± Standard Deviation Of Three Replicates are Shown by Thin Vertical Bars)

3.2 Plant Biomass Characters

3.2.1 Root and Shoot Dry Weight

Dry weight of root and shoot will help quantify the effect of the liquid bio fertilizers on plant biomass, providing insight into its effectiveness in enhancing biomass accumulation in plant part (Fig. 2). To assess the impact of a liquid bio fertilizers on dry root weight, the 40 DAS dry root weight is higher than 20 DAS plant. The similar trends were seen in dry weight of shoot (Fig. 2)

3.2.2 Total Plants Biomass

Total plant biomass is directly proportional to the photosynthetic activity of the plant and also it's significant for the growth of the plant [19-20]. Plant applied with (T2) < (T3) < (T4) < T5 shows a significant increase in the biomass production at both juvenile (20 DAS) and vegetative phase (40 DAS) as compared to the controlled plant (T1) which shows normal growth at both the stages of growth (Fig. 2). The organic substance that comes from living things is called biomass, and it is essential to the ecosystems on Earth and to the continuation of life [21]. Plants are the main producers of biomass, utilizing photosynthesis to transform carbon dioxide, water, and sunlight into molecules that are high in energy. This complex mechanism powers the planet's energy cycle and makes major contributions to many other industries, such as agriculture and energy generation. Biomass accumulation is the basic parameter of the growth that can describe the plant health [22]. Liquid biofertilizer increased the biomass accumulation in plant and increased the growth and development (Fig. 2).

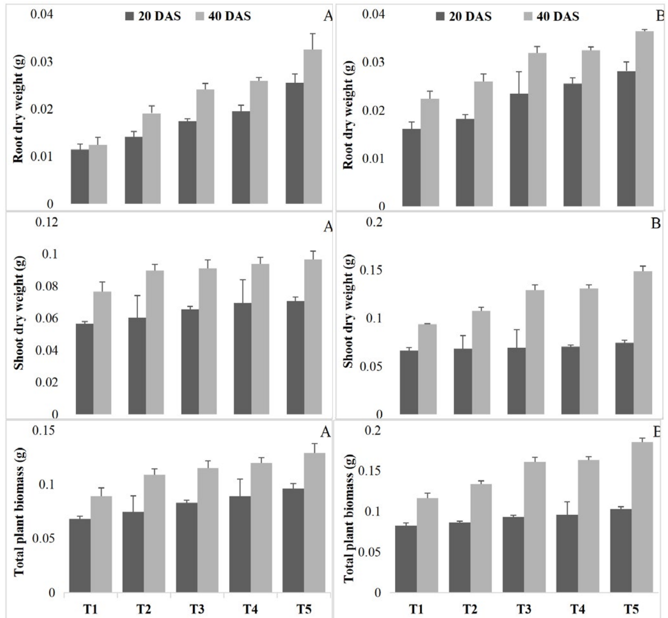

Figure 2: Effect of Liquid Bio Fertilizer on Root, Shoot And Total Plant Dry Weight Dry (g) of Selected Cultivars (A) Mung Bean (*Vigna Radiata L.*) and (B) Green Gram (*Cicer Aritinum L.*) (Mean± Standard Deviation of Three Replicates Are Shown By Thin Vertical Bars)

3.3 Growth Indices

3.3.1 Root-Shoot Ratio

Here we can see that in plant mung bean of 20 days of treatment (T5) is higher than the 40 days' treatments plant. In plant green gram increased 20 days of root shoot ratio of chronologically T1<T2< T3<T4 and <T5 while at 40 DAS of plant was not showed similar trends. The root-to-shoot ratio is a measure often used in plant biology to indicate the balance between a plant's root system and its above-ground (shoot) biomass. When studying the effects of applied liquid bio fertilizer, this ratio can provide insights into how the bio fertilizer influences plant growth and development (Fig. 3)

3.3.2 Net Primary Productivity

The net primary productivity in present study was higher at 20 DAS of plant than 40 DAS in all treatments. Treatment wise higher NPP was seen in treatment T5 than T4>T3>T2 as compared to control (T) plants (Fig. 3). Plant wise higher NPP was seen in cultivar green gram (A) than Mung bean (B). Higher value of NPP was found 0.0048 in green gram and 0.0051 Mung bean. Net Primary Productivity (NPP) is a key indicator of plant growth and ecosystem health. It measures the rate at which plants in an ecosystem produce net useful chemical energy; in other words, the difference between the total energy produced via photosynthesis (Gross Primary Productivity, GPP) and the energy consumed through plant respiration. When assessing the effect of applied liquid biofertilizer on NPP, we focus on how the biofertilizer influences plant growth and energy accumulation.

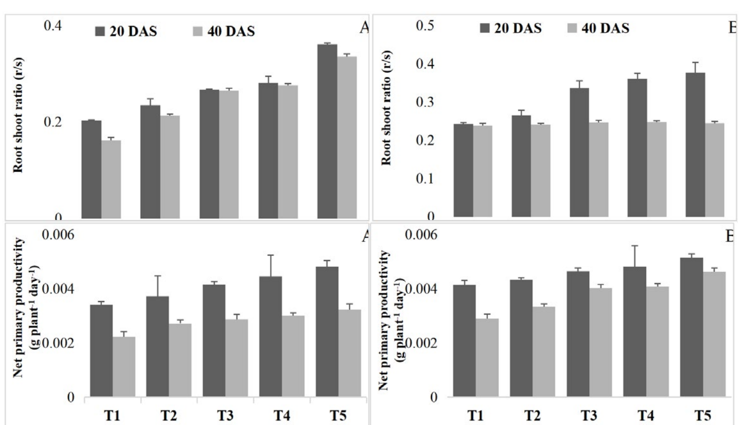

Figure 3: Effect of Liquid Bio Fertilizer on Root-Shoot Ratio (R/S) and NPP (plant-1 day-1) of Selected Cultivars (A) Mung Bean (*Vigna Radiata L.*) and (B) Green Gram (*Cicer Aritinum L.*) (Mean± Standard Deviation of Three Replicates Are Shown By Thin Vertical Bars)

3.3.3 Absolute Growth Rate

Absolute growth rate (AGR) is a measure of the increase in biomass or size of a plant over a specific period (Fig. 4). When assessing the effect of applied liquid bio fertilizer, the AGR can provide valuable insights into the overall growth performance of plants under the influence of the biofertilizer. (AGR) is (T1) plant higher than the both of treatments plant.

3.3.4 Crop Growth Rate

The crop growth rate (CGR) is another vital metric used to evaluate the effect of applied liquid bio fertilizer on plant growth (Fig. 4). CGR measures the increase in plant biomass per unit area over a specific time period and is particularly useful for understanding the productivity of crops in a given area. In fig 4 showed the crop growth rate was higher in treatment (T5) than the (T4)> (T3) and >(T2) as compared to control (T1).

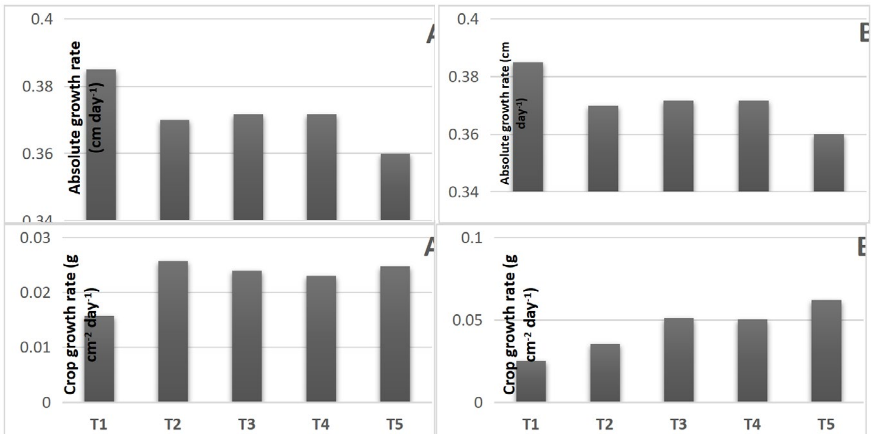

Figure 4: Effect of Liquid Biofertilizer on the Plant Absolute Growth Rate (cm day-1) and Crop Growth Rate (g cm-2 day-1) of Selected Cultivars (A) Mung Bean (*Vigna Radiata L.*) and (B) Green Gram (*Cicer Aritinum L.*)

3.4 Biochemical Changes

Liquid biofertilizer treatment had a far greater influence on the vegetative growth of the control plants in both cases. Plant height and leaf count showed a considerable difference as a result of the application of biofertilizers. A rise in plant height, leaf count, shoot length, root length, and root count that is statistically significant. Applying liquid bio fertilizers to plants can lead to various biochemical changes that enhance plant growth, health, and productivity. These changes are often due to the bioactive compounds, beneficial microorganisms, and nutrients present in the bio fertilizer. Here are some key biochemical changes observed in plants treated with liquid biofertilizers. By understanding and monitoring these biochemical changes, researchers and farmers can better evaluate the effectiveness of liquid biofertilizers and optimize their use for sustainable agricultural practices (Fig. 5).

3.4.1 Chlorophyll a

Chlorophyll a is a crucial pigment involved in the photosynthesis process of plants, algae, and cyanobacteria. It plays a primary role in capturing light energy and converting it into chemical energy. Here are key details about chlorophyll a. In 20 DAS plant A or B (T4) or (T2) plant shows higher chlorophyll a content and 40 DAS plant A or B (T1) or (T3) plant shows higher chlorophyll content (Fig. 5).

3.4.2 Chlorophyll b

Chlorophyll b is another essential pigment in the photosynthesis process of plants, algae, and some bacteria. It complements chlorophyll a by expanding the range of light wavelengths that plants can use for photosynthesis. Here are the key details about chlorophyll b. In 20 DAS plant A or B (T2) or (T2) plant shows higher chlorophyll content and 40 DAS plant A or B (T1) or (T1) plant shows higher chlorophyll content. One crucial technique for (foliar) feeding is the foliar delivery of micronutrients, which can occasionally be more successful than soil applications. Four weeks or so after emergence or transplanting, micronutrients are sprinkled on (Fig. 5).

3.4.3 Total Chlorophyll

Total chlorophyll, which includes both chlorophyll an and chlorophyll b, is a critical indicator of a plant's photosynthetic capacity and overall health. Here's an overview of the role and significance of total chlorophyll in plants. In 20 DAS plant A or B (T4) or (T2) plant shows higher chlorophyll content and 40 DAS plant A or B (T2) or (T1) plant shows higher chlorophyll content (Fig. 5). Traditionally, to test the amount of chlorophyll in a sample of leaves, the chlorophyll itself was extracted using acetone, and the absorption at 663 nm and 645 nm was quantified using spectrophotometry to determine the chlorophyll concentration. This procedure takes a long time and harms the plant material. When compared to a culture without fertilization, Gracilaria sp. has a higher chlorophyll content thanks to fertilization in culture media. An essential component of algae's photosynthetic process is chlorophyll a. N and Mg are the primary constituents of chlorophyll. The substance made up of N atoms and free electrons is called chlorophyll (Sedjati et al., 2020). As the building block of chlorophyll, nitrogen is required for the process of photosynthesis. The highest Mg mineral (54.67 mg.100 g-1) and other micro-minerals are found in FBLU treatments. Mg is involved in photosynthesis's ability to absorb light. Furthermore, nutrients have an impact on the synthesis of chlorophyll-a. According to Ismail and Osman (2016) and Yudiati et al. (2020), phosphate and nitrate are two nutrients that affect the growth and development of seaweed.

3.4.4 Carotenoids Contents

Carotenoids are a class of pigments found in plants, algae, and photosynthetic bacteria that play several vital roles in photosynthesis and plant. By understanding the role and measurement of carotenoids, researchers and agriculturists can better evaluate the impact of biofertilizers and other treatments on plant health, stress tolerance, and productivity. Carotenoids are involved in the process of quenching light and shielding cells from the harmful effects of light and superoxide radiation. Reduction in the carotenoids damages the inner cells of leaf which ultimately damages the leaf (Fig. 5). Applied liquid bio fertilizer plants T1 (100 ml) and T2 (75 ml) shows highest carotenoid content as compare to control (T5) in vegetative stage (40 DAS). The amount of chlorophyll and carotenoid pigments in Gracilaria sp. following cultivation was also considerably impacted by the addition of fertilizer to the culture media. As shown in a and b, the FBLU treatment had the highest levels of carotenoids (0.16 µmole. L^{-1}) and chlorophyll a (5.51 µg. g^{-1}).

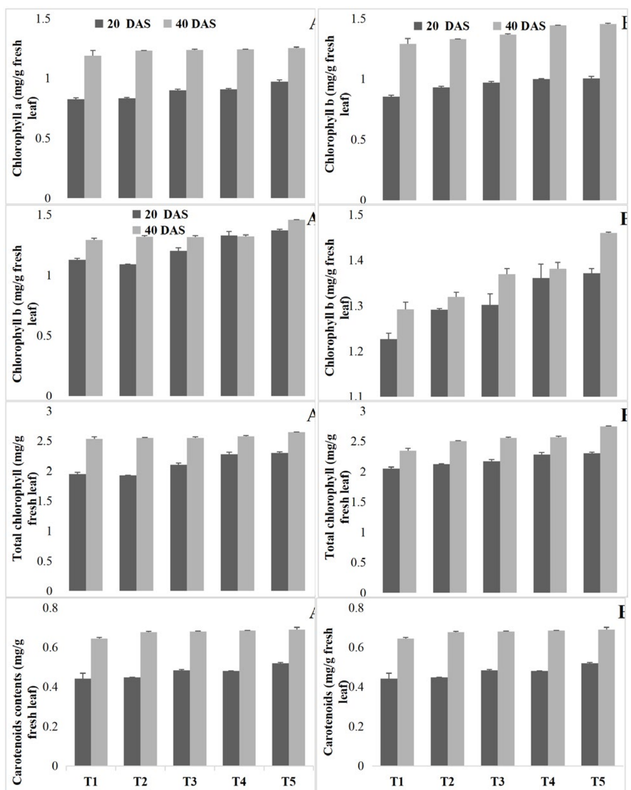

Figure 5: Effect of Liquid Bio Fertilizer on Chlorophyll A, B, Total Chlorophyll and Carotenoids (mg/g fresh leaf) of Selected Cultivars (A) Mung Bean (*Vigna Radiata L.*) and (B) Green Gram (*Cicer Aritinum L.*) (Mean± Standard Deviation of Three Replicates Are Shown By Thin Vertical Bars)

4. Conclusion

Living microorganisms found in liquid bio fertilizers improve soil characteristics and spur plant development and productivity. Applied to many crops, liquid bio fertilizers have proven to be more effective than alternative chemical or carrier-based fertilizers. There were instances where the growth of plants doubled. Depending on the purpose of the bio fertilizer, either a single or a combination of microorganisms can be used to manufacture it. Additionally, wastes and by-products from various businesses can be used to make liquid bio fertilizers, which can be an affordable and suitable alternative to specifically prepared media for the growth of bacterial cells. therefore, presented study conducted for preparation of liquid bio fertilizer from kitchen waste and its effect on plant growth and development. Resultants the application of prepared liquid fertilizer improved plant growth and biochemical properties of selected cultivars. The both cultivar showed similar trends of in growth and development. therefore, study concluded that liquid fertilizer plays important role in plant growth with dose dependence. Ultimately, further research is required to address the constraints of liquid bio fertilizers, including greater climate adaptation, longer shelf life, improved liquid inoculant, and large-scale application using low-cost or existing technology.

Evaluations of the long-term safety and effectiveness, multi-stakeholder partnerships, cost-benefit analyses, and field trials are necessary components to assess the viability of liquid bio fertilizer on an individual basis, considering factors such as climate, soil type, crop type, and location.

Based on our Observations These Key Point Where Notice for Environmental Sustainability

- The study may helpful for segregation of kitchen waste for good source of liquid fertilizer.
- Presented study will be helpful for sustainable waste management and economic growth.
- Study will also play a vital role for maintaining the soil health and pollution control technique.

Author contributions

All authors contributed equally to the writing of this article and consent to its publication. Indra Jeet Chaudhary is responsible for writing of the original draft; Pandurang Gourya Chaudhari is responsible for experimental work.

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Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Ethics Approval

Not applicable.

Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

Conflict of Interest

The authors declare no competing interests

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