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Efficacy of different formulations of fermented organic concoctions from fish entrails and banana stem on the growth and yield performance of tomato (*Solanum lycopersicum*) plants

Anabelle Poloyapoy[1], Emelor Camingawan[1], Joliboy Conol[1], Ferlyn Logronio[*1], Rosanilio Yagos[2], Kathleen Bombeo[1]

[1] *Northwestern Mindanao State College of Science and Technology, Labuyo, Tangub City, Philippines*

[2] *J. H. Cerilles State College, Mati, San Miguel, Zamboanga del Sur, Philippines*

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Abstract

Synthetic fertilizers used in food production have been associated with various negative environmental and human health effects. Consequently, recent attention has shifted towards studies and trials to formulate and apply organic fertilizers. This research focused on formulating an organic fertilizer derived from a blend of discarded fish entrails and banana stems. Additionally, it aimed to assess the efficacy of different formulations of this concoction on the growth and yield performance of *Solanum lycopersicum* plants. Two hundred and ten *Solanum lycopersicum* plants were employed in a Completely Randomized Design (CRD). Seven treatments, each with a varying formulation level, were established, and data, including root length, shoot length, number and weight of fruits, and dry matter, were collected and analyzed. The results revealed a highly significant difference in the growth parameters (p-value < 0.01) and in the number and total weight of fruits (p-value < 0.05). The highest dry matter was obtained in T2 and T7. Moreover, T7 proved to be the most effective fermented organic concoction, recording the highest values for growth and yield parameters of tomatoes. Consequently, the developed mixture is strongly recommended for tomato growers as an eco-friendly and long-lasting organic fertilizer.

*Corresponding Author: Ferlyn Logronio ✉ ferlyn.logronio@nmsc.edu.ph

Introduction

The exponential growth of the human population has led to a doubling of food requirements, resulting in increased pressures on agricultural land (Southgate, 2009; Gibson, 2020). To meet the demand for more food, various strategies, such as the massive application of chemical fertilizers, have been employed to maximize production. While this approach has historically led to increased productivity (Liu and Yi, 2021), it has also generated detrimental effects on human health, the environment (Biswas *et al.*, 2014; Sharma *and* Singhvi, 2017; Sufian *et al.*, 2020), and socio-economic status of residents in the affected areas (Nele *et al.*, 2021). Health issues associated with excessive synthetic fertilizer and pesticide consumption include low birth weight, birth defects, skin irritation, respiratory illnesses (Nganchamung and Robson, 2017), cancer, neural disorders, reproductive and developmental anomalies, and mutagenicity (Biswas *et al.*, 2014).

Furthermore, the excessive use of synthetic fertilizers poses environmental challenges, including nutrient loss, surface water and groundwater contamination, soil acidification or basification, reductions in useful microbial communities, increased sensitivity to harmful insects (Chen, 2013; Pahalvi *et al.*, 2021), and eutrophication of freshwater systems and coastal zones. Compounding these issues is the rising cost of synthetic fertilizers due to increasing demand and unstable prices of fuel and raw materials used in their manufacturing, making it challenging for small-scale farmers to afford the quantities needed to maintain soil fertility.

In response to these challenges, scientific societies are actively exploring economically viable, socially secure, and environmentally friendly alternatives. The pursuit is for products distinct from harmful chemicals, aiming to increase farm production per square meter with high-quality, healthy, chemically-free food (Bakry *et al.*, 2016).

One such alternative is the use of fish entrails and banana stems as natural fertilizers, which can significantly impact environmental safety. These materials, often discarded in the environment, contribute to solid waste management problems. Recognizing their potential as good sources of nutrition for soil bacteria, transforming nutrients into usable forms for plant growth (Jacoby *et al.*, 2017), these materials are being developed into an organic fertilizer as a substitute for chemical counterparts. Fish entrails provide essential nutrients such as proteins, amino acids, and oils, nurturing plant microbes and improving soil structure (Pavlis, 2021). They contain nitrogen, phosphorus, calcium, and magnesium. Similarly, banana stems contribute phosphorus and a high amount of potassium, crucial for optimal plant growth and morphology (Rochana *et al.*, 2017). A study by Face (2015) demonstrated that bokashi made from banana stems serves as a soil conditioner and organic fertilizer. To address the lack of nitrogen in banana stems, which is essential for leaf growth (Slyth, 2020), combining them with nitrogen-rich products like fish entrails is deemed most effective, providing a reliable nitrogen source and other trace minerals that aid plant development.

The utilization of discarded fish entrails and banana stems combines the advantages of natural fertilizer and waste reduction. These organic materials offer environmental benefits by neutralizing the soil ecosystem, naturally strengthening plant health, and not negatively impacting soil microbes with artificial compounds. They deliver nutrients at a slow yet sustainable rate that does not harm soil pH (Chen, 2013). Moreover, organic fertilizer nutrient concentrations vary widely depending on the source material, and quickly biodegradable materials serve as excellent nutrients. Over time, organic fertilizers create a healthy soil environment, improving water and nutrient holding capacity (Wazir *et al.*, 2018). The use of organic fertilizers provides economic benefits, offering a source of plant nutrients, increasing soil fertility, and being cost-effective and environmentally friendly (Ahmad *et al.*, 2016).

To assess the efficacy of the proposed organic fertilizer, this study employed tomatoes as a test medium. Tomatoes, scientifically known as *Solanum lycopersicum*, are a popular vegetable in the market and often serve as a model plant due to their ease of cultivation in various settings, including greenhouses, growth chambers, and direct soil planting. Tomatoes exhibit robust growth, flowering, and fruit development under daily light lengths between eight (8) and sixteen (16) hours (Schwarz *et al*., 2014), making them a promising experimental plant (TTGC, 2012).

This study aims to evaluate the effects of fermented organic concoctions from fish entrails and banana stems on the growth and yield performance of tomatoes (*Solanum lycopersicum*). Specifically, the objectives are to: (1) Evaluate the growth parameters of tomatoes, such as Root Length (cm) and Shoot Length (cm); (2) Determine the yield per treatment, including the Number of Fruits and Weight of Fruits (g); (3) Compare the growth and yield parameters between and among treatments; (4) Determine the dry matter content in tomato plants per treatment; and (5) Evaluate the return on investment of Tomato (*Solanum lycopersicum*) plants.

Materials and methods

Brown sugar or molasses, fish entrails, and banana stems were the primary ingredients used in the production of organic fertilizer for this study. Other components included a towel, kitchen knives for cutting, manila paper, rubber for securing the cover, a mixing and storage container, a weighing scale, a strainer, a chopping board, and water for cleaning. Furthermore, tape measure, pens, notebook, and weighing scale were used in the treatment preparation and data collection. The items utilized for planting were: shovel, fermented fish entrails (4 litres), fermented banana stem (5 litres), 280 (12×15cm) pots, commercial fertilizers (14-14-14), and tap water.

Fermented Fish Entrails

Fish entrails were collected between 6 to 8 am at the public market, ensuring the acquisition of high-quality entrails. These collected entrails were chopped into smaller fragments to facilitate the extraction of juice. Subsequently, 10 kg of the finely chopped material was placed in a basin, and an equivalent amount of crude sugar or molasses, maintaining a 1:1 ratio, was added. Thorough mixing of the concoction was carried out using a wooden ladle, ensuring uniform coating of all fish parts with sugar.

Upon completion of the mixing process, the resulting blend was carefully transferred into a plastic pail, covered with manila paper, and securely fastened with a string. Essential details such as the processing date, anticipated harvest date, and other pertinent information were written on the container's cover. The container was then stored for a period of 2 weeks in a cool, dry, and shaded location. To prevent potential infestation by pests such as cockroaches and mice, the container was doubly protected with manila paper and an additional securing string.

Following the 2-week maturation period, the fermented mixture reached its harvest-ready state. The extracted concoction was promptly transferred to a clean and sealed container to prevent contamination.

Fermented banana stem

The collection of banana stems took place between 6-8 pm to prevent the depletion of essential nutrients. Young bananas, measuring 3 feet in height, were selected as the primary material for fertilizer production. The stems were meticulously peeled until no green color was visible. Subsequently, the banana stems were finely chopped and crushed into small pieces using a kitchen knife and chopping board, facilitating easy juice extraction.

Ten (10) kg of banana stem segments were placed in a basin, followed by the addition of an equal amount of crude sugar or molasses at a 1:1 ratio. Thorough mixing with a wooden ladle ensured even coating of all banana stem parts with sugar. Subsequently, the mixture was transferred into a plastic pail, covered with manila paper, and tightly secured with a string. Essential details, including the processing date and expected harvest date, were written on the cover, and the container was stored for 2 weeks in a cool, dry, and shaded location. To prevent potential infestation by pests like cockroaches and mice, the container was also doubly safeguarded with manila paper and an additional securing string.

After the 2-week maturation period, the mixture was deemed ready for harvesting. The harvested extract was promptly transferred to a clean and sealed container to ensure protection against contamination.

Seed sowing

The seeds were soaked in warm water for 24 hours to soften the seed coat and to expedite the germination. Subsequently, they were evenly and thinly sprinkled over the surface of the container containing soil, leaving approximately 2cm – 3cm of space between each seed. The container was then covered with manila paper to maintain a consistent temperature for germination and soil moisture.

Soil preparation

The soil was precisely measured using a weighing scale, with each pot receiving 7 kg of soil. This measure was taken to ensure that no soil would be displaced during the application of various treatments.

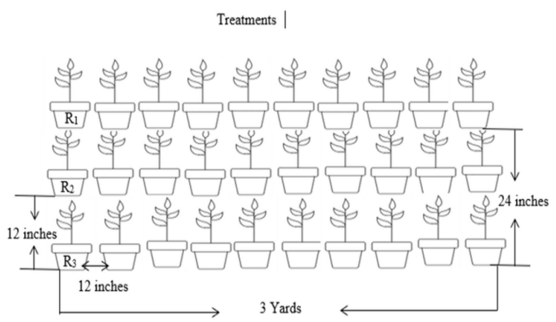

Fig. 1. Experimental lay-out

Experimental design and treatments

This study was laid out in a Completely Randomized Block Design with 7 treatments replicated 3 times. The said treatments were the following: T_1 – water (negative control), T_2 – synthetic fertilizer (positive control). 1 tablespoon of solid fertilizer / 1L of water, T_3 – 20 ml of Fermented banana stem/ 1L of water, T_4 – 20 ml of Fermented fish entrails / 1L of water, T_5 – 20 ml of Fermented banana stem and fish entrails mix/ 1L of water, T_6 – 40 ml of Fermented banana stem and fish entrails mix/ 1L of water, T_7 – 60 ml of Fermented banana stem and fish entrails mix/ 1L of water (Fig. 1).

Transplanting

The seedling was transferred to a pot (one pot with one plant) after 3 weeks. Negative control (water) was applied at least 1 week before the application of different concentrations of fermented organic fertilizer and synthetic fertilizer.

Fertilizer application

Fertilizers, both organic and synthetic, were applied through foliar methods to enhance crop development from the early to late stages of maturity, spanning a period of 6-8 weeks. The application was conducted twice a week, specifically on Mondays and Thursdays, during the early morning hours. This regimen continued for a duration of three months.

Data gathered

The study gathered data like the length, yield, dry matter and return of investment.

Statistical analysis

The data of this study were analyzed using the Analysis of Variance in a Completely Randomized Block Design in root length, shoot length, number of fruits, and weight of fruits. If found significant, further analysis was done using the Tukey's Test. The Statistical Tool for Agricultural Research computer software was utilized to test the significant difference for accuracy and convenience.

Results and discussion

Root length

Table 1 illustrates the average root length (cm) of tomato plants (*Solanum lycopersicum*) subjected to various concentrations of fermented organic concoction derived from fish entrails and banana stem. The data reveals that the tomato plants treated with T7 (60 ml of fermented banana stem and fish entrails) exhibited the highest mean root length of 78.85 cm, followed by T6 (40 ml fermented banana stem and fish entrails) with a mean of 68.66 cm, T5 (20 ml fermented banana stem and fish entrails) with a mean of 63.93 cm, T2 (synthetic fertilizer) with a mean of 60.59 cm, T3 (20 ml fermented banana stem) with a mean of 50.18 cm, and T4 (20 ml fermented fish entrails) with a mean of 47.71 cm, respectively. The lowest mean root length was observed in T1 (water) with a mean of 39.82 cm.

Table 1. ANOVA (Analysis of Variance) and Tukey's Test Result on the Root Length of *Solanum lycopersicum* plants in 90DAT (cm)

Treatment	Mean Final
T1 (water)	39.82[e]
T2 (synthetic)	60.59[c]
T3 (20 ml, fermented Banana stem)	50.18[d]
T4 (20 ml, fermented Fish entrails)	47.71[d]
T5 (20 ml, fermented banana stem, and fish entrails)	63.93[bc]
T6 (40 ml, fermented banana stem, and fish entrails)	68.88[b]
T7 (60 ml, fermented banana stem, and fish entrails)	78.85[a]
F computed =	94.61
P value =	<0.001
CV (%) =	4.10%

*Means with the same letter are not significantly different.

Upon conducting an analysis of variance, the results indicated a highly significant difference between the treatments. Specifically, the plant treated with T7 (60 ml fermented banana stem and fish entrails) exhibited the greatest root length. Subsequent application of Tukey's test revealed that T1 and T7 exhibited a significant difference from all other treatments. However, no significant differences were observed between T2 *and* T5, T3 *and* T4, and T5 *and* T6.

The results of this study indicate that a fertilizer produced from fermented banana stem and fish entrails positively influenced the growth of tomato roots. This enhancement can be attributed to the potassium content in banana stem, crucial for protein analysis and root growth, as well as the presence of phosphorus, which supports rooting (Wazir and Hussain, 2018). Altaee (2019) similarly observed that higher levels of banana stem fertilizer per plant significantly elevated all vegetative growth parameters in plants. El-Awadi *et al.*'s (2021) results align excellently with this, showing increased growth parameters in soybean plants under the influence of banana fertilizer.

Additionally, fermented fish entrails, rich in nitrogen, phosphorus, and potassium, play a role in promoting root growth. Ji *et al.*'s (2017) study on Abelmoschus esculentus (okra) plants indicated that the addition of fermented fish entrail-derived fertilizer significantly affected root length, surface area, volume, tips, and thickness. The findings of Walch-Liu *et al.* (2006) further support this, revealing that the application of fermented fish entrail-derived fertilizer on Arabidopsis thaliana plants modulated root growth and branching.

Moreover, the high nitrogen content in fermented fish entrails influences root distribution, as emphasized by Rochana *et al.* (2017). Zhang *et al.* (2017) also noted that high nitrogen fertilizers can impact root distribution in the soil, affecting deep root growth (Comfort *et al.*, 1988).

Shoot length

At 60 days after treatment (DAT) (Table 2), the data illustrated that the highest shoot length was recorded in T7 (60 ml fermented banana stem and fish entrails) with a mean of 48.44 cm, followed by T2 (synthetic fertilizer) with a mean of 46.04 cm, T6 (40 ml fermented banana stem and fish entrails) with a mean of 43.72 cm, T5 (20 ml fermented banana stem and fish entrails) with a mean of 38.56 cm, T4 (20 ml fermented fish entrails) with a mean of 36.14 cm, and T3 (20 ml fermented banana stem) with a mean of 35.69 cm, respectively. The lowest shoot length was observed in T1 (water) with a mean of 33.08 cm.

Furthermore, the analysis of variance (ANOVA) indicated a highly significant difference between treatments with a p-value < 0.01. Additionally, the results showed that the synthetic treatment, T2, exhibited no significant difference with the two treatments (T6 and T7) characterized by the highest concentration of fermented banana stem and fish entrails. In contrast, T2 exhibited a significant difference from other treatments (T3, T4, T5) with lower concentrations of banana stem and fish entrails, as well as from the water treatment (T1).

At 90 days after treatment (DAT), the highest shoot length was observed in T7 (60 ml fermented banana stem and fish entrails) with a mean of 72.73 cm, followed by T2 (synthetic fertilizer) with a mean of 72.38 cm, T6 (40 ml fermented banana stem and fish entrails) with a mean of 56.79 cm, T5 (20 ml fermented banana stem and fish entrails) with a mean of 49.03 cm, T3 (20 ml fermented banana stem) with a mean of 46 cm, and T4 (20 ml fermented fish entrails) with a mean of 45.42 cm, respectively. The lowest shoot length was observed in T1 (water) with a mean of 40.09 cm. The analysis of variance revealed a highly significant difference between treatments. Furthermore, using the Tukey test, results indicated that only T2 and T7 showed no significant difference among all treatments.

This implies that the application of T7 (60 ml fermented banana stem and fish entrails) can influence the growth of *Solanum lycopersicum* plants by providing them with a quick boost for their growth. T7 can be considered as an alternative to synthetic fertilizer, as it demonstrated comparable results from 30DAT, 60DAT, to 90DAT. This effectiveness may be attributed to the fish emulsion, a homemade fertilizer derived from fish waste, including guts, fins, and bones, which has been shown to boost plant development. The organic fertilizer provides high nitrogen, along with NPK and numerous micronutrients. It also contains essential oils, amino acids, vitamins, hormones, and enzymes that support biologically active soil (Chen, 2006).

Banana stem, known to induce significant impacts in plants on various biological aspects, plays a role in increasing the germination rate of seeds due to its high potassium content, amino acids (such as L-tryptophan), and growth promoters. When combined, these components provide the much-needed potassium for proper plant growth, as mentioned by Hubilla (2020). Moreover, banana stem is considered a potential resource for organic fertilizer due to its abundant availability, as most banana growers allow the stem to rot on the ground. Bahtiar *et al.* (2016) reported a high concentration of macronutrients in banana stem, consisting of 3087 ppm of Nitrate (NO_3), 1120 ppm Ammonium (NH_4), 439 ppm Phosphorus pentoxide (P_2O_5), and 574 ppm of Potassium Oxide (K_2O).

Studies by Ji *et al.* (2017) also demonstrated that, in a short-term pot experiment, liquid organic fertilizers substantially promoted aboveground growth by 10.2% to 77.8% and 10.7% to 33.3% when compared to chemical fertilizer. Moreover, previous studies reported that foliar application of FAA increased plant height, the number of leaves per plant, and chlorophyll content by 16.5%, 12.6%, and 8.1%, respectively, over the control (Ramesh *et al.*, 2020). This aligns with the results of Wazir *et al.* (2018), who found that plants treated with banana liquid fertilizer showed a rapid increase in growth, specifically in terms of plant height, after 60 days of emergence.

Number of fruits

Table 3 presents the average yield of tomato (*Solanum lycopersicum*) plants treated with different formulations, focusing on yield parameters. The results indicate that T7 (60 ml fermented banana stem and fish entrails) had the highest total number of fruits with a mean of 13.2, followed by T2 (synthetic fertilizer) with a mean of 12.80, T6 (40 ml fermented banana stem and fish entrails) with a mean of 12.27, T5 (20 ml fermented banana stem and fish entrails) with a mean of 12.00, T3 (20 ml fermented banana stem) with a mean of 11.90, and T4 (20 ml fermented fish entrails) with a mean of 11.60, respectively. The lowest total number of fruits was observed in T1 with a mean of 5.47. Consequently, the analysis of variance revealed a highly significant difference between treatments.

Table 2. ANOVA (Analysis of Variance) and Tukey's Test Result on the Shoot Length of *Solanum lycopersicum* plants in 30DAT, 60DAT and 90DAT (cm)

Treatment	Mean		
	30 DAT	60 DAT	90 DAT
T1 (water)	10.19^{b}	33.08^{d}	40.09^{c}
T2 (synthetic)	16.74^{ab}	46.04^{ab}	72.38^{a}
T3 (20 ml, fermented Banana stem)	16.36^{ab}	35.69^{cd}	46^{bc}
T4 (20 ml, fermented Fish entrails)	16.16^{ab}	36.14^{cd}	45.42^{bc}
T5 (20 ml, fermented banana stem, and fish entrails)	16.03^{ab}	38.56^{c}	49.03^{bc}
T6 (40 ml, fermented banana stem, and fish entrails)	16.11^{ab}	43.72^{b}	56.79^{b}
T7 (60 ml, fermented banana stem, and fish entrails)	17.40^{ab}	48.44^{a}	72.73^{a}
F computed =	3.89	39.51	30.37
P value =	0.0171	<0.001	<0.001
CV (%) =	3.36%	4.00%	7.61%

Table 3. ANOVA (Analysis of Variance) and Tukey's Test Result on the Number of fruits in *Solanum lypercicum* plant

Treatment	Mean
T1 (water)	5.47^{b}
T2 (synthetic)	12.80^{a}
T3 (20 ml, fermented Banana stem)	11.90^{a}
T4 (20 ml, fermented Fish entrails)	11.60^{a}
T5 (20 ml, fermented banana stem, and fish entrails)	12.00^{a}
T6 (40 ml, fermented banana stem, and fish entrails)	12.27^{a}
T7 (60 ml, fermented banana stem, and fish entrails)	13.20^{a}
F computed = 21.73	
**- highly significant (p value <0.01)	
P value =< 0.001	
CV (%) = 8.66%	

Further, using the Tukey test, only T1 is significantly different from the other six (6) treatments (T2 to T7) because water lacks essential macronutrients such as nitrogen, phosphorus, and potassium, thereby limiting the growth and yield of the plants.

Based on the previously discussed data, T7 demonstrates a higher number of fruits compared to other treatments, suggesting its potential as a substitute for synthetic fertilizers. Its high concentration of fermented fish entrails and banana stems can enhance soil quality and increase plant output. The banana stem, containing 3.25% phosphate and 358 mg of potassium, provides essential minerals crucial for plant growth (Zheli, 2016). Phosphorus promotes root development, blooming, and fruiting (Chandrassekaran, 2012). According to Shi et.al. (2018), fish entrail concoctions contain nitrogen and other minerals that support the growth of lactic acid bacteria, making it a valuable nutrient for plants to yield more fruits. Additionally, amino acids found in fermented fish entrails have been shown to increase nutrient uptake by plants and enhance yields. A protein hydrolysate containing 11.3% L-amino acids increased tomato yields compared to T1 (water) (Koukounaras *et al.*, 2013; Balraj, 2014).

Weight of fruits

Table 4 presents the average weight of fruits, where the pots threated with T2 (synthetic fertilizer) exhibited the highest mean weight of fruits at 510.00 g, followed by T7 (60 ml fermented banana stem and fish entrails) with a mean weight of fruits at 493.33 g, T6 (40 ml fermented banana stem and fish entrails) at 446.67 g, T5 (20 ml fermented banana stem and fish entrails) at 426.67 g, T4 (20 ml fermented fish entrails) at 416.67 g, and T3 (20 ml fermented banana stem) with a mean weight of fruits at 413.33 g, respectively. The lowest total mean weight of fruit was observed in T1 (water) with 191.67 g. The analysis of variance result indicates a highly significant difference between treatments with a p-value of 0.0006.

Table 4. ANOVA (Analysis of Variance) and Tukey's Test Result on the Weight of fruits in *Solanum lycopersicum* plants(g)

Treatment	Means
T1 (water)	191.67[b]
T2 (synthetic)	510.00[a]
T3 (20 ml, fermented Banana stem)	413.33[a]
T4 (20 ml, fermented Fish entrails)	416.67[a]
T5 (20 ml, fermented banana stem, and fish entrails)	426.67[a]
T6 (40 ml, fermented banana stem, and fish entrails)	446.67[a]
T7 (60 ml, fermented banana stem, and fish entrails)	493.33[a]
F computed = 8.15	
**- highly significant (p value <0.01)	
P value = 0.0006	
CV (%) = 15.39%	

Table 5. Percent dry matter of the tomato *(Solanum lycopersicum)* plants treated with different treatments

Treatments	Plant dry matter		
	Total weight of plants(g)	Total dry weight of plant(g)	% dry matter
T1 (water)	1700	250	15%
T2 (synthetic fertilizer)	2700	850	32%
T3 (20 ml, fermented Banana stem)	2250	450	20%
T4 (20 ml, fermented Fish entrails)	2200	450	20%
T5 (20 ml, fermented banana stem, and fish entrails	2450	650	27%
T6 (40 ml, fermented banana stem, and fish entrails)	2600	750	29%
T7 (60 ml, fermented banana stem, and fish entrails)	2800	900	32%

This result suggests that T7 (60 ml fermented banana stem and fish entrails) can be a potential substitute for synthetic fertilizer since it provides high amounts of nitrogen, phosphorus, and potassium, crucial for flower development and fruit formation, thereby improving the quality and size of the fruits. Phosphorus is one of the most prevalent nutrients in the banana stem. Jomon and Anjali (2021) reported that a high potassium concentration in the banana stem (78.10 mg/g), along with calcium, sodium, iron, and manganese concentrations (19.20 mg/g, 24.30 mg/g, 0.61 mg/g, and 76.20 mg/g, respectively), can influence fruit weight. Additionally, combining Fish Amino Acid (FAA) with other organic fertilizers can help plants produce larger fruits, resulting in increased weight.

Percentage of dry matter

Table 5 displays the percentage of dry matter of tomato (Solanum lycopercicum) plants treated with different substances. The results reveal that the tomato plants treated with T7 (60 ml of fermented banana stem and fish entrails) and T2 (synthetic fertilizer) exhibit similar percent dry matter at 32%.

The identical percentage of dry matter in T7 and T2 suggests that both treatments have a higher photosynthetic capacity, contributing to increased plant yield. Togun *et al.* (2003) reported that organic amendments enhance plant photosynthetic activities, resulting in higher dry matter production. Additionally, Manhas *and* Gills (2010) found that increased application of organic fertilizer positively impacts plant growth, dry matter accumulation, yield, and quality. Synthetic fertilizer, rich in NPK concentrations, provides essential nutrients that stimulate plant photosynthetic activities, leading to increased dry matter, yield, and plant quality. This is supported by Baghdadi *et al.*'s (2018) study, indicating no significant difference in dry matter content between synthetic fertilizer and high-concentration organic fertilizer. However, the excessive use of synthetic fertilizer can result in various problems, such as nutrient loss, water contamination, soil acidification or basification, reduction in useful microbial communities, and increased sensitivity to harmful insects (Chen, 2013).

Dry matter serves as an indicator of remaining plant carbohydrates, fats, proteins, fiber, vitamins, minerals, and antioxidants. Fresh plants typically have high water content, resulting in a lower percentage of dry matter compared to drier counterparts like hay or grain. The increase in total plant fresh weight production with an increasing number of fruits is attributed to enhanced water holding capacity (Shamsuddin *et al.*, 2007), increased supply of essential nutrients (Motta *and* Maggiore, 2013), elevated photosynthesis, and increased plant dry matter, ultimately leading to improved flowering.

The different concentrations of fermented organic concoction from fish entrails and banana stem enhanced the growth of the Tomato (*Solanum lycopersicum*) plant, particularly in terms of root length, average shoot length, and dry matter content.

Among the various treatments of fermented organic concoction from fish entrails and banana stem, T7 (60 ml fermented banana stem and fish entrails) demonstrated a favorable effect on the growth of the Tomato (*Solanum lycopersicum*) plant. This outcome suggests that incorporating T7 (60 ml fermented banana stem and fish entrails) provided a high amount of natural phenolic antioxidants, including vitamins, flavonoids, essential amino acids, growth promoters, nitrogen, potassium, and phosphorus- essential elements required for plant growth.

The different treatments of fermented organic concoction from fish entrails and banana stem also enhanced the yield of the Tomato (*Solanum lycopersicum*) plant, particularly concerning the average number and weight of fruits.

Among the diverse treatments of fermented organic concoction from fish entrails and banana stem, T7 (60 ml fermented banana stem and fish entrails), the treatment with the highest concentration of the concoction, exhibited a favorable effect on the yield of the Tomato (*Solanum lycopersicum*) plant. This was attributed to the fact that incorporating 60 ml fermented banana stem and fish entrails provided ample nitrogen, phosphorus, and potassium. These nutrients are crucial for flowering and fruit development, enhancing the quality and size of the fruits.

Therefore, T7 (60 ml fermented banana stem and fish entrails), representing one of the various treatments of fermented organic concoction made from fish entrails and banana stem, can be advantageous as a substitute for synthetic fertilizer. It demonstrated positive effects on the growth, yield, and development of tomato plants comparable to the treatment with synthetic fertilizer. Moreover, T7 is more favorable since they are composed of environmentally friendly ingredients.

Recommendation(s)

Based on the findings of the study, it is recommended to consider practical application of the concoction of fish entrails and banana stem in agricultural settings, conduct further field trials, undertake long-term impact evaluation, organize information drives and training sessions to encourage community participation in the utilization of the developed organic fertilizer, and implement monitoring systems to assess the environmental impact of the developed concoction.

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