Chemical Analysis of Organic Fertilizers from Fermented Plant Juice and Peat Water

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Abstract

Environmentally friendly practices in crop production are encouraged to address ongoing challenges. One of the approaches is the use of organic fertilizers as an alternative to chemical fertilizers. Organic fertilizers can be maximized by utilizing resources readily available in the surroundings, such as peat water and plant waste. This study aims to assess the chemical properties of a fertilizer derived from a mixture of peat water and fermented plant juice (FPJ). FPJ was prepared by separately fermenting four types of plant wastes: water spinach, spring onion, sweet potato leaves and pumpkin leaves. The mixtures of peat water and FPJ were analyzed for pH and macronutrient content, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). The pH values of the mixtures ranged from 3.7 to 4.7. The highest concentrations of N, P, K, Ca, and Mg found in these mixtures were 0.08%, 536 mg/L, 1830 mg/L, 50.7 mg/L, and 105 mg/L, respectively. In conclusion, the variation in macronutrient concentrations among the formulated mixtures reflects distinct nutrient profiles, indicating their potential relevance to crops with differing nutrient requirements. Nevertheless, comprehensive evaluation through crop growth trials and direct comparison with conventional inorganic fertilizers is required to substantiate their agronomic effectiveness.

Keywords: *Organic Fertilizer, Peat Water, Fermented Plant Juice, Plant Waste, Sustainable Agriculture*

1. Introduction

The global agricultural landscape is undergoing a significant transformation, driven by the urgent need for more sustainable and environmentally friendly practices. This shift aims to tackle pressing issues like soil degradation, nutrient depletion, and environmental pollution, which have long been associated with conventional farming methods.

The exploration of fertilization strategies becomes crucial. Organic fertilizers play a crucial role in sustainable agricultural practices by recycling biodegradable materials [1] and harnessing their inherent nutrient content [2]. Various organic fertilizers were derived from sources such as animal waste [3], human excreta [4], or vegetable waste [5].

Recent studies highlight the preference for organic fertilizers among smallholder farmers due to their affordability and comparable potential efficacy to inorganic fertilizers [6]. Inorganic fertilizers are associated with long-term environmental and human health issues [7], including soil compaction [8], soil erosion [9], reduced soil fertility [10] and the absorption of toxic chemicals into the food supply [11]. Plus, inorganic fertilizers are costlier and pose a threat if not managed properly [12]. One notable benefit of organic fertilizers is their slower nutrient release compared to chemical fertilizers [13]. This

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gradual process allows plants to process the fertilizer naturally, preventing over-fertilization and potential damage. Unlike chemical fertilizers, organic fertilizers do not contain harmful compounds, making them safer for increased use. But continuous use of inorganic fertilizers alone causes soil organic matter degradation, soil acidity and environmental pollution [14]. Moreover, organic fertilizers contribute to improving soil structure, facilitating better air circulation [15]. This, in turn, sustains beneficial microorganisms that release nutrients into the soil [16].

Despite the advantages of organic fertilizers, challenges persist, including the diverse nature of organic fertilizers which raises uncertainties about their specific effects on different vegetables. Therefore, a comprehensive screening of the chemical properties of newly derived solution fertilizers is essential. This screening aims to determine the chemical compositions in each mixture of peat water and fermented plant juices as potential fertilizers for vegetables.

1.1. Peat water

Peat water is readily available in Malaysia in large quantities in Sabah, Sarawak, Pahang, Johor, Perak and Selangor. The pH of the water found in peat soil ranges between 3 and 4, making it an acidic substance [17]. Excessive acidity can negatively impact crop growth and inhibit nutrient uptake. Most crops prefer neutral conditions. Therefore, amendments such as lime or wood ash are necessary to increase the pH level. Peat water is drained both before and after a peatland is opened for farming. The peat soils in a region may have leached some of their nutrients into the water [18] which leads people to believe that the water in such a place, whether it originates from a pond or some other type of water flow, is rich in nutrients. Peat water has also been reported to have high concentrations of organic carbon, humic acids and fulvic acids. All of these compounds can enhance soil microbial activity and augment its nutritional content. As a result of the possibility that it is rich in a variety of nutrients, it might be suitable for use as fertilizer. Despite this, nutrient composition differs among peatland sources, creating difficulties in achieving uniform fertilizer formulation.

1.2. Fermented plant juice

One of the organic fertilizer materials proven to have a lot of potential is fermented plant juices (FPJ) [19]. This type of juice uses sugar to extract the essence of the plant through osmotic pressure. The FPJ is an enzyme-rich solution that is packed with helpful microorganisms and has the ability to revive plants. It is a dynamic method that is gaining favour among underprivileged farmers who require local plants and simple on-farm extraction techniques for fertility [20]. In order to implement this strategy, farmers need local plants. However, to achieve effectiveness and better results, it is required to explore plant extracts derived from a wide variety of plant sources for FPJ [21]. FPJ is a natural growth promoter commonly applied in organic agriculture as a foliar fertilizer, seed treatment or soil amendment to support plant growth and productivity [22]. Despite its widespread application, scientific evidence regarding its crop-specific efficacy remains limited [23].

Fermentation of the shoots of actively developing plants using either brown sugar or molasses takes place for 7 to 14 days to produce this juice. Numerous studies have been carried out on the application of FPJ; nevertheless, the length of time required for the fermentation process is variable and uncertain [24, 25]. The variability in fermentation period may be influenced by several factors including plant material, sugar source, ambiance, temperature and microbial activity. Various plant sources contain different moisture levels. Materials with high moisture content may ferment more rapidly than those with lower moisture content. Recommendations on the optimal fermentation time for plant juice show some variation. While one source suggests the juice is ready for harvest 5 to 10 days after initiation [26], another advises a longer timeline, specifying that it should not be used until 7 to 10 days after fermentation has completed [27]. Synthesizing these findings, a more conservative and comprehensive guideline would be to allow for a primary fermentation period of 7 to 10 days, followed by an additional period to ensure completion, highlighting that the exact timing may depend on specific environmental conditions and desired product characteristics.

The addition of brown sugar to the plants in question induces osmosis, which causes fluids to be drawn out of the plant material. It also provides food for the bacteria responsible for the fermentation

process. The fermentation process produces a weak alcohol that eliminates ethanol-soluble chlorophyll and other plant components. It is non-hazardous to health and may be consumed. FPJ derived from green plants is rich in nutrients and plant growth hormones. In order to become fermented plant juice, green plants produce cell sap and chlorophyll by utilizing sugars that build up the osmotic pressure, which breaks down plant cells and initiates the process of decomposition by microorganism fermentation of the agents' cell walls.

The manufacturing of FPJ can be made by utilizing a wide variety of materials, such as mugwort, fruits of low quality, fallen leaves, and wild plants [28]. The majority of the raw materials used in production are ones that can be reused and are easily accessible. [29] states that water spinach can be a great growth promoter due to its rapid growth rate and high natural growth hormone content, such as auxin. According to his research, tomato plants treated with FPJ from water spinach produced more shoots and had a greater leaf area. However, there is limited research evidence for treating leafy vegetables such as Pakchoy with FPJ water spinach.

2. Methods and Materials

2.1. Peat water collection

The peat water used in this experiment was obtained from a pond on a farm near Senggarang, Johor. It required the use of bail to collect enough peat water to fill a bucket. After that, it was put into bottles so it could be preserved and mixed with FPJ.

2.2. Plant waste collection

The water spinach, spring onions, sweet potato leaves, onion peels, and pumpkin leaves that would be utilized in this study were gathered from the Jasin district, Melaka, Malaysia. The amount of plant material obtained ranged from 1 to 2 kg, respectively.

2.3. Production of fermented plant juice

FPJ were produced using the [30] methods. The wilted plant material was gathered. The plants were not cleaned to preserve the surface bacteria that promote fermentation. The plants were chopped with a knife to a length of 2 to 3 inches for FPJ preparation. Each variety of plant material was weighed and recorded. Equal amounts of brown sugar derived from sugarcane were added to the plant materials (ratio 1:1). The brown sugar and plant materials were thoroughly combined in a basin until the entire surface was coated with brown sugar to accelerate the osmotic process and extract more plant fluids. The mixtures were placed into polyethylene containers. The containers were covered with a cloth to allow air to circulate. The towels were tied with rubber bands to prevent pests and contamination . The containers were kept at room temperature and in a dark environment insulated from all light. After a day, the containers' contents were assessed to see if any modifications were required. The containers were opened every two days to release fermentation-produced gas. This will allow for a larger quantity of oxygen to support the bioreactor's activity throughout the fermentation phase. The mixtures were allowed to ferment without disturbance. The mixtures were fermented for ten days. The fermentation was complete on the tenth day, when the plant components ascended to the top of the container and the liquid descended to the bottom. The liquid was strained from the sludge using a sieve. The liquids were appropriately stored in bottles.

2.4. Formulation of liquid fertilizer

The FPJ and peat water were combined in a certain proportion (as shown in Table 1) in order to produce the liquid fertilizers. The liquid fertilizers consisted of a control that was a combination of peat water and commercialized fertilizer which is green NPK in equal amounts; a combination of peat water and FPJ made from water spinach; a combination of peat water and FPJ made from spring onion; a

combination of peat water and FPJ made from sweet potato shoots; and a combination of peat water and FPJ made from pumpkin shoots.

Table 1: Percentage of peat water and different Fermented Plant Juice (ratio 1:1).

Liquid Fertilizer	Peat Water (%)	FPJ (%)
Control (Peat water + NPK)	50	50
Peat water + FPJ Water Spinach	50	50
Peat water + FPJ Spring Onion	50	50
Peat water + FPJ Sweet Potato Shoots	50	50
Peat water + FPJ Pumpkin Shoots	50	50

2.5. Chemical and nutrients analysis of FPJ and peat water

Liquid fertilizer derived from peat water and fermented plant juice (FPJ) underwent a chemical analysis to determine their pH levels and the proportions of various macronutrients, including N, P, K, Mg and Ca.

2.6. pH of Fermented Plant Juice

A pH meter was used to analyze all of the samples to determine the pH levels. Prior to its use, the pH meter was calibrated using standard buffer solutions with pH values of 4, 7 and 10. The samples were dissolved with 50ml of distilled water in a homogenous solution. The pH levels were monitored and recorded. After completion, the electrode was rinsed with distilled water and dried with tissue. The electrode was placed back into the storage solution.

2.7. Macronutrients

The macronutrients including P, K, Mg and Ca were analyzed using Atomic Absorption Spectrometry (AAS). The peat water and FPJ were shaken using a vortex mixer. 10ml of samples were transferred into a beaker using a pipette. 5% of HNO3 were put into the beaker. After that, 10ml of 30% H_2O_2 and 20ml of HNO_3 were poured into the beaker and covered. The beaker were placed on a temperature-controlled heating plate and heated to 120 ˚C. After digestion process, the solution was cooled down to room temperature. When the volume of the residue was less than 10 ml, it was then diluted to 15 mL with 5% HNO_3 in a 15mL colorimetric tube. Afterwards, the solution passed through a hydrophilic membrane (0.45 μm) and allowed to stand for determination.

Total nitrogen content was determined using Dumas method. The 50ml samples were weighed on an analytical balance and placed into foil. 50mg of superabsorbent powder (Code A00000317) was added to the sample. The foiled were sealed and formed a capsule. Autosample was prepared by inserting the capsule. Each sample was analysed for approximately three minutes.

3. Results and Discussion

3.1. pH of liquid fertilizer

Peat water, FPJ derived from water spinach, FPJ derived from spring onion, FPJ derived from sweet potato leaves, and FPJ derived from pumpkin leaves have respective pH values of 4.06, 3.84, 3.73, 4.06, and 4.74. The results in Table 2 indicate that each sample is acidic. The FPJ from spring onion is the most acidic, while the FPJ from pumpkin leaves is the least acidic.

Table 2: The means value of pH of peat water and FPJ.

Samples	pH
Peat Water	4.06
Water Spinach	3.84
Spring Onion	3.73
Sweet Potato Leaves	4.06
Pumpkin Leaves	4.74

According to Islam et al. (1980) [31], the optimal pH range for plant growth was between 5.5 and 6.5. However, species grew differently outside of this region. There are plants that can tolerate low pH without experiencing a decrease in yield. Complicated plant-soil interactions make it difficult to determine a crop's optimal pH range. pH is the "master soil variable" that influences plant growth and biomass yield, as well as soil enzyme activity, organic additions, nitrification, and ammonia volatilization [32].

pH regulates the solubility, mobility, and bioavailability of trace elements, making it an essential factor in determining how plants translocate these elements within their tissues. After that point, it will affect plant growth and nutrient leaching [32]. When the pH level is too low, plant nutrients can leach faster. However, if the pH is excessively alkaline, the solubility of the majority of trace elements will decrease, resulting in low quantities and availability for the plants [33].

3.2. Macronutrients content in the liquid fertilizer

Table 3 displays the results of the analysis of the macronutrients content in the liquid fertilizer. The liquid fertilizer made from peat water and FPJ pumpkin leaves contains the highest concentration of nitrogen, 0.10 %. Next is the liquid fertilizer derived from peat water and FPJ sweet potato leaves, which contains 0.08 % nitrogen. Both the control and liquid fertilizer produced from peat water and FPJ water spinach contain the same amount of nitrogen, 0.07 %. Liquid fertilizer made from peat water and FPJ spring onion contains the least amount of nitrogen, only 0.02 %. Observed N percentages exhibit comparatively minor variation. These treatments contain a minimal amount of nitrogen, the nutrient that plants require most for growth and especially for the development of new cells. When it comes to crop production, nitrogen is the most important nutrient for plants. It is a component of the fundamental elements, of which the vast majority of plant structures are composed. It is an essential component of chlorophyll, enzymes, and other biological molecules. In addition to promoting root growth and crop development, it enhances the absorption of other nutrients [34].

Table 3: The macronutrient values in liquid fertilizers (mean ± SD, n= 4).

Treatments	N (%)	P (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
Control (Peat water + NPK)	0.07 ± 0.01	43.6 ± 5.8	61.9 ± 8.2	13.9 ± 2.1	4.96 ± 0.82
Peat water + FPJ Water Spinach	0.07 ± 0.01	163 ± 22	1830 ± 210	50.7 ± 7.4	87.5 ± 12.3
Peat water + FPJ Spring Onion	0.02 ± 0.00	134 ± 18	982 ± 135	115 ± 16	96.2 ± 13.8
Peat water + FPJ Sweet Potato Leaves	0.08 ± 0.01	241 ± 31	1490 ± 180	18.2 ± 3.5	101 ± 14
Peat water + FPJ Pumpkin Leaves	0.1 ± 0.01	536 ± 68	1620 ± 195	36.9 ± 5.9	105 ± 15

According to the analyses, the control liquid fertilizer, which is a mixture of peat water and green NPK, had the lowest concentration of phosphorus, which is 43.6 mg/L. The liquid fertilizer derived from peat water and FPJ pumpkin leaves has the highest concentration of phosphorus, which is 536 mg/L. The percentage of phosphorus in the remaining liquid fertilizer ranges from 130 to 250 mg/L. The exact concentrations of liquid fertilizer obtained from peat water and FPJ spring onions, peat water and FPJ water spinach, and peat water and FPJ sweet potato leaves are 134 mg/L, 163 mg/L, and 243 mg/L,

respectively. According to [35], the availability of phosphorus in soil is rarely sufficient to ensure that plants grow and develop to their full potential. This is because phosphorus is fixed in the soil. Because of this, the plants need to have a consistent optimal amount of P supplied to them in order to optimize their growth and development and to prevent nutrient insufficiency.

The amounts of K found in the liquid fertilizers are listed in the tables above. The quantity of potassium is considerably different from that of nitrogen and phosphorus; specifically, liquid fertilizer made from peat water and FPJ spinach contains the highest amount of K, which is 1830 mg/L. The liquid fertilizer made from peat water and FPJ pumpkin leaves has a K level of 1620 mg/L, making it the next highest content of K. The liquid fertilizer made from peat water and FPJ spring onion, as well as the control, both contain less than 1000 mg/L of K, with 1490 mg/L and 61.9 mg/L, respectively. K is required at an optimum amount as K is a macronutrient that is essential for the development and productivity of plants. It is a vital component of many fertilization management systems, which are designed to boost crop output as a result of the important roles it performs [36]. When compared with the absorption of nitrogen and phosphorus, the majority of a plant's potassium supply is often taken up during an earlier growth stage. In cases of extreme potassium deficiency, the leaf's burnt edge may completely split from the leaf [37].

Analyses are performed on liquid fertilizer to determine its Ca content, and the results are as documented in the table above. Fertilizer in the form of a liquid derived from peat water and FPJ spring onion contains 115 mg/L of Ca. The difference between the highest Ca content and the second highest is rather large, and the amount of the second highest may be found in liquid fertilizer that is formed from peat water and FPJ water spinach. This has Ca amount at 50.7 mg/L. The liquid fertilizer made from peat water and FPJ pumpkin leaves, peat water and FPJ sweet potato leaves, and the control all have a calcium content that is lower than the other two, coming in at 36.9 mg/L, 18.2 mg/L, and 13.9 mg/L respectively. Ca is immobile and cannot be translocated within a plant; therefore, symptoms develop first on younger leaves and leaf tips [38]. The growing tips of roots and leaves wither and turn brown. Ca deficiency is rarely observed in plants due to the fact that secondary effects of high acidity caused by soil calcium deficiency typically limit plant growth, thereby preventing the manifestation of Ca deficiency symptoms (Havlin, 2020). Without enough Ca, which is required to build solid cell walls in the form of calcium pectate, freshly emerging leaves may stick together at the margins, resulting in ripping as the leaves grow and unfurl. This may also weaken the structure of the stem. Younger leaves of certain plants may be cupped and crinkled, and the terminal bud may deteriorate [39].

The Mg content of the liquid fertilizers was the final macronutrient that was tested. The amount of Mg found in liquid fertilizer derived from peat water and FPJ pumpkin leaves is 105 mg/L, while the amount of Mg found in liquid fertilizer derived from peat water and FPJ sweet potato leaves is 101 mg/L. Both amounts of Mg are not significantly different from one another. The liquid fertilizer derived from peat water and FPJ spring onion contained a total of 96.2 mg/L of Mg, whereas the liquid fertilizer derived from peat water and FPJ water spinach only contained 87.5 mg/L of Mg and the control liquid fertilizer contained only 4.96 mg/L of magnesium. Magnesium deficiency in plants has been shown to severely influence a wide variety of important physiological and biochemical processes, which in turn leads to reductions in both growth and production. One of the common indications of magnesium deficiency is a yellowing of the leaves, which manifests itself as interveinal chlorosis on older leaves [40].

4. Conclusion

In conclusion, the macronutrients present in these mixtures are sufficient to benefit crop production. However, further research is needed to determine which crops are best suited for these mixtures, as different crops require varying amounts of macronutrients and micronutrients. Additionally, it is recommended to analyze the micronutrient content in greater detail, as deficiencies in specific micronutrients could negatively affect crop growth and development.

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Conflict of Interest

We declare no conflict regarding the publication of the study.

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