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THE EFFECT OF BLOOD-AND-BONE FERTILISER TOWARDS THE GROWTH OF WATER SPINACH (*IPOMOEA AQUATICA*)

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Abstract:

The increasing demand for sustainable vegetable production has encourage the utilisation of organic fertiliser. It can improve the total yield of plant by mitigating the environmental impact compared to synthetic nutrient. Blood-and-bone fertiliser are produced from the animal waste mainly from the slaughterhouse, have a great potential ahead as they are rich in nitrogen, phosphorus and calcium. It is rarely discussed in studies of plant growth especially the water spinach (*Ipomoea aquatica*). This study highlights the impact of blood-and-bone fertiliser on the plant growth (plant height, root length, dry biomass, chlorophyll content and the fertiliser's impact on soil pH). Five 5-cm water spinach seedlings were planted in each polybag with different concentration of blood-and-bone fertiliser: soil ration - (A) control, no fertiliser added, (B)1: 1000, (C)1:200, (D) 1:100 and (E) 3:200. Plant performance was evaluated over a five-week period. The results demonstrated that Treatment C show the best performance in plant growth, chlorophyll content, root growth. In addition, it does not affect the soil pH due to the slow-release nature of the fertiliser.

Keyword:

Agriculture, Blood-And-Bone Fertiliser, Organic, Water Spinach



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Introduction

The demand for future agriculture had increased profoundly. This had encouraged the utilisation of waste into something beneficial such as the production of organic fertiliser. There are many alternatives of the organic fertilisers available. However, one with the increasing interest among farmers is the organic fertiliser derived from the livestock by-product mainly from the slaughterhouse. Rather than disposing these wastes as waste, their transformation into organic fertiliser provides a good alternative. This is because it can recover the valuable nutrient contained within them whilst mitigating the environmental impact it may produce.

Water spinach (*Ipomoea aquatica*) is widely cultivated throughout tropical region and nearby. One of the reasons can be because of its rapid growth rate along with adaptability to wide range of environmental condition. For these reasons, it is economically important plant for local food production. It is rich in vitamins A and C, dietary fibre along with antioxidant properties (Gangopadhyay et al., 2021). Other than that, recent studies had reported that water spinach exhibit phenolic compound and strong antioxidant, genoprotective and enzyme inhibitory activities other than their medicinal value (Saikia et al., 2023). In aquaculture, water spinach bears the properties of heavy metal absorbance in improvising the water quality (Hisam et al., 2022; Ruan et al., 2024).

This increasing demands of water spinach had pushed the betterment in the agricultural practice in order to enhance the crop productivity. At the same time, environmental degradation must me at minimal. There are many factors that affect the growth of the water spinach, one of them is the availability of the essential nutrient in the soil. The three macronutrients are Nitrogen (N), Phosphorus (P) and potassium (K). These affect photosynthesis, protein synthesis, root growth, enzyme production and biomass (Brady & Weil, 2021). Although soil in general can provide these nutrients for plant, however continuous cultivation will lead to the depletion of the nutrient thus affect the plant growth.

From the previous studies, they had demonstrated the positive outcomes from the usage of organic fertiliser on water spinach growth and yield (Pohan, 2021; Noor et al., 2022). Compost (Nasrin et al., 2019) and cow manure fertiliser (Pohan, 2021) had reported to improve the plant height, leaf growth, chlorophyll concentration, fresh and dry (biomass) weight. Of all, cow manure had shown the most significant improvement in growth parameters. This is probably due to the balanced nutrient composition and their ability to support metabolic processes in plants (Pohan, 2021). Other studies had shown that organic fertiliser may improve the soil fertility (Gong et al., 2020). However, there were still a limited number of research on the effect pf blood-and-bone fertiliser on the growth of water spinach and its relation to soil fertility. Also, the information regarding the optimum application rate is still insufficient. Blood and bone

fertiliser were mainly produced from the animal waste from the slaughterhouse. Previously, they were all discarded that will affect the environment if poorly managed.

Therefore, this study was conducted to investigate the effects of blood-and-bone fertiliser on the growth of the water spinach. Growth performance was evaluated using plant height, chlorophyll content, dry biomass, root development, and soil pH as indicators. The findings of this study are expected to contribute to a better understanding of the suitability of blood-and-bone fertilizer as an organic nutrient source and to identify the optimum fertilizer rate for sustainable water spinach cultivation.

Literature Review

Fertiliser gave a significant difference to global food security in the modern agriculture practice approximately accounting for 50% increment in agricultural productivity. The absence of supplemented fertiliser can reduce the crop yield (Krasilnikov et al., 2022). Numerous studies had supported that the supplemented fertilizer improve the plant growth, nutrient uptake, yield and leaf development (Liu et al., 2021; Ibrahim et al., 2018; Noor et al., 2022).

However, fertilisers can sometime bring harm to the environment from their long-term application. It can lead to rhizosphere acidification, nutrient imbalance, water contamination and inhibit the growth of soil microbiota which to extrapolate, can affect the ecosystem health (Abebe et al., 2022; Dikir, 2023; Yadav et al., 2022).

Due to this issue, many farmers had substituted the synthetic to organic fertilisers which can be a safer option and friendlier to the environment. Organic fertiliser can be derived from the agricultural waste such as crop residues and livestock manure and respective by-products (Sari et al., 2020). It is shown that these organic fertilisers can supplement sufficient nutrient, improving soil structure and can enhance water retention capacity (Sari et al., 2025). This is parallel to the circular economy practise by transforming the waste into valuable product rather than turning them into environmental pollutants. This practise had not only improvised the crop productivity but also maintaining a healthy and sustainable resource management and conservation (Sari et al., 2025; Yadav et al., 2022).

Sustainable Nutrient Management in Vegetable Production

Population growth had demand for an increase in agricultural production worldwide. To increase the yield in crops, farmers largely depend on the synthetic fertiliser. The three most important macronutrients are N, P and K required for the plant growth as they influence the photosynthesis, energy transfer, protein and biomass accumulation (Brady & Weil, 2021). The usage of chemical fertiliser had boosted the global agricultural productivity during the Green Revolution (Krasilnikov et al, 2022). However, there are issues regarding the usage of synthetic fertiliser. Excessive usage of synthetic fertiliser had raised a concern in the soil degradation and contamination, nutrient imbalance and reduction in soil microbiome (Abebe et al, 2022; Dikir 2023). It will affect the soil physicochemical properties and affect the nutrient cycling processes. This will later contribute to the eutrophication and will affect the quality of water bodies nearby (Yadav et al., 2022)

Over time, researchers have increased their interest in the environmentally friendly yet sustainable practice while mitigating the effect on the environment. Organic fertiliser is one of the promising alternatives because they provide nutrients while improving the soil structure, water retention and can increase the productivity of the plants (Wortman et al., 2017; Diacono & Montemurro, 2010).

Sustainable Nutrient Management in Vegetable Production

Among various options of nutrient sources, animal-derived fertiliser had provided a good option as it has high nutritional content. Their nutrient composition makes it suitable for leafy vegetables. Among all organic fertiliser available in agricultural industries, one with limited number of studies was the blood and bone fertiliser. This is probably due to complicated process along the way. Blood and bone fertiliser comes from the animal by-product (processed animal blood and bone residue from livestock industries). Blood meal in general have about 10 - 13% N, but bone meal has a good amount of P and K (Momtaz et al., 2021; Sari et al., 2020). These are essential for the plant growth. Another advantage exhibited by the blood and bone is the slow-release nature. This enables the plant to absorb the gradual release nutrient. Therefore, this can minimise the nutrient losses through leaching thus, mitigate the eutrophication to the nearby water bodies (Brady & Weil, 2021). Blood and bone that are commonly produced in the slaughterhouse can be reuse into agricultural fertiliser. This can tackle the environmental problems rise from poor waste management and promote a sustainable agricultural system (Ginting, 2020).

Beyond its value, the utilisation of organic fertiliser supports the circular economy by repurpose livestock waste into useful agricultural product. (Sari et al., 2025). This can promote the resource efficiency within agricultural system

Physiological Response of Water Spinach to Nutrient Availability

Water spinach is widely cultivated due to its many nutritional advantage and rapid growth (Gangopadhyay et al., 2021). The edible parts of water spinach are mainly their leaves; therefore, vegetative growth is important aspect from the consumer's perspective. This can be improved by using the suitable fertiliser.

Plant growth is highly associated with its ability to photosynthesise thus, affected chlorophyll content. N is important for the formation of chlorophyll molecule. Other than that, N promotes the growth of the leaf and biomass production (Brady & Weil, 2021). Water spinach is mainly harvested for their leaf, hence N fertiliser is important for their growth, whereas P contributes to energy transfer, root development and metabolism. On the other hand, Calcium (Ca) helps in the growth of cell wall and plant structure in general (Brady & Weil, 2021). In terms of nutritional content, water spinach contains Vitamin A, B, C, E and K other than Ca, Iron (Fe), Magnesium (Mg), P, K and Zinc (Zn) (Gangopadhyay et al., 2021).

The effectiveness of organic fertiliser in improving vegetable growth has been widely reported. Studies involving compost, livestock manure, livestock by-product have consistently demonstrated positive effects on plant growth, nutrient uptake and soil fertility (Pohan, 2021; Wan et al., 2021)

Although considerable research has investigated the effects of organic fertilizers on vegetable production, relatively few studies have focused specifically on blood-and-bone fertilizer. Existing studies primarily emphasize its nutrient composition and its effectiveness in selected crops such as onions and leafy vegetables (Momtaz et al., 2021). However, information regarding the optimal application rate of blood-and-bone fertilizer remains limited, particularly for water spinach cultivation under controlled growing conditions.

Methodology

Experimental Design

The study was to evaluate the concentration of the fertiliser application on the growth performance of water spinach. Blood-and-bone fertilisers were used in this experiment as they are rich in N, P and Ca. The treatments were established using two replicates and four different concentrations of blood-and-bone fertiliser: (A) 0:1000, (B) 1:200, (C) 1:100 and (D) 3:200 per planting unit (based on self-observation from preliminary experiments). The selection of fertiliser rate was based on the objective of identifying the optimum concentration of fertiliser that are able to promote good growth in water spinach. The soil was bought from the local nursery. These were not supplemented with other minerals and chemicals. The fertiliser was thoroughly mixed with the soil before planting to ensure uniform nutrient distribution.

Water spinach seeds were obtained from local stores and germinated under controlled conditions. The healthy seedlings (green, no discolouration on the leaf, with healthy roots) were chosen for the experiment. These seedlings were transferred into the polybags with the fertilised soils. Each polybag contained five seedlings and considered as one replicate. The polybags were placed in a greenhouse with controlled environments. The experiments were conducted over five-week period which all treatment received identical irrigation.

Growth Assessment and Physiological Measurements

Plant growth such as plant height were monitored weekly. Photosynthetic efficiency was measured by taking chlorophyll content using SPAD chlorophyll meter. SPAD reading provide a better alternative for chlorophyll reading as it is non-invasive and rapid (Ling et al., 2011). Measurements were taken on a fully expanded leaves to ensure accurate and consistent readings taken.

Root health (root length) was measured before and after experiments. Root length was measured from the base of stem to the tip of the longest root after the removal of soil particle. This is a very important parameter as it determined the nutrient availability and nutrient uptake efficiency. Lastly, plants were harvested and dried at 75°C for 72 hours (Seepaul et al., 2019). Dry weight reflects the nutrient uptake efficiency and overall plant productivity

Soil pH Evaluation

Some fertilisers are too acidic or alkaline that will affect the nutrient availability and nutrient solubility (Brady & Weil, 2021). Therefore, it is important to measure the soil pH every week to study its suitability of the fertiliser for sustainable crop production. The measurements were taken thrice, and average value were calculated to avoid bias.

Statistical Analysis

Data collected for plant height, chlorophyll content, root length, biomass accumulation, and soil pH were summarised using descriptive statistic. Mean was calculated to compare the growth responses among different fertiliser concentration. The treatment with highest growth performance was considered as the optimum fertiliser. Results will be compared with the physiological response, nutrient absorption to support the conclusion.

Results and Discussion

Growth Performance of Water Spinach under Different Concentration Fertiliser Treatment

The application of blood-and-bone fertiliser had proven to influence the growth of water spinach throughout a five-week period. Plant height increased across all treatments, indicating that plants absorb the nutrient very well (Noor et al., 2022). From our results, the highest plant growth was recorded in treatment C reaching 30.92 ± 3.40 cm by Week 5, whereas lower growth performance in the control group (17.5 ± 0.71 cm by Week 5). This can be attributed to the nutrient composition of the blood-and-bone fertiliser, which equipped with N, P and Ca (Momtaz et al., 2021; Noor et al., 2022). N is important for leafy vegetables. Increasing in N availability will promote cell division, leaf expansion and photosynthetic activity as it contains amino acid, proteins and chlorophyll molecules. This will result in better plant elongation (shoot growth) and biomass accumulation (Brady & Weil, 2021). Similar findings were reported by Pohan (2021) who observed increased water spinach growth over fertiliser application.

However, the treatment D (highest concentration of fertiliser) did not produce the best result. Excessive fertiliser application may reduce the nutrient absorption efficiency, limiting the effects of fertiliser. These findings were similar over previous studies, where moderate fertiliser application produced better results in plant growth performance due to the better nutrient uptake (Yadav et al., 2022). This study's results indicate that the blood-and-bone fertiliser can support the water spinach growth while minimising the cost by minimising the usage of fertiliser needed for optimum growth.

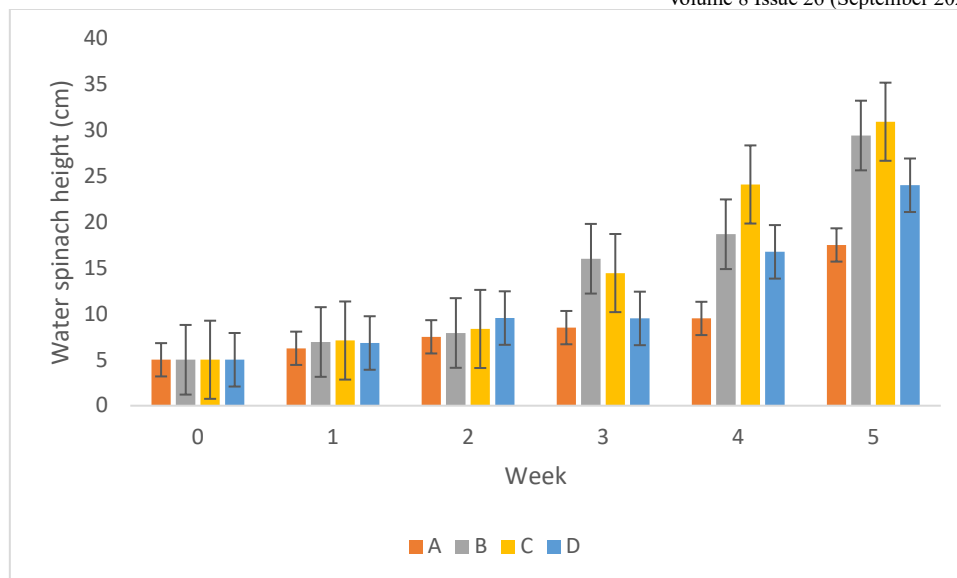


Figure 1: Growth of Water Spinach over Five-Week Course under Four Different Treatments

Influence of Blood-and-Bone Fertiliser on Chlorophyll Content

Leaf chlorophyll content reflects the difference in plant nutritional status. A variation in the chlorophyll content was observed among treatments. In general, fertilised plants showed have more chlorophyll than the unfertilised one, indicating that blood-and-bone fertiliser can increase the chlorophyll content, thus improving the photosynthetic capacity. The most promising results shown in Treatment C. Likewise, this can be attributed to the N content within the fertiliser. N influence the production of the chlorophyll molecule through the chloroplast production (Mu et al., 2021). This will result in greener leaves and greater photosynthetic activity (Momtaz et al., 2021).

Other than that, chlorophyll content also is associated with biomass production. Apparently, chlorophyll plays a major role in photosynthesis carbohydrate formation via carbon dioxide fixation. So, plants with higher chlorophyll concentrations will have better growth rates and biomass. Similar findings were reported in other studies where increase SPAD values are parallel with application of nitrogen fertiliser (Pohan, 2021). The findings suggest blood-and-bone fertiliser improved the nutrient and physiology of the water spinach.

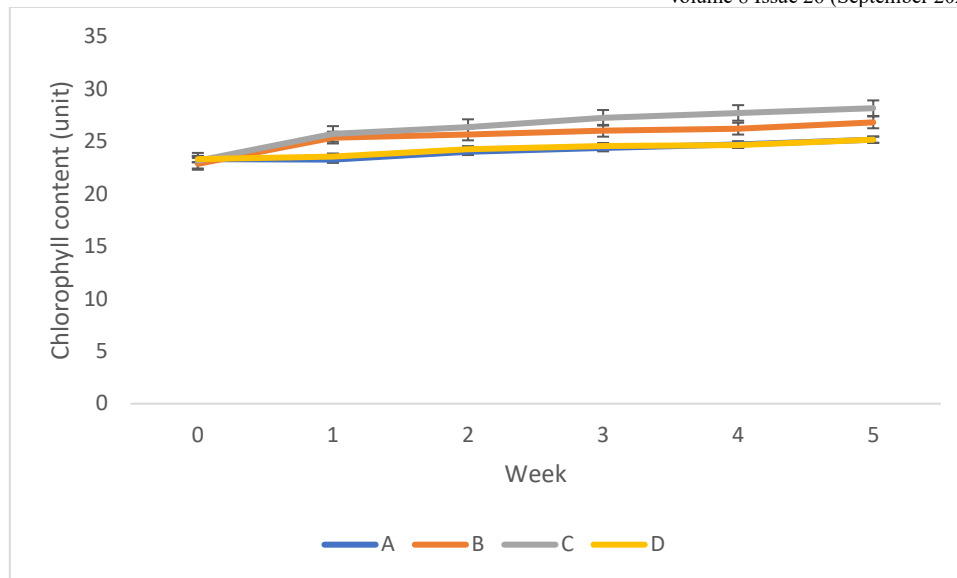


Figure 2: Chlorophyll Content over Five-Week Course under Four Different Treatments

Effects on Root Development and Biomass Accumulation

Root length and biomass are important parameter in studying the effectiveness of the fertiliser application. It reflects the nutrient absorption efficiency. This study showed positive results with the fertilised treatments compared to the control treatment. This can be attributed to the P present within the fertiliser. P is very important for the energy transfer, root growth and elongation (Liu, 2021). Plant equipped with adequate P usually grew more extensive root systems (Liu, 2021). Root growth supports the leaf development and biomass.

Dry biomass is influenced by the photosynthetic rate, respiration rate and nutrient utilisation throughout the period. In general, fertilised treatments showed better in nutrient availability to support carbon fixation in photosynthesis. Similar responses have been reported in studies involving organic amendments, where improved soil fertility and nutrient availability resulted in increased biomass production in leafy vegetable crops (Pohan, 2021).

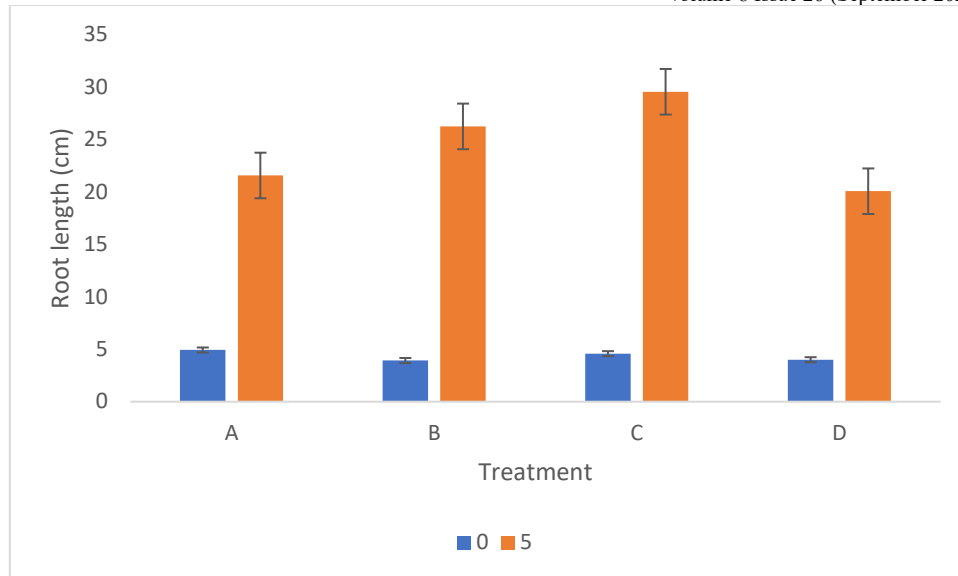


Figure 3: Root Length under Four Different Treatments

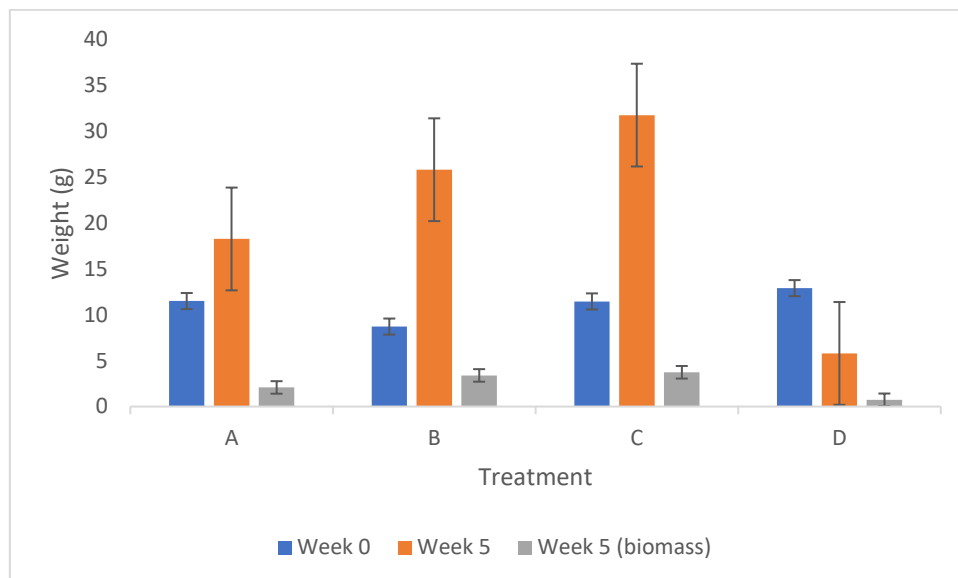


Figure 4: Dry Biomass under Four Different Treatments

Soil pH response to Blood-and-Bone Fertiliser Application

Soil pH is measured as to study the relationship in fertiliser affecting the soil chemical properties. The results showed variation in pH among treatments showing that fertiliser influence the soil environment. Unlike the synthetic fertiliser that affect the soil pH, organic fertiliser exerts a buffering effect on the soil due to the slow nutrient release (Abebe et al., 2022). Also, the presence of Ca in the fertiliser helps in maintaining the soil pH by neutralising it. A favourable pH range not only enhance the nutrient uptake efficiency to promote plant growth, but also improve the soil health in general.

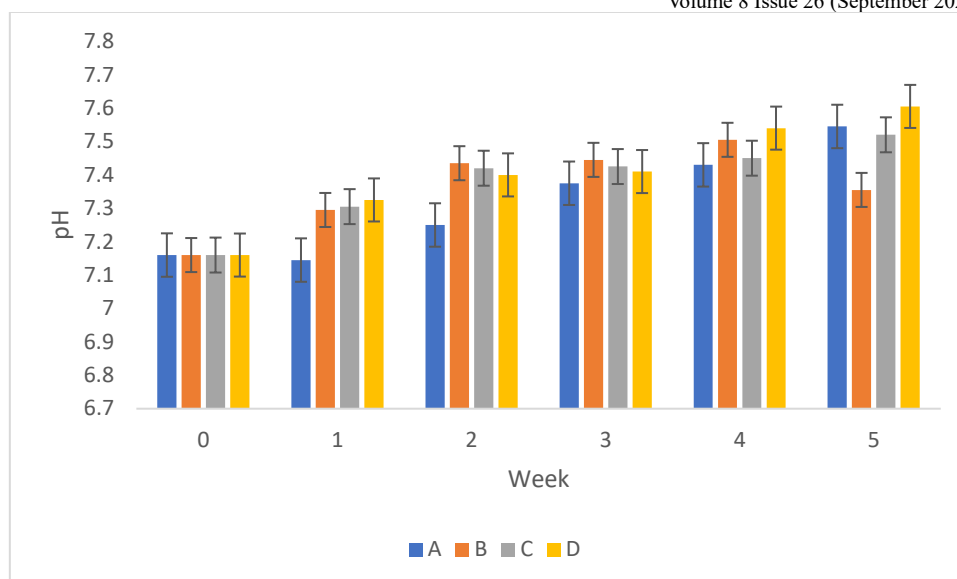


Figure 5: Soil pH over Five-Week Course under Four Different Treatments

Conclusion

This study evaluated the different application rates of blood-and-bone fertiliser on the growth performance of water spinach. Growth was evaluated through plant height, chlorophyll content, root length, biomass and soil pH. The findings demonstrated that Treatment C showed the best results for all parameters compared to the unfertilised control suggesting the potential usage of blood-and-bone fertiliser for water spinach. It is high likely from the contribution of major nutrient such as N, P and Ca from the fertiliser that affect the chlorophyll formation, root growth, nutrient uptake and productivity in general. This can be a good option to a more environmental-friendly and sustainable fertiliser in agricultural practice. Utilising animal by-product supports the circular economy and contributes to sustainable crop production by improving the agricultural waste management.

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