

**UTILIZATION OF AVAILABLE ONLINE-BASED ORGANIC
FERTILIZERS ON THE VEGETATIVE GROWTH OF
WATER SPINACH**



A THESIS

BY

MAHBUBA ALAM ANNY

STUDENT NO. 1601385

SESSION: 2022-2023

SEMESTER: JANUARY-JUNE 2023

MASTER OF SCIENCE (M. S.)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

DINAJPUR-5200

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DEDICATION

All the credits for the success of this study go to my beloved parents and respectable teachers who have been encouraging and helping me to reach at the stage where I am now, and what I want to be in the future. Their blessings are always invaluable to me.

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The authoress

ABSTRACT

The experiment was conducted at the shade besides Academic building-1 of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, from November 2022 to March 2023 to study the utilization of available online-based organic fertilizers on the vegetative growth of water spinach. The experiment was laid out Completely Randomized Design (CRD) with 8 treatments and 3 replications. A total of 24 experimental pots were used. Every treatment used as 1% Kg^{-1} soil. There were eight treatments as follows: T_1 = Control (only soil), T_2 = 1% Bonemeal Kg^{-1} soil, T_3 = 1% Cowdung Kg^{-1} soil, T_4 = 1% Neem cake Kg^{-1} soil, T_5 = 1% Oyster shell powder Kg^{-1} soil, T_6 = 1% Cocopeat Kg^{-1} soil, T_7 = 1% Vermicompost Kg^{-1} soil, T_8 = 1% Egg shell powder Kg^{-1} soil. The results showed that the vegetative growth and yield attributing components such as plant height, number of leaves plant^{-1} , fresh shoot biomass, dry shoot biomass, fresh root biomass, dry root biomass responded significantly except plant and no of leaves at early stages due to the application of available online based organic fertilizers. The highest values of different parameters such as plant height (12.40 cm) in T_5 treatment at 50 DAS considered as best time of economic yield, fresh shoot biomass (30.95 g) and dry shoot biomass (4.64 g) in T_6 treatment due to 1% cocopeat Kg^{-1} soil application, fresh root biomass (2.27 g) and dry root biomass (0.34 g) was obtained in T_3 treatment where 1% Cowdung Kg^{-1} soil were applied. The lowest results were found in the control treatment (T_1). A significant increase in the N contents in leaves, shoots and roots as well as their uptake were observed due to the different treatments. Treatment T_6 performed the highest yield as a result of 1% cocopeat Kg^{-1} soil application. Treatment T_5 composed of 1% Oyster shell Kg^{-1} soil gave the highest post-harvest soil pH and available S. The highest total N, available P, exchangeable K and OC noticed in T_7 (0.04), T_2 (25.30), T_6 (0.19) and T_4 (0.97), respectively might be better for sustainable soil health for growing crops. Overall result suggested that incorporation of 1% cocopeat Kg^{-1} soil can be better for cultivation of Water spinach in respect to higher yield response and might be efficient cultivation.

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LIST OF ABBREVIATIONS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
Analysis of Variance	ANOVA
Arbuscular Mycorrhiza	AM
Bangladesh Agricultural Research Institute	BARI
Blossom End Rot	BER
Branch Length	BL
Centemeter	cm
concentration	Conc.
Completely Randomized Design	CRD
Coefficient of Variance	CV
Cowdung	CD
Commercial Manure	CM
Cow Manure Derived Vermicompost	CMV
Chemical Fertilizer	CF
Degree Celsius	°C
Duck Manure	DM
Days After Sowing	DAS
Etcetera	etc.
And others	<i>et.al.</i>
Exempli gratia (by way of example)	<i>e.g.</i>
Food and Agricultural Organization	FAO
Farmer's Practice	FP
Farm Yard Manure	FYM
Gram (s)	g
Gross Domestic Product	GDP
Gypsum Requirement	GR
Highest Calcareous Soil	HCL
Horticulture	Hort.

International Unit	IU
Per Hectare	Ha ⁻¹
Kilogram	kg
Least Significant Difference	LSD
Lowest Calcareous Soil	LCS
Milligram	mg
Millimeter	mm
Meter	M
Marketable Shoot Biomass	MSB
Non significant	NS
Sodium Chloride	NaCl
Nitrogen, Phosphorus and Potasium	NPK
Organic carbon	OC
Organic matter	OM
Plant Height	PH
Poultry Manure	PM
Parts Per Million	ppm
Recommended Fertilizer	RF
Standard Error of Mean	SEM
Ton	t
Triple Super Phosphate	TSP
Vermicompost	VM

CHAPTER I

INTRODUCTION

Water spinach (*Ipomoea aquatica*) is a vascular semi-aquatic plant native to tropics and subtropics that grow wild and sometime cultivated in Southeast Asia, India and Southern China (Gothberg *et al.*, 2002). Water spinach is an herbaceous perennial plant belonging to the family Convolvulaceae. It has a long, hollow and viny stem, grow prostrate or floating and the roots are produced from the nodes and penetrate into wet soil or mud. The leaf shape ranges from sagittate to lanceolate. Water spinach has been recognized as rich source of micronutrients (minerals and vitamins) and antioxidants (Kala and Prakash, 2004). The roles played by Water spinach particularly during food shortage could probably be due to its being the first edible plant part to grow coupled with relative abundance compared to other plant parts used as a food item. This important feature demonstrated by the wild leafy vegetable attracts a lot of scientific research so as to assess their nutrients content. (Gupta *et al.*, 2005).

Rapid urbanization, natural disasters, global warming, as well as the uncontrolled use of chemicals and pesticides have all taken a toll on the fertility of the soil. Additionally, soil productivity has significantly reduced, soil fertility has declined, and the amount of land available to each person has decreased (Lehman *et al.*, 2015). Changing climate, increasing temperatures, regular dry spells, and the uncertainly of the meteorological conditions are just a few of the challenges to the watershed's water resources. Excessive usage of water for irrigation, unchecked contamination of water, as well as a declining trend in groundwater levels are just a few of the menaces to the watershed's water resources (Bhanja *et al.*, 2018). By 2050, the population is expected to reach 8.9 billion and the world has to produce 50% more food, thereby requiring an additional arable land that is simply not available (FAO, 2020). It is postulated that by 2050, the amount of arable land per capita will be less than 0.20 hectares, which is less than a third of what it was in 1970 (FAO, 2011). Consumers demand for organically grown vegetables is markedly increasing all over the world for both domestic and export markets. Several studies evidenced that using organic fertilizer effectively maintains soil fertility coincidence to enhance crop productivity. Organic fertilizer contains a high level of macro elements such as N, P, and K.

Application of inorganic fertilizer had been conducted to increase the yield of crop production. Unfortunately, the use of inorganic fertilizer alone may cause problems to human

health and the environment. The complementary use of organic and inorganic fertilizer has been recommended for sustainable crop cultivation. Combination application of organic and inorganic fertilizers had been conducted to enhance crop productivity worldwide. However, to minimize the cost of fertilizing and using renewable forms of energy, resuscitated organic manure application might have to be considered (Ayoola and Adeniran, 2006).

Using organic and environmentally-friendly compounds in agricultural practices is satisfied globally. The crucial part of organic farming is increasing yield and quality controls nutrient balance (Abo-Sedera *et al.*, 2016). In Bangladesh, there are various organic fertilizers commonly used by farmers to improve soil fertility and enhance crop growth. Some of these organic fertilizers notable among the fertilizers are Organic Vermi Compost, Special Bonemeal Fertilizer, Egg Shell Powder, Cowdung Powder, Neem cake, Oyster shell powder, Cocopeat, etc. Compost is a rich source of organic matter. Soil organic matter plays a vital role in sustaining soil fertility and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physicochemical and biological properties of the soil (FAO, 2002). The term vermicomposting refers to the use of earthworms for composting organic residues. Earthworms can consume practically all types of organic matter and they can eat their own body weight per day, e.g., 1 kg of worms can consume 1 kg of residues every day. The excreta (castings) of the worms are rich in nitrate, available forms of P, K, Ca and Mg. The passage of soil through earthworms enhances the growth of bacteria and actinomycetes. Actinomycetes develop well in the presence of worms and their content in worm casts is more than six times that in the original soil (FAO, 2002). Cowdung has long been found as perhaps the most desirable animal manures because of its high nutrient and organic matter content. Addition of Cowdung increases the organic carbon content of degraded soil which may lead to the increasing activity of beneficial soil microorganisms as well as the fertility status of soil by increasing the availability of nutrients for the plants from soil. Cowdung significantly increased the growth and yield of plants (Mehedi *et al.*, 2011). Coco dust is considered as most easily available and cheap soilless substrate for plant growth (Asaduzzaman *et al.*, 2020). Coco dust can be used as the soil amendment under varied soil conditions for improving the physical, chemical and biological properties of soil. It is a good source of mulch for increasing the water holding capacity and reducing the weed population (Solaimalai *et al.*, 2001). Bonemeal powder is an animal-origin waste and a by-product of cattle slaughterhouses. It is produced from defatted, dried animal bones that are ground to a fine powder. It has the potential to play a role of promoting growth and providing immunity

in plant system thereby confers resistance against pest and disease (Srinivasan *et al.*, 2021). More importantly, Bonemeal powder protects plants under adverse weather conditions. It also helps plant to attain maturity quickly (Srinivasan *et al.*, 2021). Cocopeat has excellent water-holding capacity, and it can retain moisture and release it gradually to the plants' roots. This property helps in maintaining consistent soil moisture levels, which is crucial for plant growth (Singh and Thind, 2017). Cocopeat can hold and release essential nutrients gradually, reducing nutrient leaching and wastage. Eggshells are primarily composed of Ca carbonate, which is a valuable source of Ca for plants. Ca is essential for cell wall development, nutrient uptake, and overall plant health (Salachna *et al.*, 2015). Eggshell powder gradually releases Ca into the soil, providing a long-term source of this essential nutrient for plant uptake (Nwachukwu *et al.*, 2014). Oyster shell powder gradually releases Ca into the soil, providing a long-term and consistent source of this essential nutrient for plant uptake. Adequate Ca is essential for cell wall structure and overall plant health (Wozniak *et al.*, 2018).

Practice of rooftop farming in cities has seen a significant rise due to its potential to enhance local food production, reduce urban heat island effects, and improve air quality. It provides an opportunity for urban residents to reconnect with nature and foster a sense of community while promoting sustainable, local food sources in densely populated areas. As concerns about food security and environmental sustainability continue to grow, the trend of roof farming is likely to persist and expand, contributing to a more resilient and eco-conscious urban landscape, but in this case there is a problem, Organic fertilizers are readily available in rural areas but not in urban areas. That's why people in the city find it easier to buy organic fertilizer online and some online websites and Facebook pages have taken this opportunity. Notable among them is daraz.com.bd. where many small traders are selling their manufactured organic fertilizers in packaged form and are getting good response from the buyers. That is why this study was conducted to observe the following objectives:

1. To know the effects of different online-based organic fertilizers on the vegetative growth of water spinach.
2. To find out the postharvest soil properties after using organic fertilizers.

CHAPTER II

REVIEW OF LITERATURE

Water spinach is one of the popular and important leafy vegetable throughout the tropic and subtropics and also Bangladesh. The crop has received much concentration by the researchers on various aspects especially application of manure and fertilizers. Many studies in relation to different aspects such as pest control, seedling age, planting geometry, fertilizers and irrigation management for different vegetables have been carried out in Bangladesh and as well as many countries of the world, but for the different aspect of gardening with organic fertilizer for water spinach production the conducted research is rare. This research was conducted to identify the effects of different soil mixture on water spinach in rooftop garden as well as to analyze the effect of different plant growing medium on them with their best possible interaction. Different research work in this aspect has been reviewed below.

2.1 Effect of Cowdung on growth and yield of water spinach

Kashem and Sing (2001) conducted a experiment to investigate the effect of cow manure, city waste, chicken manure and TSP on the growth of water spinach (*Ipomoea aquatica*) and the Phyto availability of phosphorous (P) in soil. The highest leaf number, maximum height, dry weight of shoot and root were obtained with the cow manure treatment of 800 mg P kg⁻¹ and lowest with the control (T₀). These results imply that cow manure could be recommended to use in the agricultural field for producing optimum yield when no additional chemical fertilizers are applied.

Iskandar (2003) conducted an experiment where the effect of Chicken manure, cow manure, and compost in vegetables and the use of manure in vegetables conferred positive results. Those were used to improve soil amendment and vegetable crop yield. Ade Oluwa *et al.* (2009) conducted an experiment to evaluate urine and neem (*Azadirachta indica* L.) as alternative sources for mineral fertilizers in fortifying organic fertilizer (OF) made from Cowdung and market waste compost, and OF fortified with urea and Bonemeal [organo-mineral fertilizer (OMF)], for yield and growth of green amaranth. Fifteen treatments, based on the percentages of N supplied, were NPK15-15-15, OMF, OF, urine, neem and ten treatments of 50, 60, 70, 80 or 90% OF supplemented with a total of 50, 40, 30, 20 and 10% urine or neem, respectively, to provide a total application rate of 100 kg N ha⁻¹, with no fertilizer treatment as a control. Planting was done in two successions (main with fertilizer

treatments and residual without further application). The fertilizer sources and levels had significant effects on plant height, number of leaves, stem girth, fresh weight and dry weight. The residual effects were also significant for plant height, number of leaves, total fresh and dry weights. Forty percent N urine amendment of the OF produced the highest total fresh amaranth biomass (269.3 g plot⁻¹ main effect and 110.8 g plot⁻¹ residual effect), which was significantly better than the values of (140 and 35.3 g plot⁻¹, respectively) obtained with respect to OMF during main planting and NPK during residual planting. Results of our study reveal that 40% N urine fortification was a viable substitute for synthetic fertilizers in production of amaranth, and that urine and neem cake can be alternatives to mineral fertilizer for crop production.

2.2 Effect of Vermicompost on growth and yield of water spinach

Hoang *et al.* (2005) studied to evaluate the response of water spinach to fertilization with increasing levels of nitrogen (0, 10, 20, 30, 40, 50, 60 kg N ha⁻¹ over 28 days) in the form of earthworm compost or urea. The biomass yield response to fertilizer N was positive and curvilinear and was greater for the earthworm compost at the higher levels of application of N. Increasing application of fertilizer N provoked linear responses in DM content, which decreased, and in crude protein content, which increased. Soil fertility was improved by the worm compost, but not by urea, as measured by the organic matter, phosphorus and potassium contents of the soil at the end of the trial. It appears that the most economical level of N is 40 kg ha⁻¹ applied over the 28day growth period.

Surrage *et al.* (2010) revealed that Forterra Royal GRO 1 (GRO 1; coconut coir/vermicompost) and Forterra Royal GRO 2 (GRO 2 aged pine bark/ coconut coir/vermicompost) attained significantly higher marketable yields plant⁻¹ compared with the plants grown in RW. A similar trend was seen in the incidence of Blossom End Rot (BER) with GRO 1 and GRO 2 having reduced numbers of BER incidences per plant when compared with RW. In conclusion, the addition of vermicompost to organic growing substrates is beneficial for tomato growth and yield.

Bhat *et al.* (2013) studied a suitable growing substrate for organic greenhouse vegetable production. A number of combinations of vermicompost, coco-peat, sphagnum peatmoss, perlite, farmyard manure and avicumus were compared with ready-to-use organic substrate for producing tomato, cucumber and capsicum under greenhouse conditions. Vegetative growth parameters (average plant height, number of leaves, chlorophyll index) and fruit yield

plant⁻¹ were used to evaluate various growing substrates. Overall, substrates containing vermicompost, coco-peat, perlite and sphagnum peat moss (2:1:1:1 or 1:1:1:1 v/v) produced significantly better growth, yield and quality in tomato, cucumber and capsicum than other substrate combinations and in some cases were better than ready to use mixes and conventional soil based growing system.

Shilpi *et al.* (2014) conducted an experiment at 1-Lorticultural Research Farm to study the effect of different doses of organic manures and inorganic fertilizers on growth, yield and quality of brinjal. The experiment consisted of different doses of FYM (100, 75, 50 and 25 %), Vermicompost (100, 75, 50 and 25 %) and Neem cake (100, 75, 50 and 25 %) along with recommended dose of fertilizer. The result showed that the yield attributing parameters were recorded maximum in terms of fruit length (22.33 cm), fruit diameter (4.88 cm), fruit weight (123.11 g), number of fruits plant⁻¹ (16.66), fruit yield plant⁻¹ (2.05 k g), fruit yield plo⁻¹ (32.80 k g) and fruit yield ha⁻¹ (75.93 ton) under 25% RDF+ 75% Neem cake while, all the yield and yield attributing parameters found minimum under control.

Sharma *et al.* (2014) studied the treatments consisting of two levels of vermicompost (0, 2.5 t ha⁻¹), three levels of potassium (0, 10 kg ha⁻¹, 20 kg ha⁻¹) and three levels of iron (0, 20 kg ha⁻¹, 40 kg ha⁻¹) were applied to crop *Trigonella foenumgraecum* var Rmt-1 as soil application. Results showed that application of vermi-compost, potassium and iron individually and in combination significantly influenced the yield attributes and yield of the crop during both the years.

Salwa (2018) conducted the experiment to observe the effect of vermicompost and plant vitalizer (hb-101) on growth and yield of red cabbage consisting of two factors: Factor A: Vermicompost (3 levels) as- Vr: No vermicompost (control condition); Vr₁: 4 ton vermicompost ha⁻¹ Vr₂: 8 ton vermicompost ha⁻¹; and Factor B: Plant vitalizer (4 levels) as- Vi₀: No vitalizer (control condition), Vi₁: 2 ml vitalizer l water⁻¹, Vi₂: 4 ml vitalizer l water⁻¹ and Vi₃: 6 ml vitalizer l water⁻¹. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different levels of vermicompost and plant vitalizer influenced significantly on most of the recorded parameters. In the case of different levels of vermicompost, the highest marketable yield (52.30 t ha⁻¹) was observed from Vr₂ treatment, while the lowest (38.47 t ha⁻¹) from Vr₀ treatment. For different levels of plant vitalizer, the highest marketable yield (51.62 t ha⁻¹) was found from Vi₃, whereas the lowest (39.62 t ha⁻¹) from Vi₀ treatment. The highest marketable yield (33.83 t ha⁻¹) was observed

from Vr₂Vi₃, while the lowest (58.77 t ha⁻¹) from Vr₀Vi₀ treatment combination. The highest benefit cost ratio (2.64) was found from Vr₂Vi₃ and the lowest (1.67) was obtained from Vr₀Vi₀. So, combination of 8 ton vermicompost/ha and foliar application of 6 ml vitalizer l water⁻¹ may be used for red cabbage cultivation.

Ferdause (2020) experimented that the application of vermicompost interaction with carrot cultivars for higher growth and yield of carrot. The experiment consists of two factors. Factor A: Three carrot Cultivar, C₁: CRS-016, C₂: New kuroda and C₃: Sangal. Factor B: four levels of vermicompost, V₀: 0 t ha⁻¹, V₁: 6 t ha⁻¹, V₂: 10 t ha⁻¹ and V₃: 14 t ha⁻¹ were used for the present study. Results showed the highest yield of carrot (19.84 t ha⁻¹) was found from Sangal cultivar and lowest yield (16.52 t ha⁻¹) was found from CRS-016. For different levels of vermicompost, the highest yield of carrot (25.35 t ha⁻¹) was found from V₂ (10 t ha⁻¹) treatment and the lowest yield (12.55 t ha⁻¹) was found from V₀ (control) treatment. In case of combined effect, the highest yield of carrot (29.60 t ha⁻¹) was produced from C₃V₂ (Sangal and 10 t ha⁻¹) treatment combination and the lowest yield (11.46 t ha⁻¹) was found from C₁V₀ (CRS-016 and control) treatment combination. From the treatment combination of Sangal with 10 t ha⁻¹ vermicompost appeared to be the best for cultivation of carrot.

Tabassum (2020) investigated the influence of vermicompost on growth and yield of kohlrabi cultivars during the period from October 2018 to January 2019. The experiment consisted of two factors: Factor A: three kinds of cultivar (V₁= Quick star, V₂= White Vienna, V₃= Early 005), Factor B: Four levels of vermicompost (M₀= Control, M₁= 6 t ha⁻¹, M₂= 8 t ha⁻¹, M₃= 10 t ha⁻¹). The experiment was performed with Randomized Complete Block Design with three replications. The results indicate that the morphological parameters and the reproductive components, as well as yield were influenced significantly among the treatments. By applying vermicompost (M₃) maximum yield per hectare was found (13.12 t ha⁻¹) in White Vienna (V₂) and minimum (7.00 t ha⁻¹) in Early 005 (V₃). In the case of interaction effect maximum yield per hectare (16.29 t ha⁻¹) was obtained from V₂M₃, while minimum (6.48 t ha⁻¹) was obtained from the V₃M₀. So, it can be concluded that applying M₃ = 10 t ha⁻¹ vermicompost among three cultivars white Vienna gave the highest yield.

2.3 Effect of Coco dust on growth and yield of water spinach

Reddy and Mallareddy (2004) studied the acclimatization of 4 parwal (*Trichosanthes dioica*) genotypes, i.e. Swarna Alaukik, elite selection-1, Swarna Rekha and male, studied in different substrates, i.e. vermiculite, soilrite, cocopeat, coco-peat+sand in 3:1 and 2:2 ratio, and sand+vermiculite+ coco-peat in 1:1:1 ratio, in the greenhouse. Swarna Alaukik recorded the highest survival percentage (89.94%), followed by elite Selection-1 (85.71%) and Swarna Rekha (81.42%), in coco-peat, whereas Male survived better in vermiculite (64.28%). Shoot length (10.06 cm) and number of leaves (7.97) were higher in coco-peat than in any other substrate after 28 of growing period.

Arcidiacono *et al.* (2005) conduct trial on different substrates for soilless cultivation in an open system were compared. The experimental protocol includes three randomized blocks made of six rows of pots filled with six different substrates: Etna lapillus, expanded clay, perlite, peat, cocopeat, and sand. Then, tomato plants were planted in each pot. In the central pot of each row, thermo-resistance probes were installed at different locations in the substrates in order to monitor the temperature of the media. The total solar radiation, the air temperature and relative humidity were measured inside and outside the greenhouse. The net radiation was also measured inside the greenhouse just above the substrates. The effect of the nature of the different substrates on their thermal regimes was examined on the basis of the collected data. Moreover, the connections between the substrate temperatures and the microclimatic variables were analysed.

Botrini *et al.* (2006) studied the growth rate and quality of tomato seedlings grown on 2 cocopeat growth media, with organic ferti irrigation, and the effects of these techniques on seedling development after transplanting were evaluated. The daily increase in fresh weight and height of seedlings grown on cocopeat supplemented with borlanda and natural fertilizers were similar to those of seedlings grown with a traditional system based on peat and synthetic fertilizers. At the time of transplanting, the qualitative parameters of the seedlings were the same for the traditional growth system and the organic system based on cocopeat with borlanda and natural fertilizers.

Engida *et al.* (2007) studied high heritability and expected genetic advances were recorded for vine length, vine inter node length, leaf area, above ground fresh and dry weights, number of storage root plant⁻¹, individual storage root weight, storage root fresh yield plant⁻¹.

Hegde and Reddy (2012) study the rapid regeneration protocol of brinjal was conducted. The shoot tip and hypocotyl explants from the in vitro grown sterile seedling were used for regeneration. In hardening, the highest survival percentage (100%) and healthy growth of plantlets were observed in mixture of vermiculite, farmyard manure and coco-peat in 1:1:1 ratio.

Bohme *et al.* (2014) reported that the spinach yield was on average approximately 20% higher on rock wool than on coco-peat mainly due to a higher number of fruits harvested but the fruits on rock wool were also longer than on coco-peat. Regarding the quality in the fruits grown on coco peat a higher mineral content, in particular K, P and Mg, was determined. In both substrates there are significant differences between the genotypes of bitter gourd.

Nunal *et al.* (2014) conducted the effectiveness of cocopeat and rice hull powder obtained from agricultural wastes as bio-carriers for an oil-degrading bacterial consortium. Scanning electron microscopy revealed colonization and strong attachment of bacterial cells on the surface of both carriers. Results of a 60-day in vitro seawater bioremediation trial showed significant oil reduction and high cultivable bacterial counts in treatments augmented with the carrier-attached bacterial consortia compared to treatments supplemented with the same consortium in free living and encapsulated forms. Significant degradations in both aliphatic and aromatic fractions were obtained in treatments augmented with carrier-immobilized consortia. The developed immobilized cells showed sustained activities and viabilities during storage for six months. Results of this study demonstrated that inexpensive waste materials can be utilized as biocarriers of an oil-degrading consortium and that immobilization on bio carriers can enhance the bioremediation of oil contaminated seawater.

2.4 Effect of Bonemeal on growth and yield of water spinach

Genisel *et al.* (2012) lead the study to determine the effects of BP on dry weight and contents of total chlorophyll, soluble protein and sugar as indicators of physiological response in the leaves. For this purpose, bone powder solutions (BPS) were prepared at different concentrations (0.5%, 1%, 1.5% and 2%) and applied to growing media of the 10-day wheat seedlings. Afterward, the 14-day seedlings were harvested, and the effects of BPS on plant response were determined. The results showed that BPS treatments significantly stimulated dry weight and contents of total chlorophyll, protein and sugar compared to control seedlings. The best stimulatory effect of BPS was determined at 1% concentration. According to these

results, it is possible to say that BP may be used to meet the inorganic element requirements of plants in poor soils and hydroponic systems.

Erdal (2012) elucidated the effectiveness of inorganic element composition (except for Ca and phosphorus) of bone powder (BP) on some morphological (root and shoot length and dry weight) and biochemical (protein, sugar, chlorophyll, and inorganic element contents) parameters in bean seedlings. For this, BP was compared with Ca phosphate (CP), which is used as Ca and phosphorus source. Bone powder solutions (BPS) (0.5, 1, 1.5, and 2%) and CP solution (0.1 M) were applied to growing media of 12-day bean seedlings. Seedlings were harvested on the 20th day. Both BPS and CP treatments significantly stimulated plant growth and increased dry weight, pigment, protein, and sugar contents compared to control seedlings; however, BPS treatments were found to be more effective than CP treatment. The best stimulatory effect on plant growth was determined at 1.5% concentration of BPS. Besides, BP treatment significantly increased contents of K, S, Fe, Zn, Mg, Mn, and Cu compared to control and CP- treated seedlings. This result clearly elucidated that the other elements existing in structure of BP also participated in plant structure, and they played important roles on growth and development in bean seedlings. It is possible to say that BP may be used as an important source of the other inorganic elements as well as Ca and P in agriculture studies for improving plant growth and productivity. This is the first report revealing the effect of BP on inorganic element content of plants.

Nogalska *et al.* (2013) carried out a two-factorial field experiment with a randomized block design, in north-eastern Poland to determine the effect of increasing doses of Bonemeal applied every second year as an organic fertilizer on maize (*Zea mays* L.) grown for grain. Experimental factor I was meat and Bonemeal (Bonemeal) dose (2.0, 3.0, 4.0, and 5.0 Mg ha⁻¹ applied every second year), and experimental factor II was the year of the study (two consecutive years). Increasing Bonemeal doses applied every second year increased maize grain yield and improved grain plumpness, in comparison with mineral fertilization. The highest yield-forming effect was observed when Bonemeal was applied at 3 Mg ha⁻¹. Macronutrient uptake by maize plants and macronutrient concentrations in maize grain were affected by the year of the study rather than Bonemeal dose. The results of a 2- year experiment indicate that Bonemeal is a valuable source of N and P for maize grown for grain, and that it is equally or more effective when compared with mineral fertilizers.

2.5 Effect of Neem cake on growth and yield of water spinach

Eifediya *et al.* (2015) investigated that the influence of neem cake on the growth and yield of various vegetable crops, including green leafy vegetables like spinach. It reported positive effects on plant growth, pest control, and overall crop yield. The use of neem cake, a byproduct of neem seed oil extraction, as a soil conditioner and fertilizer can have various effects on the growth of green leafy vegetables. While scientific studies specifically focused on the effects of neem cake on green leafy vegetables may be limited, there are studies on the broader effects of neem cake on vegetable crops and soil properties that can provide insights. Here's a reference related to the impact of neem cake on vegetable crops:

2.6 Effect of Oyster shell powder on growth and yield of water spinach

Maragou *et al.* (2012) assessed that the influence of oyster shell powder on the growth and yield of vegetable crops. It reported positive effects on plant growth, soil pH adjustment, and increased Ca availability.

Diallo *et al.* (2015) focused on the influence of oyster shell powder on nutrient uptake in corn. It discusses how oyster shell powder affected the availability and uptake of essential nutrients by corn plants.

2.7 Effect of Egg shell powder on growth and yield of water spinach

Arabhosseini and Faridi (2007) stated that, the eggshell has been attracted as an alternative liming source in agricultural production. Eggshells present healthy, balanced Ca due to their trace amounts of other minerals and are probably the best natural source of Ca. Eggshells contain up to 95% Ca carbonate and various macro and micro-nutrients such as magnesium, potassium, iron, and phosphorus. Therefore, eggshells are also good for plant growth, stimulate root development, and can be reused to make fertilizers. Application of eggshell powder on several crops (such as cowpea, red chili, tomato, etc.) showed better growth and yield. In the development of Vietnam's livestock, egg production and consumption continuously increase up to a total of 473.660 tons in 2020 (Faostat, 2020). It will bring out the huge potential to produce and use eggshell powder as an alternative Ca source for agricultural production.

Marschner (2012) conducted that, Ca (Ca) plays an important role in plant growth and yield because it is as a structural component of the cell wall, a regulator of cell homeostasis, an enzyme activator, and participates in ion absorption. Compared to other crops, groundnut has

high Ca requirements for both vegetative growth and healthy pod development. The Ca deficiency possibly causes a lower yield in groundnut production and leads to a high percentage of aborted seeds (empty pods or pops) and improperly filled pods enough Ca around groundnut pods leads to increased yield, oil content, and protein content of the kernel. However, Ca does not show improvements in the yield of groundnut when the soil has adequate Ca. Over-application of Ca even causes an imbalance in plant nutrients which leads to reduce the groundnut yield. Therefore, the appropriate supplement of Ca should be practiced to maintain a high yield in groundnut production.

2.8 Effect of Cowdung on soil properties:

Adekiya *et al.* (2016) conducted a field experiment during the early cropping seasons of 2014 and 2015 at the Teaching and Research Farm of the Federal University of Technology Akure, Ondo State, Nigeria. The soil at Akure is an Alfisol classified as clayey Skeletal Kaoliniticisohyperthermic Oxic Paleustalf or ferric Luvisol. Each year, the experiment was conducted to assess the effect of six levels (0, 2, 4, 6, 8, and 10 t ha⁻¹) of Cowdung on soil physical properties, growth and yield of maize (*Zea mays*). The 6 treatments were arranged in a randomized complete block design and replicated four times. Results show that application of Cowdung increased porosity, moisture content, infiltration rate and maize growth and yield and reduced bulk density, soil temperature and soil dispersion ratio compared with no application of manure. Increasing levels of Cowdung from 0-10 t ha⁻¹ improve these physical properties and maize yield. Application of 10 t ha⁻¹ Cowdung increased the weight of dry grains of maize by 115, 79, 75, 65 and 49 % compared with 0, 2, 4, 6 and 8 t ha⁻¹ Cowdung respectively. Increased total porosity associated with reduction in soil bulk density was found in this study to result in increased water infiltration and retention leading to reduction in soil temperature and higher maize yield. Therefore, regular addition organic matter in forms of manure should be an integral management plan of tropical Alfisol to enhance infiltration rate, reduce bulk density and increase crop performance.

Another study by Ekwealor *et al.* (2020), the application of different rates of Cowdung on the growth of *Solanum lycopersicum L.* grown for six weeks in polyethylene bags. The treatments were done in triplicates which include 30kg of soil uniformly mixed with 5kg, 10kg, 15kg, and 20kg of Cowdung manure and control without (Cowdung) manure. Each treatment was replicated three times. The data collected were analyzed using a one-way analysis of variance and mean separation by Duncan Multiple Range Test (DMRT). *Solanum lycopersicum* with

the rate of 20 kg ha⁻¹ increased the percentage germination (2.66±2.8), height of plant from (7.66±1.040) in week 1 to (63.26±7.166) in week 6, leaf area from (2.14±1.540) in week 1 to (71.04±7.005) in week 6, stem girth from (1.60±0.264) in week 1 to (4.23±0.251) in week 6 and the number of branches from (3.00±1.000) in week 1 to (14.33±4.041) in week 6 respectively. The control (0kg ha⁻¹) gave the lowest in percentage germination (0.60±0.100%), in height, from (5.06±0.702) in week 1 to (14.50±3.968) in week 6, leaf area from (0.87±0.280) in week 1 to (7.18±4.447) in week 6, in stem girth from (0.50±0.100) in week 1 to (2.43±0.251) in week 6 and lowest in number of branches from (0.00±0.00) in week 1 to (6.00±1.000) in week 6 respectively. Thus, this study alluded that Cowdung can be used to enhance the growth, productivity and yield of tomato in low nutrient soil in the rate of 20kg ha⁻¹ which showed a significant increase in growth and yield of tomato.

2.9 Effect of Vermicompost on soil properties:

Shi-wei and Fu-Zhen (1991) conducted that, vermicompost have large particulate surface areas that provide many micro sites for microbial activity and for the strong retention of nutrients. Vermicompost are rich in microbial populations and diversity, particularly fungi, bacteria and actinomycetes. Due to their different production processes, compost and vermicompost might exhibit different physical and chemical features which might influence plant growth and morphology in diverse ways. Generally, after vermicomposting the organic material is ground up to a more uniform size which gives the final substrate a characteristic earthy appearance while the resulting material after composting has normally a more heterogeneous appearance.

Zende (1998) reported increased yields of sugarcane after amending soils with vermicompost at rates of 5 t ha⁻¹ together with 100% of the recommended application rate of inorganic fertilizers. Mulberry (*Muro ssp*) growth increased after amending soils with vermicompost applied at rates of 10 t ha⁻¹ together with 100% of the recommended application rates of inorganic fertilizers to soils. Flowering of China aster (*Callistephus chinensis* L.) increased when it was grown in soils amended with 10 t ha⁻¹ vermicompost, produced from farm manures, together with 100% of the recommended application rate of inorganic fertilizers. Previous studies showed that the combination of compost with chemical fertilizer further enhanced the biomass and grain yield of crops. Furthermore, positive changes have been reported in the quality of wheat flour, because of increasing the amount of gluten after compost treatment. Further, several examples in the literature show that compost and

vermicompost are able to enhance the growth of a wide range of plant species further what can be expected because of the supply of nutrients.

2.10 Effect of Coco peat on soil properties

Sarath Kumarasinghe *et al.* (2015) studied that, Coconut coir peat (CP) is an organic renewable source which is an environmentally sound substitute for peat as a soilless growing media for containerized nurseries in the world. Coco peat consists of short fiber (3 of water). Fine (≤ 0.5 mm), medium (3 mm - 0.5 mm) and coarse (4 mm $<$) particle ranges were separated using set of sieves. Completely randomized design with five replicates was used. Four separate experiments were conducted for tomato, bell pepper, cucumber and cab-bage. Germination percentage, no. of leaves per seedling and seedling height were recorded as growth parameters during the nursery period. Highest germination percentage of tomato (95%), bell pepper (88%) and cucumber (84%) were observed in medium size particle range and the fine particle range resulted the highest germination value in cabbage (94%). The highest no. of leaves per seedling of tomato (7.2) and bell pepper (6.1) were recorded in medium size particle range and in cucumber (4.8) and cabbage (6.5) the fine particle range gave the highest value. The highest maximum seedling heights of tomato (17.2 cm), bell pepper (20.3 cm), cucumber (14.3 cm) and cabbage (8.0 cm) were observed in medium size particle range media. Overall results revealed that, medium size (3 mm - 0.5 mm) particle range of coco peat is the best for practicing nurseries of tomato, bell pepper, cucumber and cabbage in greenhouse cultivations.

2.11 Effect of Bonemeal on soil properties

Novelo *et al.* (1998), conducted an experiment on the effectiveness of Bonemeal and positively evaluated, soil application is a promising strategy for a sustainable recycling of Bonemeal. In fact, this organic residue contains a large amount of nutritive elements such as N ($\approx 8\%$), P ($\approx 5\%$), Ca ($\approx 10\%$) mainly in organic form or organically bounded and low amounts of K and Mg. The high content of organic matter of Bonemeal has a positive effect on the physical, chemical and microbiological properties of the soil. It may therefore be a useful fertilizer for various crops. soil application of Bonemeal is an agricultural practice permitted by the current European legislation (European Commission, 2002) provided they derived from TSE free animals and were appropriately treated (heating by steam vapour at $133\text{ }^{\circ}\text{C}$ for 20 min and 0.3 MPa) to eliminate any transmissible disease to human and animals. Such a strong thermal treatment makes Bonemeal a safe product regarding possible harmful

hygienic impacts of their utilization as fertilizer. In addition, Bonemeal is among the fertilizers allowed by the European legislation on organic farming. However, the mineralization dynamics of Bonemeal in soil needs to be thoroughly evaluated since it is the main process regulating nutrient availability. In particular, because most of the N in Bonemeal is organically bounded, it is important to investigate N mineralization, the mineral forms in which N can be present in the soil and the processes involved in their transformations for a reliable evaluation of Bonemeal as N fertilizer.

Conesa *et al.*, (2005) revealed that, Bonemeal could be characterized by a significant content of lipids. Lipids are usually extracted from Bonemeal after the thermal treatment because of its potential use in the pharmaceutical industry. However, the extraction process requires sophisticated and expensive equipment and is profitable only if a high and constant amount of Bonemeal is assured for a long time. This makes, under some circumstances, more profitable for rendering companies to produce non-defatted Bonemeal. Addition of Bonemeal with high lipid content to the soil could modify specific soil characteristics such as adsorption processes and hydrological properties, affecting the availability of elements and the normal functionality of microorganisms. Furthermore, lipids represent an anomalous high load of nutritive materials for microorganisms that may cause a shift on microbial populations by favoring those microorganisms that are able to utilize them more rapidly and efficiently. In this perspective, little is known about the influence of lipids on Bonemeal mineralization and microbial equilibria.

2.12 Effect of Neem cake on soil properties

Elnasikh *et al.* (2011) conducted a laboratory experiment to evaluate the effects of Neem seed cake on the main groups of soil microflora and some soil properties. Soil samples were collected from El Rawakeeb Desertification Research Station Farm. Four treatments, replicated three times, were included with the application of 0, 2, 4 and 6 mg of Neem seed cake calculated as 0, 5, 10 and 15% of the basal dose of urea ($40 \text{ mg bottle}^{-1}$). A composition of 60 grams soil, Urea, Neem seed cake and a moisture level of $2/3$ field capacity were incubated at room temperature. After 2, 4, 6 and 8 weeks from incubation soil samples were withdrawn for determination of soil microflora. At the end of incubation, soil samples were taken for determination of exchangeable Ca, iron, manganese, copper and zinc. Another experiment was conducted with the same components and under the same conditions for the determination of electrical conductivity in 1:5 soil water ratio after 1,3,7,9,13 and 19 days.

The results revealed that Neem seed cake positively affected the population of organic nitrogen users and actinomycetes and affected negatively the population of fungi, Nocardia, Bacteroides and the whole population of inorganic nitrogen users which include nitrifying bacteria. On the other hand, it exerted fluctuating effects on Mycobacterium, Micromonospora and Arthrobacter. Moreover, Neem seed cake significantly increased electrical conductivity, exchangeable Ca, iron, manganese, copper and zinc content.

2.13 Effect of Oyster shell powder on soil properties

Lee *et al.* (2008) stated that the Oyster shell, a byproduct of shellfish-farming in Korea and containing a high amount of CaCO_3 , has a high potential to be used as a liming material in agriculture. However, the agricultural utilization of oyster shell is limited due to its high concentration NaCl. The oyster-shell meal collected had a low concentration of water soluble NaCl (mean 2.7 g kg^{-1}), which might be a result of stacking the material for 6 months in the open field. It has a very similar liming potential with Ca carbonate, with 3.4 and 3.8 Mg ha^{-1} for silt loam (SiL, pH 6.2) and sandy loam (SL, pH 5.8) to bring the soil pH to 6.5, respectively. To determine the effect of crushed oyster-shell meal on improving soil chemical and biological properties and crop plant productivity, oyster-shell meal was applied at rates of 0, 4, 8, 12, and 16 Mg ha^{-1} before transplanting Chinese cabbage (*Brassica campestris* L.) in the two soils mentioned above. Soil pH was significantly increased to 6.9 and 7.4 by 16 Mg ha^{-1} shell meal application (4 times higher level than the recommendation) in SiL and SL, respectively, at harvesting stage. The effect of liming was found higher in SL compared to SiL soil, probably due to the different buffering capacity of the two soils. The concentration of NaCl and EC value of soils were found slightly increased with shell meal applications, but no salt damage was observed. Oyster-shell meal application increased soil organic matter, available P, and exchangeable cations concentrations. The improved soil pH and nutrient status significantly increased the microbial biomass C and N concentrations and stimulated soil enzyme activities. With the exception of acid phosphomonoesterase (PMEase) activity, which decreased with increasing soil pH in SL but slightly increased in SiL, the activities of urease and alkali PMEase increased markedly with increasing soil pH by shell meal application. The improved soil chemical and biological properties resulted in increased crop productivity. The highest yield in Chinese cabbage was achieved following the application of 8 Mg ha^{-1} oyster-shell meal. Conclusively, crushed oyster shell could be used as an alternative liming material to restore the soil chemical and microbial properties in upland soil and to increase crop productivity.

2.14 Effect of Egg shell powder on soil properties

Yuki Ohshima *et al.* (2015) found that eggshells have high bioavailability and can be used as a source of Ca. The main component is CaCO_3 , which, when heated, is converted to CaO. Seashells are also mainly composed of CaCO_3 and were previously found to exhibit antimicrobial activity after being heated. In this study, heated eggshell powder (HESP) was found to have antimicrobial activity against bacterial vegetative cells, fungi and bacterial spores. Parameters, such as the minimum inhibitory concentration, were determined with kinetic analysis using an indirect conductimetric assay. Moreover, HESP was able to kill the *Bacillus subtilis* spores. There were no significant differences in the activity between HESP, heated scallop-shell powder and pure CaO. The MIC values for HESP against bacteria and fungi were 0.29-0.43 and 1.3-1.5 mg mL^{-1} , respectively. Against *B. subtilis* spores, a reduction of two orders of magnitude of viability was confirmed following 20 min of treatment at 10 mg mL^{-1} at 60°C. The active oxygen generated from the HESP slurry was examined with chemiluminescence. The intensity of this increased with increasing concentrations of the HESP slurry. This suggests that HESP could be used as a natural antimicrobial agent. Although a high pH is the main contributor to this antimicrobial activity, active oxygen species generated from HESP are likely to be the main antimicrobial agents.

Thang *et al.* (2022) experimented that influence of Eggshell Powder on Soil pH and Nutrient Availability. The use of eggshells as an alternative source of Ca carbonate for groundnut can reduce the impact on the natural reserves of limestone, a non-renewable natural source. This study aimed to investigate the effects of eggshell powder application on the growth and yield of groundnut. The Ca treatments were lime application (A_0) at 500 kg ha^{-1} and four rates of eggshell powder application including A_1 (200 kg ha^{-1}), A_2 (300 kg ha^{-1}), A_3 (400 kg ha^{-1}), and A_4 (500 kg ha^{-1}). Two application times, T_1 (applying 5-days before sowing) and T_2 (applying 5-days after flowering) were employed. The result showed that eggshell powder could be a useful alternative source to supply Ca for groundnut. Application of eggshell powder before sowing resulted in significantly higher pod yield and total Ca uptake with better growth parameters than after flowering. Increasing eggshell powder application rates also increased soil pH and Ca contents, and plant Ca uptake. The application rate of eggshell powder before sowing at the rate of 300 kg ha^{-1} produced the highest pod yield and was suggested to be optimum.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the shade besides Academic building-1 of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, from November 2022 to March 2023. A brief description of the experimental site, characteristics of soil, climate, planting material, soil collection, soil and pot preparation and sowing, experimental design, treatments, fertilizer doses at different treatments, intercultural operations, harvesting, data collection, soil sample preparation, soil analysis and statistical analysis have been described in this chapter.

3.1 Experimental site

The experiment was conducted at the shade besides Academic building-1 of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, from November 2022 to March 2023. Geographically the experimental site was at 25°13' N latitude and 88°23' E longitude with an elevation of 37.5m above the mean of sea level. It belongs to the Agro Ecological Zone (AEZ-1) named Old Himalayan Piedmont Plain.

3.2 Characteristics of Soil

The general characteristics of the soil are presented in Table 3.1-3.3

Table 3.1 Morphological characteristics of the soil of Soil Science Research

Field of HSTU Morphology	Characteristics
Location	Soil Science Laboratory-1, Department of Soil Science, HSTU
AEZ	Old Himalayan Piedmont plain (AEZ-1)
General soil type	Non- calcareous brown floodplain soil
Parent material	Piedmont alluvium
Drainage	Well drained
Topography	Medium high land
Flood level	Above flood level

Table 3.2 Physical characteristics of the soil of soil Science research field of HSTU

Characteristics	Value
Sand (%)	53.20
Silt (%)	29.60
Clay (%)	17.20
Textural class	Sandy loam

Table 3.3 Chemical characteristics of the initial soil sample.

Characteristics	value
Soil pH	6.05
Organic carbon (%)	0.37
Organic matter (%)	0.64
Total nitrogen (%)	0.02
Available phosphorus (ppm)	57.75
Available sulfur (ppm)	12.04
Exchangeable K (m.eq.100g ⁻¹ soil)	0.12
Cation exchange capacity (CEC) (meq 100g ⁻¹)	18.12

Table 3.4: Chemical characteristics of organic fertilizer

Organic Fertilizer	Total N (%)	Available P (ppm)	Exchangeable K (m.eq.100g⁻¹ soil)	Available S (ppm)
Vermicompost	0.01	1.53	9.29	13.97
Bonemeal	0.02	5.59	2.56	8.41
Cowdung	1.19	1.10	0.60	0.30
Neem cake	5.20	1.00	1.40	5.50
Oystershell Powder	0.36	10.38	0.09	7.60
Cocopeat	0.41	0.81	1.32	6.20
Egg shell powder	1.19	0.30	0.14	9.40

3.3 Climate

The experimental area belongs to a subtropical climatic zone which has heavy rainfall, high humidity, high temperature, and a relatively long day period during Kharif season (April-September) and scanty rainfall and low humidity, low temperature, and short - day period during Rabi season (October-March). The experiment was conducted during Rabi season from November 2022.

3.4 Planting material

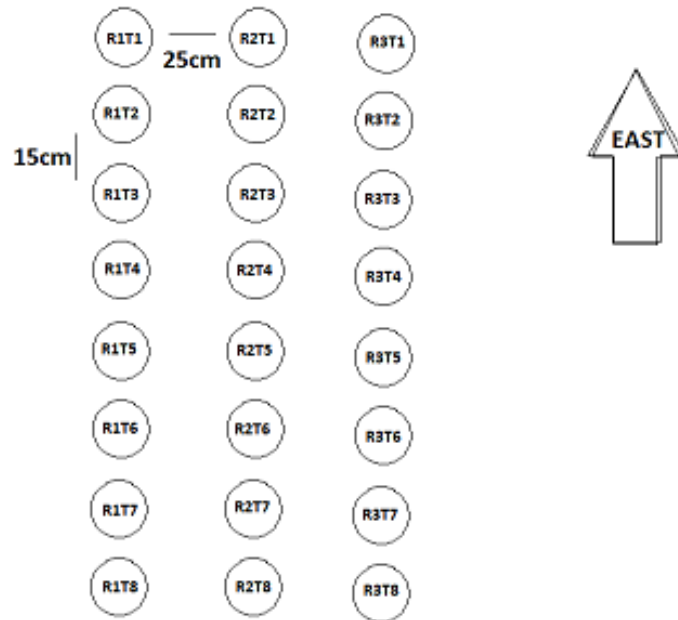
The plant material of the experiment was water spinach (*Ipomoea aquatic* L.). It is an herbaceous aquatic or semi-aquatic perennial plant of the tropics or subtropics. Its leaves are flat, and vary in shape depending on genotype, from heart-shaped to long, narrow and arrow-shaped. Narrow leaves are 1-2.5 cm wide and 20-30 cm long. The large, attractive flowers have the typical open, trumpet shape of convolvulus or bindweed flowers. If the environmental conditions are not extreme, water spinach can grow adaptively and adjust to environmental conditions. In general, water spinach can be harvested four weeks after planting with the water spinach still not showing flowers.

3.5 Soil collection, soil and pot preparation and sowing

Soil was collected from Soil Science Research Field, HSTU, Dinajpur from a depth of 0-20 cm. The collected soil was dried. Weeds and stubbles presented in the soil were removed. Then the all the ingredients such as soil, sand, Cowdung, vermicompost, cocopeat, Bonemeal, neem cake, oyster shell powder, egg shell powder along with other chemical mixed fertilizers i.e. NPKS were well mixed in per pot. The total weight of the soil mixture for one pot was 10 kg. The pots were kept in 7 to 10 days for rest. Then the seeds were collected from Krishi Beej Bhandar, Paurasava Station Road, Dinajpur. Seeds were soaked for 8-12 hours and sown on the pots at 27th November 2022.

3.6 Experimental design

The experiment was laid out Completely Randomized Design (CRD) with 8 treatments and 3 replications. A total of 24 experimental pots were used.



3.7 Treatments and Fertilizer doses at different treatment

Every treatment used as 1% Kg^{-1} soil. There were eight treatments as follows:

T_1 = Control (only soil)

T_2 = 1% Bonemeal Kg^{-1} soil

T_3 = 1% Cowdung Kg^{-1} soil

T_4 = 1% Neem cake Kg^{-1} soil

T_5 = 1% Oyster shell powder Kg^{-1} soil

T_6 = 1% Cocopeat Kg^{-1} soil

T_7 = 1% Vermicompost Kg^{-1} soil

T_8 = 1% Egg shell powder Kg^{-1} soil

In case of inorganic mixed fertilizers, NPKS were also mixed with each treatment mixtures after 1 month of pot preparation as $\frac{1}{2}$ Tea spoon $^{-1}$ Pot $^{-1}$.

3.8 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were followed:

3.8.1 Weeding

The experimental pots were monitored and weeds were removed regularly from the pots.

3.8.2 Irrigation

The experimental pots were monitored regularly and plants were watered whenever necessary.

3.8.3 Thinning

The plants were thinned out for better growth rest of the plants which were selected for final result of the experiment.

3.9 Harvesting

Harvesting was started on 22th February, 2023 and continued harvesting till the plant growth was maximum for use as vegetable. Final harvesting was done on 7th March 2023 to evaluate the yield was harvested at final days after sowing at 100 days. The yield was carefully harvested and carefully weighted each of plant of each pot.

3.10 Data collection

First data collection was done on 22th December 2022. Last data was collected on 7th March 2023. As per objectives of the study, some data were collected in final harvest from randomly selected 3 plants from the 10 plants per pot.

- I. Plant height
- II. Number of leaves plant⁻¹
- III. Fresh shoot biomass
- IV. Fresh root biomass
- V. Dry root biomass

3.10.1 Plant height (cm)

The plant height was measured from randomly selected 3 sample plants in centimeter from the ground level to the leaf at the top.

3.10.2 Number of leaves plant⁻¹

The number of leaves per plant were counted from the selected 3 plants and mean value was calculated.

3.10.3 Fresh shoot biomass (g)

Fresh weight of 10 plants shoot from each pot was measured in grams (g).

3.10.4 Fresh root biomass (g)

Fresh weight of 10 plants root from each pot was measured in gram (g).

3.10.5 Dry root biomass (g)

Dry weight of 10 plants root from each pot was measured in gram (g).

3.11 Soil sample preparation

After harvesting, soil samples were collected from all the pots and sun-dried. Then the dried samples were sieved through a 2mm (10 mesh) sieve. The soil was stored in a clean plastic container for analysis.

3.12 Analysis of soil sample

Chemical properties of all soil samples were analyzed at the Soil Science Laboratory-1, Department of Soil Science, HSTU, Dinajpur. The following analysis of soil sample were done

- i. Soil pH
- ii. Organic Carbon (OC)
- iii. Particle density (PD)
- iv. Total N content
- v. Available P
- vi. Exchangeable K
- vii. Available S

3.12.1 Soil pH

Soil pH was determined using a glass electrode pH meter at 1:2.5, soil-water ratio. The suspension was allowed to stand for one hour with occasional shaking before determination (Jackson, 1967).

3.12.2 Organic Carbon (OC)

Organic carbon was calculated by wet oxidation method using $K_2Cr_2O_7$, H_2SO_4 and $FeSO_4$ solution as outlined by Jackson (1967). This was estimated following the method developed

by Walkley and black (1935). The principle underlying the method is to oxidize the organic matter with the excess of 1N $K_2Cr_2O_7$ solution in presence of concentrated H_2SO_4 and to titrate the remaining un-reacted $Cr_2O_7^{2-}$ solution with 1N $FeSO_4$. Finally, the organic carbon contents were then calculated by multiplying the % organic carbon the Van-Bemmelen factor 1.724 (Piper, 1966).

3.12.3 Particle density (PD)

The particle density of a soil = dry mass (g) of soil volume⁻¹ of soil particles. Where PD is particle density; OD is oven-dry weight of soil; V_s is volume of solids. Particle density takes into account the mass and volume occupied by the solid particles only. It excludes the volume occupied by air and water.

3.12.4 Total nitrogen (N)

Soil N was determined was determined by Micro-Kjeldahl method (Bremner and Mulvaney, 1982). The Soil sample (1.0 g) was digested with 3 ml concentrated H_2SO_4 and 1.1 g catalyst mixture (K_2SO_4 : $CuSO_4 \cdot 5H_2O$: Se powder in a ratio 100:10:1). N was estimated by distillation with 40% NaOH followed titration distillate trapped in H_3BO_3 indicator solution with 0.01 N (Page *et al.*, 1989).

3.12.5 Available phosphorus (P)

Available P was extracted from the soil with 0.5 M sodium bicarbonate solution pH 8.5 (Olsen *et al.*, 1954). P in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and color intensity was measured colorimetrically at 660 nm wavelength (Page *et al.*, 1989).

3.12.6 Exchangeable potassium (K)

Exchangeable K was determined by the ammonium acetate extraction method using a flame photometer as described by Page *et al.* (1989).

3.12.7 Available sulphur (S)

Available S was determined by extraction the soil sample with 0.01 M $Ca(H_2PO_4)_2$. The S content in the extract was estimated and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.13 Statistical analysis

The data were presented as the mean value. Statistix 10 software was used to perform statistical analysis. One-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) was performed to determine significant differences among treatments. The values of $p < 0.05$ were considered as significant.

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from the present study are systematically presented in this episode under different captions following necessary discussion by taking proper support of the previous findings of the published works of others as accessible, and the established scientific principles as well. Moreover, six tables have been added in this chapter to clarify the findings. Furthermore, one appendix has been included at the end of the thesis for further information as needed to highlight the findings.

4.1 Plant Height

Insignificant variation was observed in plant height of Water spinach at 30 DAS and 40 DAS due to the application of online based organic fertilizer ($p > 0.05$) but significant variation was observed at 50 DAS, 60 DAS and 70 DAS. At 30 DAS represented in (table 4.1), the highest plant height (6.50 cm) was observed in T₅ treatment due to application of 1% of Oyster shell Kg⁻¹ soil which was statistically parallel to T₃ (5.63 cm), T₇ (5.63 cm), T₄ (5.56 cm), T₆ (5.56 cm) and T₂ (5.20 cm), the lowest plant height (5.13 cm) was found at T₁ (Control) treatment which was statistically parallel to T₃ (5.63 cm), T₇ (5.63 cm), T₄ (5.56 cm), T₆ (5.56 cm) and T₂ (5.20 cm). At 40 DAS, the highest plant height (10.13 cm) was observed in T₂ treatment due to application of 1% of Bonemeal Kg⁻¹ soil which is statistically akin to T₄ (10.00 cm), T₇ (9.93 cm), T₆ (9.70 cm), T₅ (9.36 cm), and T₃ (9.33 cm), the lowest plant height (8.13 cm) was found at T₁ (Control) treatment which was statistically closer to T₅ (9.36 cm), T₃ (9.33 cm) and T₈ (8.96 cm). At 50 DAS, the highest plant height (12.40 cm) was observed in T₅ treatment due to application of 1% of Oyster shell Kg⁻¹ soil which is statistically residual to T₄ (12.30 cm), T₇ (11.8 cm), T₂ (11.66 cm), T₈ (11.53 cm), T₆ (11.43 cm) and T₃ (11.16 cm), the lowest plant height (9.67 cm) was found at T₁ (Control) treatment. At 60 DAS, the highest plant height (16.96 cm) was observed in T₄ treatment due to application of 1% of Neem cake Kg⁻¹ soil which is statistically parallel to T₇ (15.53 cm), the lowest plant height (12.26 cm) was found at T₁ (Control) treatment, which is statistically parallel to T₈ (13.40 cm). At 70 DAS, the highest plant height (17.70 cm) was observed in T₃ treatment due to application of 1% of Cowdung Kg⁻¹ soil which is statistically parallel to T₇ (17.65 cm) and T₄ (17.53 cm), the lowest plant height (13.03 cm) was found at T₁ (Control) treatment, which was statistically parallel to T₈ (14.16 cm). A pot experiment was conducted to investigate the effect of Cowdung on growth and yield response of *Ipomoea aquatic* and

found positive effect on plant height (Zaman *et al.*, 2017). In our experiment, in T₃ treatment highest plant height was observed due to the use of 1% Cowdung Kg⁻¹ soil because it improves soil structure, helps regenerate the soil, and is an effective source of nutrients needed for growing plants.

4.2 Number of leaves plant⁻¹

Insignificant variation was observed in number of leaves plant⁻¹ of water spinach at 30 DAS and 40 DAS due to the application of online based organic fertilizer ($p > 0.05$) but significant variation was observed 70 DAS represented in (table 4.2). At 30 DAS, the highest number of leaves Plant⁻¹ (5) was observed in T₄ treatment due to application of 1% of Neem cake Kg⁻¹ soil which is statistically parallel to T₁ (4), T₂ (4), T₃(4), T₅ (4), T₆ (4) and T₇ (4), the lowest number of leaves plant⁻¹ (3) was found at T₈ treatment due the application of 1% Egg shell powder Kg⁻¹ soil, which was statistically parallel to T₁ (4), T₂ (4), T₃ (4), T₅ (4), T₆ (4) and T₇ (4). At 40 DAS, the highest number of leaves Plant⁻¹ (8) was observed in T₆ treatment due to application of 1% of Cocopeat Kg⁻¹ soil which is statistically parallel to T₃ (8) and T₇(8) the lowest number of leaves plant⁻¹ (7) was found at T₁ (Control) treatment which was statistically parallel to T₄ (7), T₅ (7), T₈ (7) and T₂ (7). At 70 DAS, the highest number of leaves plant⁻¹ (45) was observed in T₃ treatment due to application of 1% Cowdung Kg⁻¹ soil which is statistically parallel to T₄ (15) and T₇ (14) the lowest number of leaves Plant⁻¹ (11) was found at T₁ (Control) treatment. A pot experiment was conducted to investigate the effect of Cowdung on growth and yield response of *Stevia rebaudiana* and found positive effect on number of leaves Plant⁻¹ (Zaman *et al.*, 2017). In our experiment, in T₃ treatment highest number of leaves plant⁻¹ was observed due to the use of 1% Cowdung Kg⁻¹ soil because it improves soil structure, helps regenerate the soil, and is an effective source of nutrients needed for growing plants.

Table 4.1: Effect of online based organic fertilizer on plant height of water spinach

Treatment	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
T ₁	4.90	8.55	9.67b	12.26 e	13.03 c
T ₂	5.20	10.13	11.66 a	14.53 bcd	15.93 b
T ₃	5.63	9.33	11.16 a	14.60 bcd	17.70 a
T ₄	5.56	10.00	12.30 a	16.96 a	17.53 a
T ₅	6.50	9.36	12.40 a	15.26 bc	15.86 b
T ₆	5.56	9.70	11.43 a	13.96 cd	15.56 b
T ₇	5.63	9.93	11.80 a	15.53 ab	17.65 a
T ₈	5.13	8.96	11.53 a	13.40 de	14.16 c
SEM	0.45	0.36	0.46	0.48	0.41
CV	8.23	6.64	6.93	5.75	4.52
LS	NS	NS	*	**	**

The data was presented as the mean value. *= 5% level of significance; **= 1% level of significance; NS= Non significant; CV= Coefficient of variance; LS=Level of Significance.

In the column figures having a similar letter(s) do not differ significantly at 5% level of significance. Treatment combinations were as follows

T₁ = Control (only soil), T₂ = 1% Bonemeal Kg⁻¹ soil, T₃ = 1% Cowdung Kg⁻¹ soil, T₄ = 1% Neem cake Kg⁻¹ soil, T₅ = 1% Oyster shell powder Kg⁻¹ soil, T₆ = 1% Cocopeat Kg⁻¹ soil, T₇ = 1% Vermicompost Kg⁻¹ soil, T₈ = 1% Egg shell powder Kg⁻¹ soil.

Table 4.2: Effect of online based organic fertilizer on number of leaves plant⁻¹ of water spinach

Treatment	30 DAS	40 DAS	70 DAS
T ₁	4	7	11 c
T ₂	4	7	13 b
T ₃	4	8	16 a
T ₄	5	7	15 ab
T ₅	4	7	13 b
T ₆	4	8	13 b
T ₇	4	8	14 ab
T ₈	3	7	13 b
SEM	0.31	0.31	0.66
CV	8.96	7.28	8.47
LS	NS	NS	**

The data was presented as the mean value. *= 5% level of significance; **= 1% level of significance; NS= Non significant; CV= Coefficient of variance; LS=Level of Significance.

In the column figures having a similar letter(s) do not differ significantly at 5% level of significance. Treatment combinations were as follows

T₁ = Control (only soil), T₂ = 1% Bonemeal Kg⁻¹ soil, T₃ = 1% Cowdung Kg⁻¹ soil, T₄ = 1% Neem cake Kg⁻¹ soil, T₅ = 1% Oyster shell powder Kg⁻¹ soil, T₆ = 1% Cocopeat Kg⁻¹ soil, T₇ = 1% Vermicompost Kg⁻¹ soil, T₈ = 1% Egg shell powder Kg⁻¹ soil.

4.3 Shoot biomass

Significant variation was observed in weight of fresh shoot biomass of Water spinach at 70 DAS, 95 DAS and at harvesting time due to the application of online based organic fertilizer ($p < 0.01$) represented in (table 4.3). At 70 DAS, the highest weight of fresh shoot biomass (45.00 g) was observed in T₅ treatment due to application of 1% of Oyster shell powder Kg⁻¹ soil which is statistically parallel to T₆ (43.66 g) and T₇ (43.03 g), the lowest weight of fresh shoot biomass (32.90 g) was found at T₁ (Control) treatment. At 95 DAS, the highest weight of fresh shoot biomass (46.43 g) was observed in T₆ treatment due to application of 1% of

Cocopeat Kg⁻¹ soil which is statistically parallel to T₃ (45.18 g), T₄ (44.28 g) and T₇ (44.19 g), the lowest weight of fresh shoot biomass (30.78 g) was found at T₁ (Control) treatment. At harvest, the highest weight of fresh shoot biomass (30.95 g) was observed in T₆ treatment due to application of 1% of Cocopeat Kg⁻¹ soil which is statistically parallel to T₃ (30.12 g), T₄ (29.52 g) and T₇ (29.46 g), the lowest weight of shoot biomass (20.52 g) was found at T₁ (Control) treatment. Significant variation was observed in weight of dry shoot biomass of Water spinach after harvest due to the application of online based organic fertilizer ($p < 0.01$) represented in (table 4.3). after harvest, the highest weight of dry shoot biomass (4.64 g) was observed in T₆ treatment due to application of 1% Cocopeat Kg-1 soil which is statistically parallel to T₃ (4.51 g), T₄ (4.42 g) and T₇ (4.41 g), the lowest weight of fresh shoot biomass (3.07 g) was found at T₁ (Control) treatment. A pot experiment was conducted to investigate the effect of cocopeat on growth and yield response of *Ipomoea aquatic* and found positive effect on shoot biomass (Md. Zulfikar Khan *et al.*, 2019). In our experiment, in T₆ treatment highest weight was observed due to the use of cocopeat, because cocopeat makes plant healthy due to its anti-fungal properties. It is also resistant to mold which intern will help protect our plant from disease and decay as they grow.

4.4 Root biomass plant⁻¹

Significant variation was observed in Root biomass Plant⁻¹ of Water spinach after Harvesting time due to the application of online based organic fertilizer ($p < 0.01$) represented in (table: 4.3). After harvest, the highest weight of fresh root biomass plant⁻¹ (2.27 g) was observed in T₃ treatment due to application of 1% of Cowdung Kg⁻¹ soil which is statistically parallel to T₄ (2.01 g), the lowest weight of Fresh root biomass plant⁻¹ (1.27 g) was found at T₁ (Control) treatment. After harvest, the highest weight of dry root biomass plant⁻¹ (0.34 g) was observed in T₃ treatment due to application of 1% of Cowdung Kg⁻¹ soil which was statistically parallel to T₄ (0.30 g), the lowest weight of Fresh root biomass plant⁻¹ (0.19 g) was found at T₁ (Control) treatment, which was statistically parallel to T₈ (0.23 g). An experiment was conducted on effects of cowdung from farms with different feeding strategies on germination and initial root growth of cress (*Lepidium sativum* L.) and found positive effect on root growth (N.J Hoekstra *et al.* 2002). Here in T₃ treatment highest fresh and dry root weight observed due to application of cowdung because it improves soil structures helps regenerate the soil and is an effective source of nutrients needed for growing plant of all types.

4.5 Effect of different organic fertilizer on the properties of the post - harvest soil:

4.5.1 p^H

There was significant variation observed in pH as soil properties due to application of different level of organic fertilizer ($p < 0.01$) represented in (table 4.4). The highest pH (6.65) was observed in T₅ treatment due to application of 1% of Oyster shell powder. The lowest pH (6.055) was found in T₁ (control). The increasing order of pH is T₁ < T₃~ T₂ < T₈ < T₄~T₇ < T₆ < T₅. Organic fertilizer with its alkaline nature increases the soil pH and increases crop yield, alleviating the acid stress (Cornelissen *et al.* 2018).

Table 4.3: Effect of online based organic fertilizer on Fresh shoot, fresh root and dry root biomass plant⁻¹ of water spinach

Treatment	Marketable Fresh shoot biomass (g) pot ⁻¹			Dry shoot biomass (g)	Fresh root biomass plant ⁻¹ (g)	Dry root biomass plant ⁻¹ (g)
	70 DAS	95 DAS	At Harvest			
T ₁	32.90 f	30.78 d	20.52 d	3.07 d	1.27 d	0.19 d
T ₂	38.96 de	43.68 b	29.12 b	4.36 b	1.86 bc	0.27 bc
T ₃	41.41 bcd	45.18 ab	30.12 ab	4.51 ab	2.27 a	0.34 a
T ₄	40.41 cde	44.28 ab	29.52 ab	4.42 ab	2.01 ab	0.30 ab
T ₅	45.00 a	42.61 b	28.40 b	4.26 b	1.84 bc	0.27 bc
T ₆	43.66 ab	46.43 a	30.95 a	4.64 a	1.90 bc	0.28 bc
T ₇	43.03 abc	44.19 ab	29.46 ab	4.41 ab	1.69 bc	0.25 bc
T ₈	37.83 e	38.56 c	25.71 c	3.85 c	1.57 cd	0.23 cd
SEM	1.07	0.90	0.60	0.09	0.11	0.01
CV	4.61	4.61	3.74	3.74	9.47	7.24
LS	**	**	**	**	**	**

The data was presented as the mean value. *= 5% level of significance; **= 1% level of significance; NS= Non significant; CV= Coefficient of variance; LS=Level of Significance.

In the column figures having a similar letter(s) do not differ significantly at 5% level of significance. Treatment combinations were as follows

T₁ = Control (only soil), T₂ = 1% Bonemeal Kg⁻¹ soil, T₃ = 1% Cowdung Kg⁻¹ soil, T₄ = 1% Neem cake Kg⁻¹ soil, T₅ = 1% Oyster shell powder Kg⁻¹ soil, T₆ = 1% Cocopeat Kg⁻¹ soil, T₇ = 1% Vermicompost Kg⁻¹ soil, T₈ = 1% Egg shell powder Kg⁻¹ soil.

Table 4.4: Effect of organic fertilizer on p^H, total N, available P, exchangeable K, available S and OC of post- harvest soil.

Treatments	PH	OC (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq 100 g ⁻¹ soil)	Available S (ppm)
T ₁	6.05 d	0.38 h	0.02 c	16.34 f	0.10 d	7.80 f
T ₂	6.15 cd	0.69 d	0.02 c	25.30 a	0.13 cd	20.97 d
T ₃	6.10 cd	0.82 b	0.02 c	20.14 c	0.13 cd	19.15 de
T ₄	6.44 b	0.97 a	0.02 c	21.67 b	0.14 c	15.81 e
T ₅	6.65 a	0.73 c	0.03 b	17.62 e	0.14 bc	41.35 a
T ₆	6.49 ab	0.58 f	0.03 b	13.35 g	0.19 a	36.18 bc
T ₇	6.44 b	0.65 e	0.05 a	20.80 c	0.18 ab	36.93 b
T ₈	6.23 c	0.54 g	0.04 b	18.73 d	0.11 cd	32.83 c
SEM	0.056	0.011	0.002	0.286	0.013	1.219
CV	1.55	2.68	3.64	2.58	15.01	8.01
LS	**	**	**	**	**	**

The data was presented as the mean value. *= 5% level of significance; **= 1% level of significance; NS= Non significant; CV= Coefficient of variance.

In the column figures having a similar letter(s) do not differ significantly at 5% level of significance. Treatment combinations were as follows

T₁ = Control (only soil), T₂ = 1% Bonemeal Kg⁻¹ soil, T₃ = 1% Cowdung Kg⁻¹ soil, T₄ = 1% Neem cake Kg⁻¹ soil, T₅ = 1% Oyster shell powder Kg⁻¹ soil, T₆ = 1% Cocopeat Kg⁻¹ soil, T₇ = 1% Vermicompost Kg⁻¹ soil, T₈ = 1% Egg shell powder Kg⁻¹ soil.

4.5.2 Organic Carbon (OC%)

There was significant variation observed in OC as soil properties due to application of different level of organic fertilizer ($p < 0.01$) shown in (table 4.4). The highest OC (0.97%) was observed in T₄ treatment due to application of 1% of Neem Cake. The lowest OC (0.38%) was found in T₁ (control). The increasing order of OC (%) is T₁<T₈<T₆<T₇<T₂<T₅<T₃<T₄.

Organic fertilizer substitution (OFS) technology effectively mitigates the adverse effects of excessive synthetic fertilizer application while promoting soil organic carbon (SOC) sequestration in farmlands. However, how the permanganate oxidizable carbon fractions (KOCs) transformation affects SOC under OFS remains unknown. In this study, two typical farmland soils (grey desert soil, GS; meadow soil, MS) were selected for a 3-year field fertilization experiment (no fertilization, NF; synthetic fertilizer alone, SCF; and organic fertilizer substituted 20% synthetic N fertilizer, OFS). Field experiments conducted from 2018 to 2020 showed that SOC could be used to evaluate wheat yield and soil quality, so further study the effects of OFS on SOC and KOCs and their corresponding C pool management index (CPMIs). The results showed that OFS in GS and MS increased SOC (by 3.37%–15.62%, 4.92%–20.28%) and its fractions content (except low-activity KOC, LKOC) and CPMIs (except CPMI-L) year by year compared to SCF and NF. The recalcitrant organic C (ROC), KOC, high-activity KOC (HKOC), and medium-activity KOC (MKOC) were the key fractions affecting SOC (Hao *et al.* 2023)

4.6 Total N, available P, exchangeable K and available S of post- harvest soil

4.6.1 Total N

There was significant variation observed in soil properties containing total N due to application of online based organic fertilizer ($p < 0.01$) represented in table 4.4. The highest total N content (0.049%) was observed in T₇ treatment due to the application of Vermicompost. The lowest total N content (0.021%) was found in T₄ treatment due to the application of Neem cake. The increasing order of total N content was T₄~T₃~T₂~ T₁<T₅~T₆~ T₈<T₇. Field experiments conducted from 2018 to 2020 showed that SOC could be used to evaluate wheat yield and soil quality, so further study the effects of OFS on SOC and KOCs and their corresponding C pool management index (CPMIs). The results showed that OFS in GS and MS increased SOC (by 3.37%–15.62%, 4.92%–20.28%) and its fractions content (except low-activity KOC, LKOC) and CPMIs (except CPMI-L) year by year

compared to SCF and NF. The recalcitrant organic C (ROC), KOC, high-activity KOC (HKOC), and medium-activity KOC (MKOC) were the key fractions affecting SOC. (Hao *et al.* 2023)

4.6.2 Available P

There was a significant variation observed in soil properties containing total available P due to application of online based organic fertilizer ($p < 0.01$) represented in (table 4.4). The highest total available P content (25.31 ppm) was observed in T₂ treatment due to the application of Bonemeal. The lowest total available P content (13.35 ppm) was found in T₆ treatment due to the application of Cocopeat. The increasing order of total Available P content is T₆<T₁<T₅<T₈<T₃<T₇<T₄<T₂. Field experiments conducted from 2018 to 2020 showed that SOC could be used to evaluate wheat yield and soil quality, so further study the effects of OFS on SOC and KOCs and their corresponding C pool management index (CPMIs). The results showed that OFS in GS and MS increased SOC (by 3.37%–15.62%, 4.92%–20.28%) and its fractions content (except low-activity KOC, LKOC) and CPMIs (except CPMI-L) year by year compared to SCF and NF. The recalcitrant organic C (ROC), KOC, high-activity KOC (HKOC), and medium-activity KOC (MKOC) were the key fractions affecting SOC. (Hao *et al.* 2023)

4.6.3 Exchangeable K

There was significant variation observed in soil properties containing total Exchangeable K due to application of online based organic fertilizer ($p < 0.01$) represented in (table 4.4). The highest total exchangeable K content (0.19 ppm) was observed in T₆ treatment due to the application of Cocopeat. The lowest total exchangeable K content (ppm) was found in T₁ (control). The increasing order of total exchangeable K content is T₁<T₈~T₂~T₃ <T₄<T₅ <T₇ ~T₆. Field experiments conducted from 2018 to 2020 showed that SOC could be used to evaluate wheat yield and soil quality, so further study the effects of OFS on SOC and KOCs and their corresponding C pool management index (CPMIs). The results showed that OFS in GS and MS increased SOC (by 3.37%–15.62%, 4.92%–20.28%) and its fractions content (except low-activity KOC, LKOC) and CPMIs (except CPMI-L) year by year compared to SCF and NF. The recalcitrant organic C (ROC), KOC, high-activity KOC (HKOC), and medium-activity KOC (MKOC) were the key fractions affecting SOC. (Hao *et al.* 2023)

4.6.4 Available S (ppm)

There was a significant variation observed in soil properties containing total available S due to application of online based organic fertilizer ($p < 0.01$) represented in (table 4.4). The highest total available S content (41.35 ppm) was observed in T₅ treatment due to the application of Oyster shell powder. The lowest total available S content (7.80 ppm) was found in T₁ (control). The increasing order of total available S content is T₁<T₄<T₃~T₂<T₈<T₆~T₇<T₅. Field experiments conducted from 2018 to 2020 showed that SOC could be used to evaluate wheat yield and soil quality, so further study the effects of OFS on SOC and KOCs and their corresponding C pool management index (CPMIs). The results showed that OFS in GS and MS increased SOC (by 3.37%–15.62%, 4.92%–20.28%) and its fractions content (except low-activity KOC, LKOC) and CPMIs (except CPMI-L) year by year compared to SCF and NF. The recalcitrant organic C (ROC), KOC, high-activity KOC (HKOC), and medium-activity KOC (MKOC) were the key fractions affecting SOC. (Hao *et al.* 2023)

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

The experiment was conducted at the shade besides Academic building-1 of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during November 2022 to January 2023 (Rabi season) to study utilization of available online-based organic fertilizers on the vegetative growth of water spinach. The experiment was laid out Completely Randomized Design (CRD) with 8 treatments and 3 replications. A total of 24 experimental pots were used. Every treatment used as 1% Kg⁻¹ soil. There were eight treatments as follows: T₁ = Control (only soil), T₂ = 1% Bonemeal Kg⁻¹ soil, T₃ = 1% Cowdung Kg⁻¹ soil, T₄ = 1% Neem cake Kg⁻¹ soil, T₅ = 1% Oyster shell powder Kg⁻¹ soil, T₆ = 1% Cocopeat Kg⁻¹ soil, T₇ = 1% Vermicompost Kg⁻¹ soil, T₈ = 1% Egg shell powder Kg⁻¹ soil.

Seeds were sown on the November, 2022 in the pot. The crop was allowed to grow until maturity and intercultural operation such as weeding, thinning, irrigation were done. Whenever required in order to support normal growth of the plant. Pot wise growth and yield component were recorded. Soil sample were collected before organic fertilizer application and after harvest. Initial and post-harvest soil samples were analyzed for physical and chemical properties of soil using the standard methods. The statistical analysis was done by using statistics 10 software. One-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) was performed to determine significant differences among treatments. The values of $p < 0.05$ were considered as significant.

The result reveals that the highest plant height, number of leaves plant⁻¹, fresh shoot biomass, dry shoot biomass, fresh root weight and dry root weight. Insignificant variation was observed in plant height of Water spinach at 30 DAS and 40 DAS, but significant variation was observed at 50 DAS, 60 DAS and 70 DAS. At 30 DAS, the highest plant height (6.5 cm) was observed in T₅ treatment, the lowest plant height (5.13 cm) was found at T₁ (Control) treatment. At 40 DAS, the highest plant height (10.13 cm) was observed in T₂ treatment, the lowest plant height (8.13 cm) was found at T₁ (Control) treatment. At 50 DAS, the highest plant height (12.4 cm) was observed in T₅ treatment due, the lowest plant height (9.67 cm) was found at T₁ (Control) treatment. At 60 DAS, the highest plant height (16.96 cm) was observed in T₄ treatment, the lowest plant height (12.26 cm) was found at T₁ (Control)

treatment. At 70 DAS, the highest plant height (17.70 cm) was observed in T₃ treatment, the lowest plant height (13.03 cm) was found at T₁ (Control) treatment, Insignificant variation was observed in number of leaves plant⁻¹ of Water spinach at 30 DAS and 40 DAS but significant variation was observed 70 DAS. At 30 DAS, the highest number of leaves plant⁻¹ (5) was observed in T₄ treatment, the lowest number of leaves plant⁻¹ (3) was found at T₈ treatment. At 40 DAS, the highest number of leaves plant⁻¹ (8) was observed in T₆ treatment, the lowest number of leaves plant⁻¹ (6) was found at T₁ (Control) treatment. At 70 DAS, the highest number of leaves plant⁻¹ (16) was observed in T₃ treatment, the lowest number of leaves plant⁻¹ (11) was found at T₁ (Control) treatment. Significant variation was observed in weight of fresh shoot biomass of Water spinach. At 70 DAS, the highest weight of fresh shoot biomass (45.00 g) was observed in T₅ treatment. The lowest weight of fresh shoot biomass (32.90 g) was found at T₁ (Control) treatment. At 95 DAS, the highest weight of fresh shoot biomass (46.43 g) was observed in T₆ treatment, the lowest weight of fresh shoot biomass (30.78 g) was found at T₁ (Control) treatment. At harvest, the highest weight of fresh shoot biomass (30.95 g) was observed in T₆ treatment, the lowest weight of fresh shoot biomass (20.52 g) was found at T₁ (Control) treatment. Significant variation was observed in weight of dry shoot biomass of Water spinach after harvest, the highest weight of dry shoot biomass (4.64 g) was observed in T₆ treatment and the lowest weight of dry shoot biomass (3.07 g) was found at T₁ (Control) treatment. Significant variation was observed in root biomass plant⁻¹ of water spinach after harvesting. After harvest, the highest weight of fresh root biomass plant⁻¹ (2.27 g) was observed in T₃ treatment, the lowest weight of fresh root biomass plant⁻¹ (1.27 g) was found at T₁ (Control) treatment. After harvest, the highest weight of dry root biomass plant⁻¹ (0.34 g) was observed in T₃ treatment. The lowest weight of Fresh root biomass plant⁻¹ (0.19 g) was found at T₁ (Control) treatment.

Application of online based organic fertilizer resulted in considerable influence on the properties of the post-harvest soil, such as total N content, available P, exchangeable K and available S. There was significant variation observed in pH as soil properties due to application of different level of organic fertilizer. The highest pH (6.65) was observed in T₅ treatment. The lowest pH (6.05) was found in T₁ (control). There was significant variation observed in OC as soil properties. The highest OC (0.97) was observed in T₄ treatment. The lowest OC (0.38) was found in T₁ (control). The highest total N content (0.04%) was observed in T₇ treatment due to the application of VC. The lowest total N content (0.02%) was found in T₄ treatment. The highest total available P content (25.30 ppm) was observed in

T₂ treatment due to the application of Bonemeal. The lowest total available P content (13.35 ppm) was found in T₆ treatment. The highest total exchangeable K content (0.19 ppm) was observed in T₆ treatment due to the application of Cocopeat. The lowest total exchangeable K content (ppm) was found in T₁ (control). The highest total available S content (41.35ppm) was observed in T₅ treatment. The lowest total available S content (7.80 ppm) was found in T₁ (control).

5.2 Conclusion

Considering the overall results of this experiment it was observed that cultivation of water spinach in the pot having T₆ (1% Cocopeat Kg⁻¹ soil) gives better vegetative growth compared to the other organic fertilizer.

5.3 Recommendation

Considering the above observation of the experiment further studies in the following may be suggested:

1. Considering the above observations, people can be suggested to apply T₆ (1% Cocopeat Kg⁻¹ soil) at their pot cultivation to fulfill their family demand.
2. However, before recommendation additional research in this theme must first be conducted.

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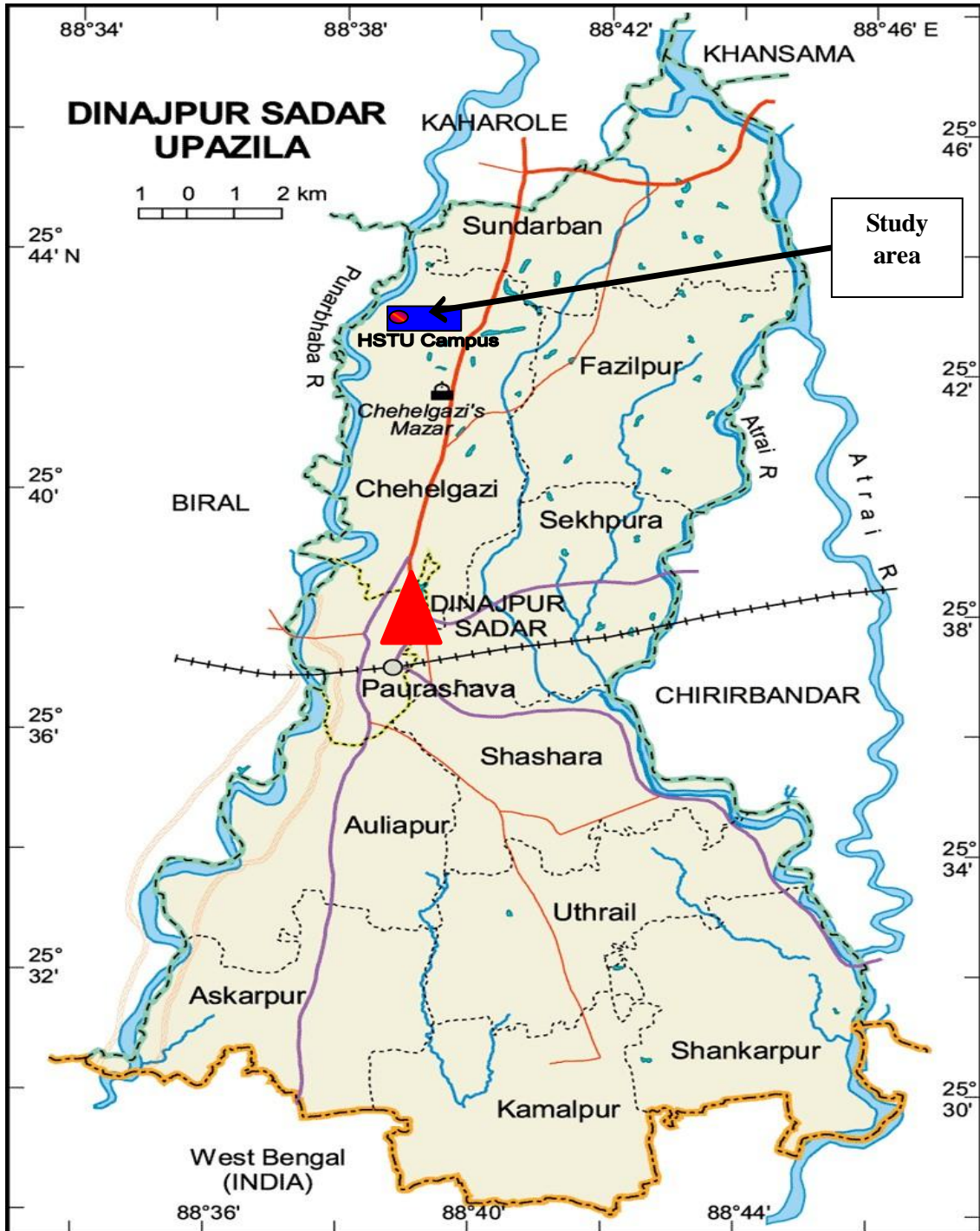
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APPENDICES

Appendix I . Location of the experimental site (map of Dinajpur Sadar Upazila showing the research site)



Appendix II: Monthly records of average air temperature, relative humidity, rainfall and sunshine during the experimental period (November 2022 to January 2023)

Month	**Temperature (°C)	*Relative humidity (%)	*Rainfall (mm)	**Sunshine (hrs)
November	24	73.25	4.0	8.5
December	22	72.05	3.2	7.2
January	22	75.62	5.5	8.4

**=Monthly Average,*=Monthly Total

Source: Weather yard, Bangladesh Wheat and Maize Research Institute (BWMRI), Nashipur, Dinajpur

Appendix III: Some Photographs during research period

