# EFFECT OF DIFFERENT SOIL MIXTURES ON THE GROWTH AND YIELD OF INDIAN SPINACH (*Basella alba* L)

**A THESIS**

**BY**

**MD. SAHARUL ISLAM**
**Student No. 1701202**
**Session: July-December 2023**

**MASTER OF SCIENCE**

**IN**

**SOIL SCIENCE**

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**Submitted to**
**The Department of Soil Science**
**Hajee Mohammad Danesh Science and Technology University, Dinajpur**
**in partial fulfillment of the requirements for the degree of**

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**Approved as to the style and content by:**

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**DECEMBER, 2023**

DEDICATED
TO
MY BELOVED FAMILY

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# ABSTRACT

The experiment was conducted in the shade beside Academic building-1 in Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh from February to May 2023 to find out the effect of pot mixture amended with organic and inorganic source on the vegetative growth of Indian spinach. The experiment was laid out in a Completely Randomized Design (CRD) with 7 treatments and 3 replications. The treatments were as follows; T1 = Control (only soil) T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder, T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder, T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder, T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder, T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder, T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder Where, VM = Vermicompost respectively. respectively. The highest plant height (68.66 cm), branch length (3.82 cm), fresh yield (199.33g), root length (12.98 cm), the maximum leaf number per plant (49.33), root weight (12.91 g) and K (23.08) was found in $T_7$. P (97.91) recorded in $T_4$. The lowest plant height 24.66 cm in $T_1$ treatment, leaf number per plant (21.33), branch length (3.00 cm), fresh yield (132.67 gm), root length (9.06 cm), root weight (10.57 g), N (0.01), P(76.45), K(13.33), S (63.31) and EC 1.46. The lowest fresh yield (132.67 gm) was found in $T_{1.}$

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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 | $C^{\upsilon}$ |
| Duck Manure | DM |
| Days After Sowing | DAS |
| Etcetera | etc. |
| And others | *et.al.* |
| Exempli gratia (by way of example) | *e.g.* |
| 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

Basella alba belongs to the family Basellaceae. *B. alba* is a fast-growing vegetable, native to tropical Asia (India or Indonesia) and extremely heat tolerant (Grubben and Denton, 2004). It is commonly known as commonly known as Puishak. It is fast growing perennial plant but it is sometimes cultivated as an annual for home gardens and as a cash crop. It is an easy growing plant propagated by seed, root or long tip cuttings. B. alba is commonly grown for its leaves and young shoots, which are high in protein 1.9%, carbohydrate 3.0%, iron 1.4 mg/100g, vitamin A 3250 IU/100g, calcium 0.15% according to Bose *et al.* (2008). Due to its mucilaginous nature of leaves and stems, the juice of leaves has been prescribed against constipation especially for children and pregnant women. Nutritive value of Indian spinach is very high with a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and water (Ghosh and Guha, 1933). Its thick, semi succulent, heart-shaped leaves have a mild flavour and mucilaginous texture. Daily consumption of Indian spinach has been shown to provide vitamin A especially in populations at high risk of vitamin A deficiency (Haskell et al., 2004). Indian spinach has been used from a long time back for the treatment of many diseases like dysentery, diarrhoea, anaemia, cancer etc. (Adhikari *et al.,* 2012). It thrives well in tropical and subtropical climates, where true spinach often performs poorly due to insect pests and high temperatures (Grubben, 1997). It grows best in sandy loam soils rich in organic matter with pH ranging from 5.5 to 8.0 (Grubben and Denton, 2004). B.alba can grow under conditions of moderate soil fertility but production is enhanced with application of fertilizers. Fertilizer is any organic or inorganic material of natural or synthetic origin that is added into a soil to supply one or more plant nutrients essential for the growth of plant. Organic fertilizers are environmentally friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density; and they foster a diverse population of beneficial soil microorganisms (Bulluck *et al.*, 2002 and Akhter *et al.,* 2019). Inorganic fertilizers dissolve quickly and are made available to the plants for their use within a short time. The combination of organic and inorganic fertilizers can increase plant production (Mahmoud *et al.,* 2009). Vermicompost contains most of the macro as well as micro nutrients which is beneficial for long-term sustainability and crop productivity (Ansari *et al.,* 2016). More importantly, bone meal powder protects plants under adverse weather conditions. It also helps plant to attain maturity quickly (Srinivasan *et al.,* 2021). Coco dust is considered as most easily available and cheap soilless substrate for plant growth (Asaduzzaman *et al.,* 2020). It is a good source of mulch for increasing the water holding capacity and reducing the weed population (Solaimalai *et al.,* 2001). A soil analysis is essential to determine the soil nutrient status prior to fertilizer application. The fertilizer requirement is based on the target yield. Paudel and Chang (2003) recommended application

of compost or manure at 3-4-ton $ha^{-1}$ during plot preparation and side dressing once a month at 1.0-1.5 kg ha-1. High nitrogen level application reduces fruit size due to growth of vegetative matter in leafy vegetables which may shift sink to the leaves instead of the racemes. It is a constituent of a large number of important compounds found in living cells, such as amino acids, enzymes and nucleic acids. Thus, it is critical in improving growth and yield of vegetable crops. A neglected crop such as B. alba has a potential in alleviating malnutrition among certain vulnerable groups in the rural communities but there is lack of appropriate agronomic practices leading to reduced leaf yield. Farming on the rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014). The first benefit of this practice is increased local supply of fresh food. Leafy vegetables are one of the most important fresh vegetables grown in urban agriculture including rooftop farming (Ackerman *et al.*, 2013, Baudoin *et al.*, 2017 and Harada *et al.*, 2018). Under such circumstance, this study was conducted to find out suitable dose and effects of organic matter and inorganic matter on better growth and higher yield of Indian spinach. So, in the light of the above scenario, the present work was conducted with the following specific objectives:

i. To observe the effect of different soil mixtures on the post-harvest soil properties in respect to grow crops on the next season.

ii. To find out the impact of organic and inorganic fertilizers with the addition of different soil mixtures on the quality, growth and yield of Indian spinach.

# CHAPTER II

# REVIEW OF LITERATURE

A comprehensive and critical review of relevant past studies is important for further research. It not only enhances knowledge of studies in the same and other fields, but also provides an understanding of concepts, materials and methods used by others. It remains the basis of the work describing the main points. Finally, critical analysis even provides a good basis for supporting the results and discussion of all ongoing studies. However, some important studies are included in this section and the effects of organic and inorganic fertilizers on Indian spinach are shown as follows:

## 2.1 Effects of organic fertilizers on the growth and yield of Indian spinach

Afrad *et al.* (2021) attempted to develop new technologies to increase productivity through new soil management. Experimental results show that the use of organic fertilizers and non-organic fertilizers will create significant changes in crop growth and yield ($p < 0.05$). In addition, the best fresh fruit yield in chicken manure treatment was roughly fresh fruit yield (29.50 t $ha^{-1}$), okra fresh fruit yield (20.80 t $ha^{-1}$) and Indian spinach yield (74.16 t $ha^{-1}$) to other treatments.

Islam and others. (2020) conducted an experiment in different ponds to examine the effect of different fish ponds on growth and yield and then determine the nutritional quality of Indian spinach. This test consists of two parts; (P) Pond type (P) (three different ponds with different fish species: P1 = shrimp and carp, P2 = shrimp and sunfish, P3 = shrimp, sunfish and carp), each pond contains many different fish species); and lake sediment (M) (three levels: M1 = lakeshore soil, M2 = 50% lake mud and 50% lakeshore soil, M3 = 100% lake soil). The organic matter of the underground lake is 2.79 (P3) and the EC value is 790 (µS cm-1). Minerals such as Ca (%), P (%), and S (mg/100 g) were detected more in plants treated with P2M3 compared to other combined treatments.

Monira (2020) determined the effects of salt on the morphophysiological and yield contributing characteristics of Indian spinach (*Basella alba* L.). Experimental treatments were considered for different salinity levels. S0 = no salt (control), S1 = 25mM, S2 = 50mM, S3 = 75mM, S4 = 100mM and S5 = 150mM sodium chloride. Plant tallest (106.91 cm), number of branches per plant (13.51), longest leaf (10.62 cm), widest leaf (8.42 cm), largest leaf area (85.54 cm2) and is a deciduous plant. leaves a plant (40.83). and the largest plant (1.59 cm). S0 or control condition had the highest SPAD value (74.83), highest germination rate (77.76%), plant fresh weight (417.18 g), maximum plant dry weight (60.36 g) and highest dry matter. (14.40%), while S5 (150 mM NaCl) treatment has the lowest value. The S5 or 150 dS

m-1 salt has the highest moisture content (88.87%). From S0 to S5, the highest value gradually decreases to the lowest.

Roy *et al.* (2014) conducted an experiment to examine the effects of commercial fertilizer and poultry manure on the growth and composition of Indian spinach (Basella alba) grown in saline soil. To analyze these effects, they added commercial fertilizer (CM), chicken manure (PM), and a mixture of CM and PM at a rate of 10 t $ha^{-1}$. So, there are 4 different treatments. Fertilizer cannot be added (T1), CM (T2), PM (T3) and CM + PM (T4). The results showed that the addition of organic fertilizer to the soil increased all parameters such as new weight, number of leaves, shoot and root length. In addition, K, Ca, Mg, Fe and Mn concentrations in all parts of the plant increased 2-3 times compared to the control, regardless of organic changes.

**2.2 Effects of inorganic fertilizers on the growth and yield of Indian spinach**

Sarker *et al.* (2014) investigated the benefits of Indian spinach (*Basella alba* L.) and its phosphorus supplementation and utilization from acidic soil enriched with lime and phosphorus. Lime and phosphorus and their combination had significant effects ($p < 0.001$) on aboveground and root biomass, aboveground and root phosphorus concentration, phosphorus uptake and phosphorus utilization in Indian spinach. Although lime and phosphorus increased biomass yield, top and root phosphorus concentration, and phosphorus uptake in Indian spinach, this effect was enhanced by the use of lime with phosphorus. The results also show that 1000 kg of lime plus 100 kg of phosphorus is sufficient for plant growth. The presence of phosphorus has a positive relationship with the phosphorus uptake of the plant ($p = 0.000$). The results of this study show that the combined use of lime and phosphorus can increase plant growth. Mondal (2011) investigated the effects of chitosan application on the morphological characteristics, growth and economic yield of Indian spinach through a pot experiment. These experiments include five levels of chitosan concentration: 0 (control), 25, 50, 75, and 100 ppm. The highest fresh weight was branch $plant^{-1}$, LA $plant^{-1}$ SLW, leaf and stem, and the total fresh weight was found in 75 ppm chitosan, followed by 100 ppm chitosan. In contrast, control plants showed the lowest values among the above subjects. However, Indian spinach showed the highest yield, leaf and stem fresh weight, and total fresh weight when chitosan was sprayed at 75 ppm. These results indicate that application of 75 ppm chitosan is good for plant growth and development of Indian spinach.

Quader (2007) published an experiment to examine the effects of planting time and fertilizer on the growth and yield of Indian spinach. Two factors were considered in this experiment. Factor A: Planting time (stage 3) on 19 February 2007 (T1); Sowing on March 6, 2007 (T2) and Sowing on March 21, 2007 (T3) and B factor: fertilizer (4 levels), For example, control (F0); cow manure (25 t $ha^{-1}$) (F1); chicken litter (15 t ha-1) (F2) and inorganic fertilizer (F3) - urea (400 kg $ha^{-1}$), TSP (120). kg $ha^{-1}$) and MP (180 kg $ha^{-1}$). At 60 DAS, the tallest plant

height (87.32 cm) was recorded from T2 (planted on 6 March 2007), while the shortest plant height (83.66 cm) was recorded from T1 (planted on 19 February 2007). The highest dry matter content (13.69%) was recorded at T2, while the lowest dry matter content (11.90%) was recorded at T2. The highest yield (19.86 t $ha^{-1}$) was recorded in T2 and the minimum yield was recorded in T2. (16.37 t $ha^{-1}$ collected from T1). At 60 DAS, the tallest plant height (92.11 cm) was recorded from F3, and the shortest plant height (67.56 cm) was recorded from F0 (control).

### 2.3 Combined effects of organic and inorganic fertilizers on growth of Indian spinach

Acker *et al.* (2021) conducted an experiment to examine the effect of organic fertilizers such as bioslurry and inorganic fertilizers on the growth and yield of Indian spinach (*Basella alba* L.). Treatments T1-inorganic fertilizer (100%), T2-inorganic fertilizer (75%) + biological slurry (25%), T3-inorganic fertilizer (50%) + biological slurry (50%), T4-inorganic fertilizer (25%) It is in the form.). %) and bioslurry (75%), T5- organic fertilizer (100%) and T6- no organic or inorganic fertilizer (control). Maximum vine length (31.13 cm), leaf/tree (40.80 cm), leaf length (15.67 cm), leaf width (9.13 cm), number of branches per tree (7.00), vine diameter (0.71 cm), yield per unit area T4 (Inorganic fertilizer: 25%, organic fertilizer: 75% Treatment area (16.20 kg), per hectare (30.92 tons), leaf dry problem (11.27%) and vine dry matter (6.11%). The lowest values are vine length (18.33 cm), number of leaves per plant (22.07 cm), leaf length (11.61 cm), leaf width (6.78 cm). cm), number of branches per plant (2.33) and vine diameter (0.47 cm), T6 (control) treatment yield per plot (4.08 kg) and yield per hectare (8.03 tons), leaf It was determined as dry matter (9.86%) and grapevine dry matter (5.5%). Compared with the control, vine length in the T4 treatment increased by 40% and 41% at days 30 and 45 after planting, respectively.

Basunia *et al.* (2020) reported a pot experiment to evaluate the effects of bioslurry on the growth, yield and nutrition of Indian spinach. The two experiments included two varieties of Indian spinach, i.e., BARI Puishak-1 and BARI Puishak-2, and five levels of bioslurry (i.e., no bioslurry and no fertilizer (control), with a recommended consumption of 10 u, 15, 20 t $ha^{-1}$) Chemical slurry and inorganic fertilizers. The results of the study showed that 20 t $ha^{-1}$ bioslurry was almost the same as inorganic fertilizers. Since bio-slurry contains sufficient nitrogen, potassium and phosphorus, it can be a good source of nutrients in place of chemical fertilizers in sustainable and eco-friendly spinach production in India.

Agbulow *et al.* (2014) investigated the effect of different levels of inorganic fertilizers and poultry manure on the growth and yield of Indian spinach (Basella alba) cultivation (2 WAP). The results showed that application of nitrogen, phosphorus and potassium at 200 kg $ha^{-1}$ (6.5 g $pot^{-1}$) increased the leaf length, leaf area, leaf area, weight and dry weight of Indian spinach compared to other treatments. This was followed by NPK 100 kg $ha^{-1}$ (2.5 g $pot^{-1}$) application. Therefore, 200 kg $ha^{-1}$ (6.5 g $pot^{-1}$) of inorganic NPK fertilizer is sufficient for the optimal

development of Indian spinach. This information is useful for growers of this vegetable, especially for mass production.

Mehedi *et al.* (2012) conducted an experiment to examine the effects of cow manure, municipal waste, chicken manure, and TSP on water spinach (Ipomoea aquatica) growth and phytoavailability of phosphorus (P) in soil. In 800 mg P $kg^{-1}$ cattle manure application, the highest leaf, shoot and root dry weight was observed, while the control (T0) had the lowest value. Phosphorus concentrations in shoots and roots of control plants were 1188 and 1171 mg $kg^{-1}$, respectively. At the highest phosphorus application rate (800 mg P•$kg^{-1}$), phosphorus concentrations in soil treated with cow manure, municipal waste, chicken manure, and TSP manure were 4894, 3815, 5528, and 6179 mg•$kg^{-1}$, respectively. The corresponding values in the roots were 3704, 4397, 4717 and 4926 mg $kg^{-1}$. The phosphorus extraction rate of different transformations is in the following order: TSP > cow manure > chicken manure > municipal waste. Soil Olsen P was found to be positively correlated with spinach juice ($r = 0.718$, $p = 0.000$) and root P concentrations ($r = 0.548$, $p = 0.000$) above P; This indicates that Olsen P is suitable for estimated plant phosphorus content. These results show that the use of cow manure in agriculture without the use of additional fertilizer can be recommended for good results.

### 2.4 Effects of different media on yield of Indian spinach

Şahin (2023) examined the changes in essential and non-essential minerals in lettuce plants (*Lactuca sativa* L. cv. Sementel) grown in soil and soilless. This plant grows in low calcareous soil (LCS) and high calcareous soil (HCS). The best growth was observed in plants grown on coir fiber, followed by rockwool, LCS and HCS. Plants grown on rockwool and coconut fiber contain more N, P and Zn than those grown in soil. Ca, Ti, Sr, Al, Zr and Ba levels were found to be lower in soilless plants than in soiled plants. Lettuce plants grown in HCS, rockwool, or coconut fiber had higher K and S concentrations than plants grown in LCS. Mg and Mn concentrations are highest in coconut and LCS plants. The highest copper concentration in HCS was found in lettuce.

### 2.5 Effects of vermicompost on the growth and yield of Indian spinach

Moria *et al.* (2023) conducted an experiment to evaluate the effects of farmyard manure (FYM) and vermicompost (VC) with or without zinc fertilizer application on dry biomass yield, zin uptake of Indian spinach (*Beta vulgaris* L.) and various distributions. Effect of zinc content in soil after harvest. The results showed a positive response in terms of both dry biomass yield and zinc uptake when 2% FYM or VC was applied alone and together with 5 mg kg-1 Zn with $ZnSO_4•7H_2O$.

Das *et al.* (2022) investigated the effects of a single application of vermicompost and NPK fertilizer on the growth and nutritional quality of Indian spinach (*Basella alba* L.). Plants were

planted three times in the same pot for 113 days in soil treated with different CMV (5, 10, and 20% t $ha^{-1}$) and NPK fertilizers (50, 100, and 200%) and control. Do not use CMV or NPK fertilizers for treatment. The results showed that 20 t $ha^{-1}$ CMV (CMV-20) had significant effects on plant growth and N, P, K content in shoots for up to six cycles in the third cycle.

Tabassum (2020) investigated the effects of vermicompost production on the growth and yield of kohlrabi varieties. The experiment consists of two factors: Factor A: three types (V1 = Fast star, V2 = White Vienna, V3 = Early 005), Factor B: vermicompost production at four levels (M0 = control, M1 = 6 t $ha^{-1}$), M2 = 8 t $ha^{-1}$, M3 = 10 t $ha^{-1}$). The results showed that each treatment had a significant effect on morphological lesions, production and yield. When using vermicompost (M3), Vienna White (V2) had the highest output per hectare (13.12 t $ha^{-1}$) while early 005 (V3) had the lowest output per hectare (7.00 t $ha^{-1}$). 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 V3M0. Results suggested that applying M3 = 10 t $ha^{-1}$ vermicompost, White Vienna gave the highest yield among three cultivars.

Shilpi *et al.* (2014) conducted an experiment to study the effect of different doses of organic manures and inorganic fertilizers on the 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 per plant (16.66), fruit yield per plant (2.05 kg), fruit yield per plot (32.80 kg) and fruit yield per hectare (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) examined the effects 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 $ha^{-1}$) Fenugreek has Rmt-1 as soil application. The results showed that individual and combination of vermicompost, potassium and iron affected crop yields and yields in two years.

Surrage *et al.* (2010), Forterra Royal GRO 1 (GRO 1; coconut fiber / vermicompost) and Forterra Royal GRO 2 (GRO 2 old wood / coconut / coir / vermicompost) and Forterra Royal GRO 2 (GRO 2 Old Pine Bark/ Coconut Coir fiber) /Coir Coir/Vermicomposted vermicompost) More commercially produced than tomato plant 1 in RW. The incidence of blossom end rot (BER) in GRO 1 and GRO 2 also showed similarities; there was a decrease in BER per plant compared to RW. The results show that adding vermicompost to organic growing media can have a positive effect on tomato growth and yield.

Madhabi *et al.* (2006) carried out an experiment during 2006 at college farm, College of Agriculture, ANGRAU, Hyderabad on Indian spinach (*Beta vulgaris* var. benghalensis Hort.).

The objective of the study was out to determine the effect of different levels of vermicompost, castor cake, poultry manure and biofertilizers on the growth and yield of the crop. The investigation clearly indicated that higher growth parameters and leaf yield was recorded with the application of recommended dose of fertilizers (80 N: 40 P: 50 K kg $ha^{-1}$) and were on a par with poultry manure 8 t $ha^{-1}$+ Azospirillum (2 kg $ha^{-1}$) + Phosphoras solubilising bacteria (2 kg $ha^{-1}$) than control (No manures, biofertilizers and inorganic fertilizers).

# CHAPTER III
# MATERIALS AND METHOD

In this research, the materials and methods have been presented which include brief description of experimental site, soil, climate, materials used, and methodology followed in the experiment. The details of these series are described below.

## 3.1 Location of the study

The experiment was held in the shade beside Academic building-1 in Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh from September to November 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.

## 3.2 Weather and Climate

The experimental site was a subtropical Kharif Climate and is characterized by moderately high temperature and heavy rainfall during the Kharif season (April-September) and moderately low temperature with low rainfall during the Rabi season (October-March). Temperature during the cropping period ranged between 20 to $35^0$C with generally 60 to 85% humidity in the air. The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experiment site during the cropping season are presented in (Appendix-1).

## 3.3 Soil

The soil needed for the pot experiment was taken from the research field of Soil science, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The soils of the plot are from the Old Himalayan Piedmont Plain (AEZ-1). Drainage system of the land was well developed.

## 3.4 Experimental periods

The experiment was carried out during 17 August, 2023 to December, 2023. Seeds were sown on 17 August, 2023 and harvested up to mid of December, 2023.

## 3.5 Collection of pots

The plastic pots were collected from Nimtola, Sador Dinajpur. The size of the pot was 24 cm × 17 cm.

### 3.6 Collection of manures and fertilizer

The vermicompost, bone meal and cocopit were collected from Dhaka Online. Well decomposed urea, TSP, MP, Gypsum were collected from Basherhat, HSTU, Dinajpur.

### 3.7 Soil description

The general characteristics of the soil are presented in Table 1-3.

**Table1. Morphological characteristics of the soil**

| Morphology | Characteristics |
|---|---|
| Location | Soil Science Laboratory-1, Department of Soil Science, |
| 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-2 Physical characteristics of initial soil**

| Particle size distribution | Value |
|---|---|
| Sand (%) | 58 |
| Silt (%) | 28 |
| Clay (%) | 14 |
| Textural class | Sandy loamy |

**Table-3 Chemical characteristics of initial soil**

| Chemical characteristics | Analytical data |
|---|---|
| pH | 5.25 |
| Organic carbon content (%) | 1.67 |
| Total N (%) | 0.14 |
| Available phosphorus (ppm) | 162.98 |
| Exchangeable potassium (m.eq.100g$^{-1}$ soil) | 1.21 |
| Available sulfur (ppm) | 224.87 |

### 3.8 Setting of pots for the experiment

The pots were placed in the selected open space in 7 rows and 3 columns.

### 3.9 Treatments

There were 7 treatments combination consists of soil, sand, bone meal, vermicompost, basic fertilizers including one control. The treatment combination for the experiment was as follows:

$T_1$ = Control (only soil)
$T_2$ = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g $kg^{-1}$ bone meal powder
$T_3$ = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g $kg^{-1}$ bone meal powder
$T_4$ = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g $kg^{-1}$bone meal powder
$T_5$ = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g $kg^{-1}$bone meal powder
$T_6$ = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$bone meal powder
$T_7$ = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder
Where, VM = Vermicompost respectively.

### 3.10 Experimental design

The experiment was laid out Completely Randomized Design (CRD) with 7 treatments and 3 replications. A total of 21 experimental pots were used.

The layout of the experimental pot shown in the figure. 1

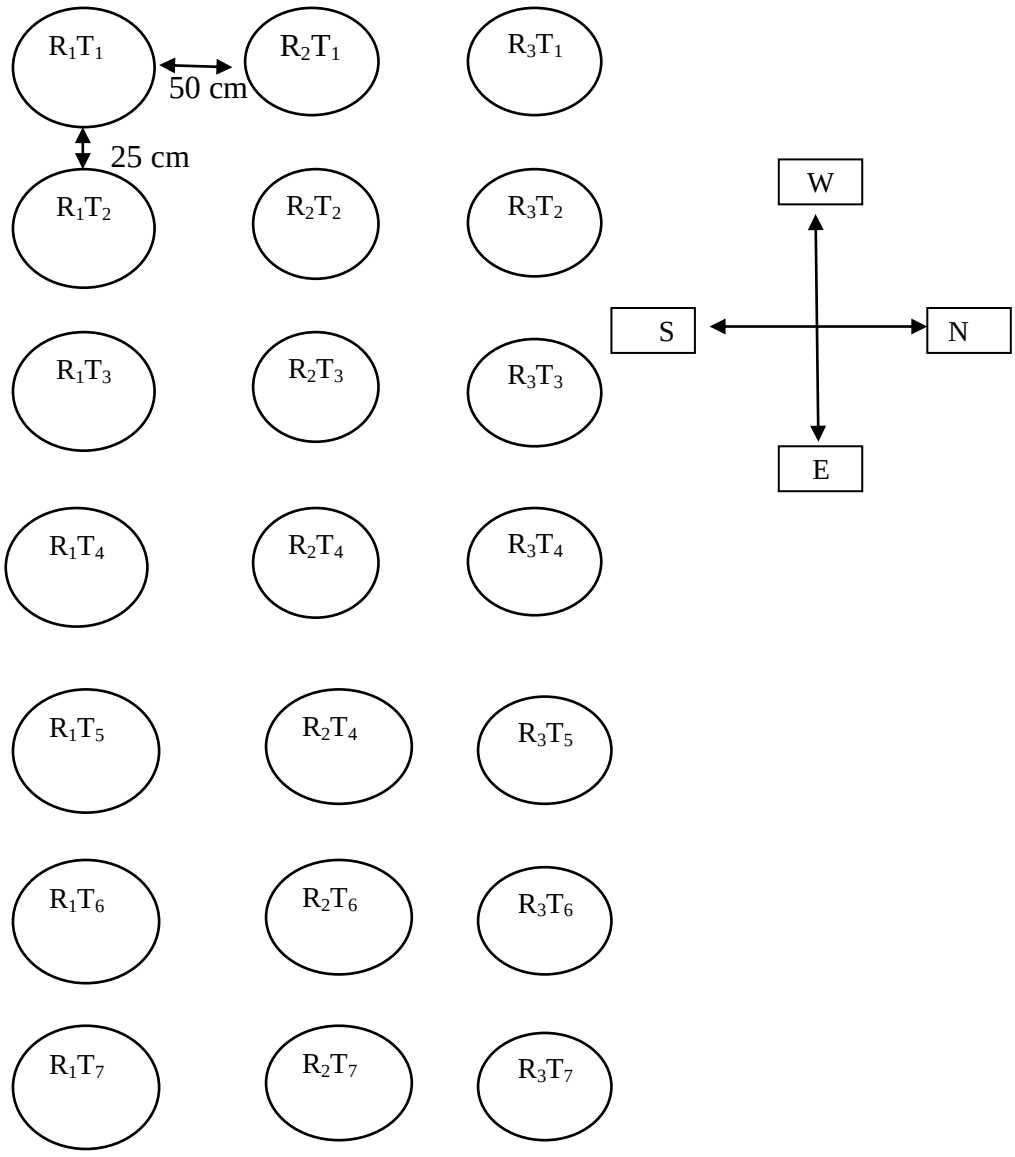


Fig. Layout of the experiment

### 3.11 Application of manures and fertilizers

In case of chemical fertilizers, Urea, TSP, MP and Gypsum were also mixed with each treatment mixtures during soil preparation as per 2.45 g $kg^{-1}$, 0.85 g $kg^{-1}$, 1.25 g $kg^{-1}$ and 490 mg $kg^{-1}$ material, respectively.

### 3.12 Pot preparation

There were 21 pots used in this experiment. Each treatment soil was prepared separately. 21 pots were contained 60 kg of soil was mixed with proper amount of manures and fertilizers and homogenized according to each treatment. Mixed soils were left for 10-15 days in the air, and then the pots were filled with fertilizer, manure and soil. Prepared soil without mixing any kind of manure and fertilizers was used as control. The pots were kept for 10-15 days in a shading place.

### 3.13 Seed rate and sowing seed

The recommended seed rate 1000gm $ha^{-1}$ seed was used. Before sowing seed in the pot, seeds were soaked in water for 24 hours and were sown in the pot on 17 August, 2023. Ten healthy and uniform seeds of indian spinach were sown at equal distance in each pot. After two weeks of seedling emergence, three seedlings were kept in each pot.

### 3.14 Intercultural operations

Intensive care was taken during the growing period to ensure adequate growth and development of the plant, which are given bellow:

#### 3.14.1 Weeding

Weeding was done to keep the plots free from weeds and for better aeration of soil, which ultimately ensured better growth and development. Newly emerged weeds were uprooted carefully after complete emergence of seedling of Indian Spinach. Breaking the crust of the soil was done when needed.

#### 3.14.2 Irrigation

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was provided as and when needed. Stagnant water was drained out at the time of heavy rain.

#### 3.14.3 Insect and pest control

There was no pest and diseases during the experimental period and hence no control measures were used.

### 3.15 Harvesting and post-harvest process

The plants were harvested at full maturity on 04 December, 2023. The yield was carefully harvested and carefully weighted each of plant of each pot.

### 3.16 Procedures of data collection

First data collection was done on 8th September 2023. Last data was collected on 30th December, 2023**.** The following parameters were recorded at harvest:

i. Branches per plant
ii. Branch height
iii. Plant height
iv. Number of leaves per plant
v. Root length
vi. Harvestable shoot biomass (Yield).

**Branches per plant**

Number per branches was measured from plants of each treatment and the number of branches per plant was recorded two times. It was considered only main lateral shoot.

**Plant height (cm)**

Plant height was measured from plants of each treatment from the base of the plant to the growing tip by holding the plant vertically at am interval of 15 day. The plant height was expressed in centimeter (cm).

**Branch height (cm)**

Branch height was measured from the base of the main shoot up to the tip of the top most leaf and expressed in cm.

**Number of leafs per plant**

Number of leaves of 3 randomly chosen plants was counted at 45, 60 and 75 days after seed sowing (DAS) all the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting the average number of leaves of 3 plants gave the number of leaves per plant

**Root length (cm)**

Length of the root of 3 plants per pot was measured in centimeter (cm) after harvest.

**Harvestable shoot biomass (Yield)**

The fresh weight of 3 plants shoot biomass was measured with an electrical balance from each treatment and their average was calculated at gram (g).

### 3.17 Analysis of soil sample

Initial and post-harvest soil samples for chemical properties were analyzed in the laboratory of the department of Soil Science, HSTU, Dinajpur. The soil chemical properties under the study were pH, total nitrogen, available P, exchangeable K contents.

### 3.17.1 Collection and preparation of soil sample

#### 3.17.1.1 Initial soil sample

The initial soil sample was collected before pot preparation from the depth plough layer (0-15cm). Samples were taken by means of an auger from 5 locations covering the whole area from where soils were collected and mixed thoroughly to make a composite sample, the composite sample was air dried, grounded and sieved through a 20-mesh sieve and stored in a plastic bag for physical and chemical analyses.

#### 3.17.1.2 Post harvest soil samples

After harvesting the crop soil samples were collected from each pot at 0-15 cm depth. The soil samples were air dried, grounded and sieved through a 20-mesh sieve. Prepared soil samples were stored in plastic bags for chemical analysis only.

### 3.17.3 Soil pH

The soil pH was measured with a glass electrode pH meter using soil water suspension of 1: 2.5 as described by Jeng (1962).

### 3.17.4 Available phosphorus (ppm)

This was extracted from the soil by shaking with 0.5 M sodium bicarbonate, at the pH 8.5 following. The phosphorus in the extract was determined by developing blue color using $SnCl_2$, reduction of phosphomolybdate complex. The absorbance of the phosphomolybdate blue color was measured at 660 nm wavelength in a spectrophotometer and available P calculated with the help of a standard curve.

### 3.17.5 Exchangeable potassium (me 100 g)

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

### 3.17.6 Available sulfur (ppm)

Available sulfur was determined by extracting the soil samples with $CaCl_2$ solution (0.15%). The S content in the extract was estimated turbid metrically with a spectrophotometer at 420 nm wavelength (Harade, 1984).

### 3.18 Statistical analyses

Data were analyzed by Statistical-10 software following the ANOVA technique at 5% level of significance. The mean differences among the treatments were compared by Welch's Test.

# CHAPTER IV
# RESULTS AND DISCUSSION

## 4.1 Plant height

Significant variation was observed in the plant height of Indian spinach at 45 DAS, 60 DAS, and 75 DAS due to the application of different levels of VM and bone meal powder. At 45 DAS, the highest plant height was found in $T_7$ (63.20 cm) when 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder was applied, which is statistically. The lowest plant height (24.66 cm) was found in $T_1$ (control). At 60 DAS, the highest plant height was observed in $T_5$ (31.58cm) 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g $kg^{-1}$ bone meal powder was applied. The lowest plant height (28.33 cm) was found in $T_3$. At 75 DAS, the highest plant height was observed in $T_4$ (67.83cm) 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g $kg^{-1}$ bone meal powder was applied. The lowest plant height (48.66 cm) was found in $T_1$ (control). In accordance with the present study, the positive role of nitrogen in enhancing plant height was reported by Wahocho *et al.* who showed that application of N at 140 kg $ha^{-1}$ increased plant height and other growth characters significantly.

**Table 4.1 Effect of organic and inorganic matter on the plant height of Indian spinach at different days after sowing (DAS)**

| Treatments | Plant height (cm) | | |
|---|---|---|---|
| | AT 45 DAS | AT 60 DAS | AT 75 DAS |
| $T_1$ | 24.66± 0.54 c | 30.66± 0.88 ab | 48.66± 6.69 c |
| $T_2$ | 51.08± 3.74 ab | 31.75± 0.25 a | 64.66± 3.28 ab |
| $T_3$ | 35.00± 1.26 bc | 28.33± 0.84 b | 53.0± 5.13 bc |
| $T_4$ | 34.03± 3.70 bc | 31.50± 0.5 a | 67.83± 6.58 ab |
| $T_5$ | 37.00± 5.50 bc | 31.58± 1.12 a | 62.0± 2.29 abc |
| $T_6$ | 61.66± 1.63 a | 31.50± 0.76 a | 67.50± 6.64 ab |
| $T_7$ | 63.20± 6.01 a | 31.33± 1.76 a | 68.66± 1.76 a |
| CV (%) | 24.66 | 30.66 | 48.66 |
| Significant Level | ** | ** | ** |

The data were presented as mean values.

PH=Plant height, *=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of significance.

Here,

T1 = Control (only soil)

T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g $kg^{-1}$ bone meal powder

T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g $kg^{-1}$ bone meal powder

T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g $kg^{-1}$bone meal powder

T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g $kg^{-1}$bone meal powder

T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$bone meal powder

T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder

Where, VM = Vermicompost and SE= Standard error, respectively.

### 4.2 Number of leafs

At 45 DAS, the maximum leaf number per plant (49.33) was observed in $T_7$ due to the application of 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder was applied. The minimum leaf number plant (21.33) was found in $T_1$ (Control). At 60 DAS, the maximum leaf number per plant (34) was observed in $T_2$ with 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g $kg^{-1}$ bone meal powder was applied, which is statistically analogous to $T_2$ (33.3 cm) and $T_5$ (32.0 cm). The minimum number leaf per plant (30.66) was found in $T_4$. At 75 DAS, the highest leaf number per plant (77.0) was observed in $T_4$ with 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder was applied, which is statistically similar to $T_7$ (75.0 cm) and $T_5$ (73.66 cm) $T_3$ (72.0 cm). The lowest leaf number plant (56.0) was found in $T_1$ (Control) which is similar to $T_2$ (58.0 cm). Hamid *et al.,* (1986) reported that nitrogen increased number of leaves $plant^{-1}$.

**Table 4.2 Effect of organic and inorganic matter on the number of Indian spinaches at different days after sowing (DAS)**

| Treatment | Leaf number/plant | | |
|---|---|---|---|
| | Leaf number per plant at 45DAS | Leaf number per plant at 60DAS | Leaf number per plant at 75DAS |
| $T_1$ | 21.33± 1.33 c | 31.00± 0.58 a | 56.00± 1 b |
| $T_2$ | 43.66± 1.33 ab | 34.00± 1.53 a | 58.00± 5.57 b |
| $T_3$ | 35.33± 0.33 b | 31.66± 0.33 a | 72.00± 4.58 a |
| $T_4$ | 32.00± 3.51 bc | 30.66± 1.20 a | 77.00± 4.93 a |
| $T_5$ | 31.33± 3.18 bc | 31.66± 2.73 a | 73.66± 1.76 a |
| $T_6$ | 38.33± 4.18 ab | 31.66± 0.88 a | 66.33± 2.60 ab |
| $T_7$ | 49.33± 8.82 a | 32.66± 0. 33 a | 75.00± 5.77 a |
| CV | 20.08 | 7.27 | 10.53 |
| Significant Level | ** | ** | NS |

The data were presented as mean values.
*=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of significance.
Here,
T1 = Control (only soil)
T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder
T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder
Where, VM = Vermicompost and SE= Standard error, respectively.

### 4.3 Length of branches

Significant variation was observed in branch length at 75 DAS due to the application of different levels of soil VM, sand and bone meal powder. At 75 DAS the maximum branch length (3.82 cm) was observed in $T_3$ when 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder applied which is statistically analogous to $T_6$ (3.66 cm) and $T_2$ (3.31 cm). The minimum branch length (3 cm) was observed in $T_1$ (control). It was noticed that the performance of organic fertilizers was much better and showing significant superiority over chemical fertilizer. The findings of Yaseen et al., (2009) are also in line that organic fertilizers i.e. mixture of farmyard and chicken manure, improved the vegetative growth characters of spinach plants.

**Table 4.3 The effect of organic and inorganic matter on the branch length of Indian spinach at different days after sowing (DAS)**

| Treatment | length of Branch (cm) 75 DAS |
|---|---|
| $T_1$ | 3.00± 0 b |
| $T_2$ | 3.31± 0.3 ab |
| $T_3$ | 3.82± 0.03 a |
| $T_4$ | 3.45± 0.02 ab |
| $T_5$ | 3.67± 0.32 ab |
| $T_6$ | 3.66± 0.33 ab |
| $T_7$ | 3.56± 0.29 ab |
| CV | 12.53 |
| Significant Level | ** |

The data were presented as mean values.

BL=Branch length; *=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of variation.

Here,
T1 = Control (only soil)
T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder
T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder
Where, VM = Vermicompost and SE= Standard error, respectively.

### 4.4 Biomass production

#### Fresh yield

There was insignificant variation was observed in fresh yield of Indian spinach at 75 DAS due to application of VM, Sand, and bone meal powder. At 75 DAS, the highest marketable shoot biomass (199.33 g) was found in $T_5$ treatment when 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder applied which is statistically analogous to $T_7$ (199.61 g). The lowest marketable shoot biomass (132.61g) was found in $T_1$. This finding was supported by Islam (2008).

#### Root length (cm)

There was significant variation was observed in root length of Indian spinach due to application of VM, Sand and Bone meal powder. The highest root length (12.98 cm) was found in $T_7$ treatment when 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder applied which is statistically parallel to $T_4$ (12.47 cm) and $T_3$ (12.07 cm). The lowest root length (9.06 cm) was observed in $T_2$ which is statistically similar to $T_5$ (10.52 cm). Roy et al., (2014) also found that organic manure additions to soil increased all the vegetative growth parameters expressed as fresh weight, leaf number, shoot and root length.

#### Root fresh weight $plant^{-1}$

Significant variation was observed in root fresh weight $plant^{-1}$ of Indian spinach due to application of VM, Sand and Bone meal powder. The highest root fresh weight $plant^{-1}$ (12.54 g) was found in $T_6$ treatment when 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$ bone meal powder application which is statistically similar to $T_3$ (11.55g). The lowest root fresh weight $plant^{-1}$ (10.55g) was found in $T_4$. Parraga *et al.* (1995) reported that poultry dropping produced the minimum root diameter and they also mentioned that application of organic matter with NPK fertilizers increased the diameter of root per plant, which supports the findings of the present study.

**Table 4.4 Organic and inorganic matter on marketable shoot biomass, total shoot biomass, root length, and root fresh weight of Indian spinach**

| Treatment | Fresh yield(g)/pot 75 DAS | Root length (cm): | Root fresh weight /plant (g) |
|---|---|---|---|
| $T_1$ | 132.67± 12.25 e | 11.96± 1.15 ab | 12.91± 1.81 a |
| $T_2$ | 148.00± 9.53 de | 9.06± 0.67 b | 10.92± 1.18 a |
| $T_3$ | 159.00± 1.15 cd | 12.07± 0.56 a | 11.55± 1.66 a |
| $T_4$ | 171.67± 7.68 bcd | 12.47± 1.62 a | 10.57± 0.85 a |
| $T_5$ | 199.33± 11.14 a | 10.52± 1.05 ab | 10.62± 0.83 a |
| $T_6$ | 175.33± 3.17 abc | 11.75± 1.16 ab | 12.54± 0.87 a |
| $T_7$ | 190.67± 2.51 ab | 12.98± 1.03 a | 11.66± 1.25 a |
| CV | 8.17 | 14.41 | 19.04 |
| Significant Level | ** | * | ** |

The data were presented as mean values.

*=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of significance.

Here,
T1 = Control (only soil)
T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder
T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder
Where, VM = Vermicompost and SE= Standard error, respectively.

### 4.5 Properties of post harvest soil

#### pH

There was considerable variation observed in pH of post harvest soil. The highest pH (6.73) was recorded in $T_5$ due to application of 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder which is statistically similar to $T_4$ (6.46). The lowest pH (5.90) was recorded in $T_3$ which is statistically similar to $T_7$ (5.95). The decreasing order of pH is $T_5$>$T_4$ >$T_2$>$T_1$>$T_6$~$T_7$>$T_3$. Among the organic treatments, the PM treatment resulted in the highest pH value as because poultry manure contained varying amounts of calcium carbonate (Camberato and Mitchell, 2011)

**EC (ds/cm) of post-harvest soil**

There was considerable variation recorded in EC of post-harvest soil. The highest EC (2.70) was recorded in $T_6$ this is due to 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$ bone meal powder compared to other. The lowest EC (1.46) was recorded in $T_1$ (control) treatment. The decreasing order of EC is $T_6 > T_4 > T_5 > T_2 > T_3 > T_7 > T_1$.

**Table 4.5 Effect of organic and inorganic matter on the properties of post-harvest soil**

| Treatments | pH | EC (ds/cm) |
|---|---|---|
| $T_1$ | 6.30 ± 0.152 bc | 1.46± 0.04 e |
| $T_2$ | 6.36 ± 0.088 bc | 2.40 ± 0.052 cd |
| $T_3$ | 5.90 ± 0.057 d | 2.47± 0.012 bcd |
| $T_4$ | 6.46 ± 0.145 ab | 2.61 ± 0.03 ab |
| $T_5$ | 6.73 ± 0.033 a | 2.53 ± 0.020 bc |
| $T_6$ | 6.10 ± 0.05 cd | 2.70 ± 0.008 a |
| $T_7$ | 5.95 ± 0.05 d | 2.34 ± 0.113 d |
| CV | 2.67 | 3.81 |
| Significant Level | ** | ** |

The data were presented as mean values.

*=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of significance.

Here,

T1 = Control (only soil)

T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder

T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder

T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder

T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder

T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder

T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder

Where, VM = Vermicompost and SE= Standard error, respectively.

### 4.6 Nutrient status of post harvest soil

#### % Total N

There was considerable variation observed in total N content of post harvest soil. The highest N content (0.02) was recorded in $T_6$ due to 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$ bone meal powder compared to other treatment. The lowest nitrogen content (0.01) was recorded in $T_4$ treatment. The increasing order of N is $T_4 < T_5 < T_2 \sim T_7 < T_3 < T_1 < T_6$. Similar results were found by Majeeduddin *et al.* (2015) they reported that plant height increased with the increasing levels of nitrogen application. Qamar-uz-Zaman *et al.* (2018) also agreed with this result. This experiment revealed that there was no remarkable difference in plant height of indian spinach compare to roof top and open field.

#### Available P (ppm)

Significant variation was observed in available P content in post harvest soil. The highest available P (97.91) content was observed in $T_4$ this is due to the 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal. The lowest available P content (76.45) was observed in $T_1$ (Control). The increasing order of available P is $T_1 < T_2 < T_3 < T_7 < T_6 < T_5 < T_4$. Majeeduddin *et al.* (2015) they reported that plant height increased with the increasing levels of phosphorus application.

#### Exchangeable K (me/100 g soil)

Considerable variation was observed exchangeable K in post-harvest soil. The highest exchangeable K (23.08) was recorded in $T_7$ due to 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder compared to other treatment. The lowest exchangeable K (11.9) was recorded in $T_2$. The increasing order of exchangeable K is $T_2 < T_1 < T_3 < T_5 \sim T_4 \sim T_6 < T_7$. Similar result was also found in their research with fertilizers and manures where NPK (Suggested dose) fertilizers gave the best yield and yield contributing parameters of Indian spinach (Islam et al., 2011; Olanrewaju, 2011)

#### Available S (ppm)

There was significant variation was recorded in available S of post-harvest soil. The maximum available S (73.33) was found in $T_1$ (Control) which is statically similar to $T_2$. The minimum available S (63.31) was recorded in $T_6$. The decreasing order of available S is $T_1 \sim T_2 > T_7 \sim T_4 \sim T_3 > T_5 > T_6$. Nuruzzaman (1999) and Quader (2007) reported similar results earlier. It was found that organic fertilizers performed better in comparison to chemical fertilizer.

**Table 4.6 Effect of organic and inorganic matter on the properties of post-harvest soil**

| Treatment | N % | P (ppm) | K (me/100 g soil) | S (ppm) |
|---|---|---|---|---|
| $T_1$ | 0.018± 0.001 b | 76.45± 0.594 g | 13.33± 0.44 d | 73.33± 0.422 a |
| $T_2$ | 0.015± 0.000 c | 80.93± 0.381 f | 11.9 ± 0.220 e | 73.21± 0.174 a |
| $T_3$ | 0.016± 0.000 bc | 87.51± 0.349 e | 19.16± 0.440 c | 70.55± 0.456 b |
| $T_4$ | 0.011± 0.000 d | 97.91± 0.220 a | 21.00± 0.288 b | 70.58± 0.683 b |
| $T_5$ | 0.013± 0.000 cd | 96.68± 0.213 b | 20.50± 0.763 b | 66.45± 0.785 c |
| $T_6$ | 0.022 ± 0.001 a | 94.83± 0.175 c | 21.75± 0.433 b | 63.31± 0.158 d |
| $T_7$ | 0.015 ± 0.001 c | 92.66±0.572 d | 23.08± 0.217 a | 71.08± 0.575 b |
| CV | 11.46 | 0.63 | 4.06 | 1.28 |
| Significant Level | ** | ** | ** | ** |

The data were presented as mean values.
*=5% level of significance; **=1% level of significance; NS=Not significant; CV=Coefficient of significance.

Here,
T1 = Control (only soil)
T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder
T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder
T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg-1 bone meal powder
T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg-1 bone meal powder
Where, VM = Vermicompost and SE= Standard error, respectively.

# CHAPTER V
# SUMMARY AND CONCLUSION

## 5.1 Summary

Growing media are used in smaller quantities and have a great role in the fertilizer program to achieve higher and sustainable crop yields. There is enormous potential for container gardening systems to utilize organic waste products from other industries and at the same time, recycle valuable nutrients. The experiment was conducted at HSTU, Dinajpur from August to December 2023, to study the different soil mixtures effect on the growth and yield of Indian spinach. The experiment was laid out in a Completely Randomized Design (CRD) with 7 treatments and 3 replications. The treatments were as follows; T1 = Control (only soil); T2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g $kg^{-1}$ bone meal powder; T3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder; T4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg-1 bone meal powder; T5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg-1 bone meal powder; T6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g $kg^{-1}$ bone meal powder; T7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder; Where, VC = vermicompost, respectively. The collected data were analyzed and the mean differences were compared by the Least Significant Difference test (LSD test) at a 5% level of significance. The results revealed that the highest growth and yield characteristics such as plant height, leaf number per plant, branch length, marketable shoot biomass, total shoot biomass, root length, root fresh weight $plant^{-1}$. Indian spinach responded significantly due to the application of different soil mixtures. The result found that significant variation was observed in the plant height of Indian spinach. At 45 DAS, the highest plant height was found in $T_7$ (63.20 cm) the lowest plant height (24.66 cm) was noticed in $T_1$ (control). At 60 DAS, the highest plant height was observed in $T_2$ (31.75 cm) the lowest plant height (22.9 cm) was found in $T_1$ (control). At 75 DAS, the highest plant height was noticed in $T_7$ (68.66 cm). The lowest plant height (48.66 cm) was found in $T_1$ (control). Insignificant variation was observed in the number of leaves per plant at 45 DAS and 75 DAS but there was significant variation was observed in the number plant at 45 DAS, 60 DAS and 75 DAS. The maximum leaf number per plant (49.0 cm) was found in $T_7$ at 45 DAS and the minimum leaf number per plant was noticed in $T_1$ (21.33 cm). The highest leaf number per plant (49 cm) was observed in $T_7$ at 45 DAS and the lowest leaf number plant (22.33) was found in $T_1$ (Control). The maximum leaf number per plant (32.66) was observed in $T_7$ at 60 DAS and the minimum number per plant (30.64) was found in $T_4$ (Control). The highest leaf number per plant (77.0) was noticed in $T_4$ at 75 DAS and the lowest leaf number plant (56.0) was found in $T_1$ (Control). Significant variation was observed in branch length. At 75 DAS the maximum branch length (3.82 cm) was observed in $T_3$ and the minimum branch length (3.0 cm) was observed in $T_1$ (control). There was insignificant variation was observed in Marketable shoot biomass of Indian spinach. At 75 DAS, the highest marketable shoot biomass (199.33g) was

found in $T_5$ treatment and the lowest marketable shoot biomass (132.67g) was found in $T_1$. Significant varation was observed in total shoot biomass of Indian spinach. The highest root length (12.47 cm) was found in $T_4$ treatment. The lowest root length (9.06 cm) was observed in $T_2$ Control). Significant variation was observed in root fresh weight plant$^{-1}$ of Indian spinach. The highest root fresh weight plant$^{-1}$ (12.99 g) was found in $T_1$ treatment the lowest root fresh weight plant$^{-1}$ (10.62g) was found in $T_5$(Control). There was considerable variation observed in pH of post harvest soil. The highest pH (6.73) was recorded in $T_5$. The lowest pH (5.95) was recorded in $T_7$ the decreasing order of pH is $T_5>T_4>T_2>T_1>T_6\sim T_7>T_3$. Considerable variation was observed in particle density of post harvest soil. There was considerable variation observed in total N content of post harvest soil. The highest N content (0.22) was recorded in $T_6$. The lowest nitrogen content (0.11) was recorded in $T_4$ treatment. The increasing order of N is $T_4< T_5 <T_2 \sim T_7< T_3< T_1< T_6$. Significant variation was observed in available P content in post harvest soil. The highest available P (97.91) content was observed in $T_4$. The lowest available P content (76.45) was observed in $T_1$ (Control). The increasing order of available P is $T_1<T_2< T_3< T_7< T_6<T_5 <T_4$. Considerable variation was noticed exchangeable K in post harvest soil. The highest exchangeable K (23.08) was recorded in $T_7$. The lowest exchangeable K (11.09) was recorded in $T_2$. The increasing order of exchangeable K is $T_2<T_1< T_3 <T_5 \sim T_4\sim T_6<T_7$. There was significant variation recorded in available S of post harvest soil. The maximum available S (73.33) was found in $T_1$. The minimum available S (63.31) was recorded in $T_6$ (control). The decreasing order of available S is $T_1\sim T_2>T_7 \sim T_4\sim T_3 >T_5>T_6$. There was considerable variation recorded in EC of post harvest soil. The highest EC (2.7) was recorded in $T_6$. The lowest EC (1.44) was recorded in $T_1$ (control) treatment. The decreasing order of EC is $T_6>T_4 >T_5 >T_2 > T_3 >T_7>T_1$. There was considerable variation observed in CEC of post harvest soil. The maximum CEC (15.0) was found in $T_4$. The minimum CEC (10.6) was observed in $T_1$ (control). The increasing order of CEC is $T_1< T_7< T_6 <T_2 <T_3 <T_5 <T_4$.

### 5.2 Conclusion

Above all findings, the best soil mixture is T7(60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg$^{-1}$ bone meal powder) and further research is required across our country to evaluating the role of soil mixtures in improving growth and yield of Indian spinach.

### 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 $T_7$ (60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g $kg^{-1}$ bone meal powder) at their rooftop cultivation to fulfill their family demand.
2. Further research can be conducted to know how soil physiochemical properties after the incorporation of different soil mixtures can impact quality characters of Indian spinach

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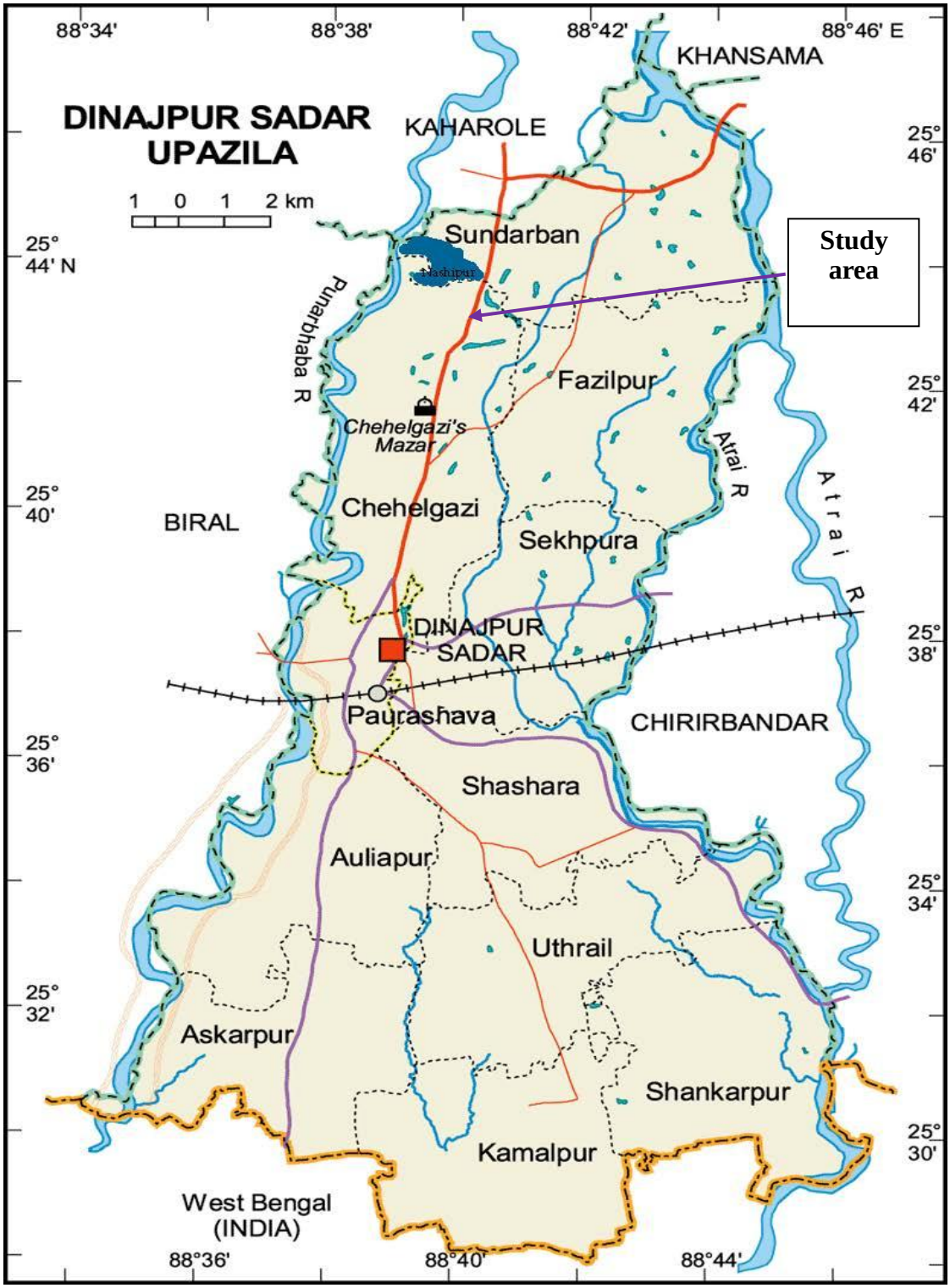
## APPENDICES

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



# Experimental Photos