

**EFFECT OF DIFFERENT DOSES OF COW DUNG WITH  
CHEMICAL FERTILIZER ON NAPA SHAK (*Malva verticillata* L.)**

**A THESIS**

**BY**

**MST. SABINA YEASMIN**

**Student No. 1601335**

**Session: 2021-2022**

**Thesis Semester: January - June, 2023**

**MASTER OF SCIENCE (M.S.)**

**IN**

**SOIL SCIENCE**



**DEPARTMENT OF SOIL SCIENCE**

**HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY**

**UNIVERSITY, DINAJPUR, BANGLADESH**

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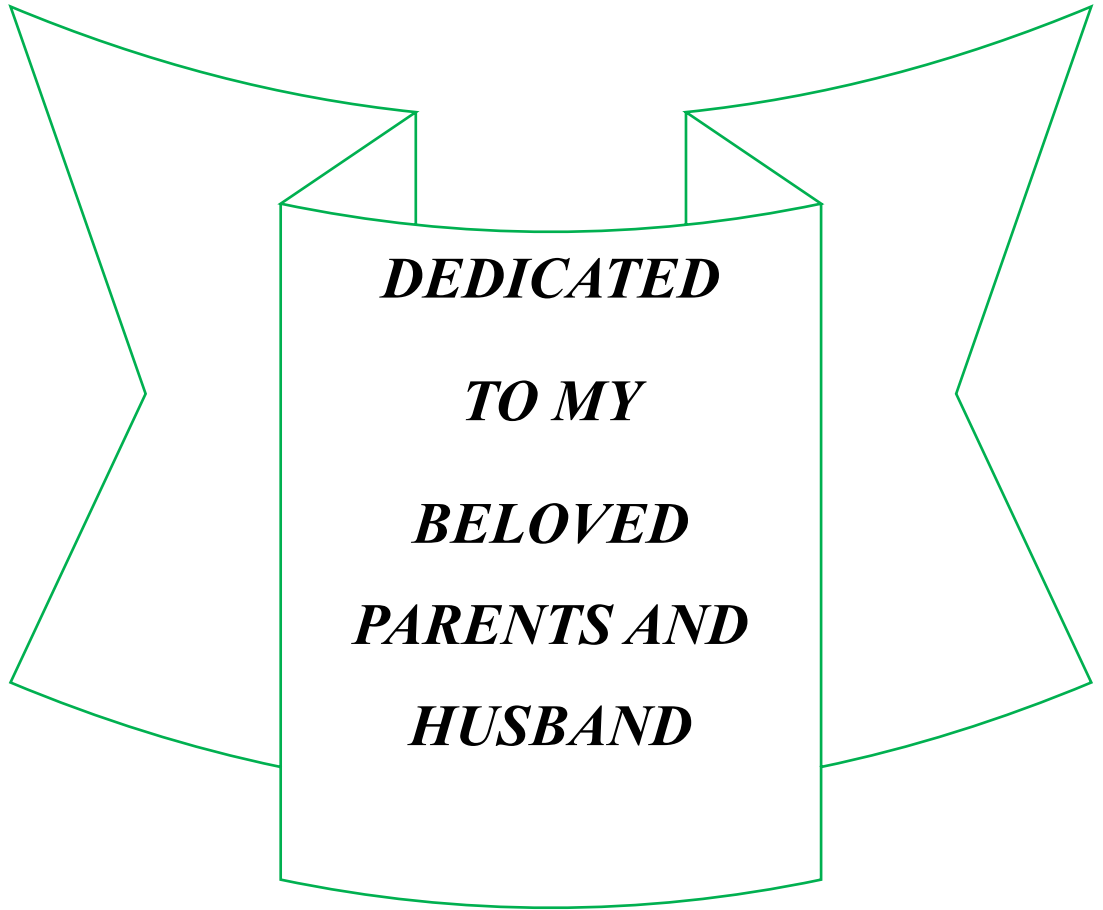
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**DEPARTMENT OF SOIL SCIENCE  
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY  
UNIVERSITY, DINAJPUR, BANGLADESH**

**DECEMBER 2023**



***DEDICATED***  
***TO MY***  
***BELOVED***  
***PARENTS AND***  
***HUSBAND***

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*The Authoress*

## ABSTRACT

A field experiment was conducted at Soil Science Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh December 2022 to February 2023 aimed to evaluate the impact of various organic and chemical fertilizers and their combination on Napa Shak growth. The experiment involved six treatments: T<sub>1</sub> = Control, T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP) in RCBD experimental design. The data was collected on plant height (cm), fresh shoot weight (g), fresh root weight (g) and availability of post-harvest soil S (ppm), P (ppm), exchangeable K (meq 100 g<sup>-1</sup> soil), total N (%), pH, OC (%), and OM (%). The Statistix 10 program was used for data analysis, and the Least Significant Difference (LSD) test was utilized to evaluate disparities between treatments. The study found that cow dung combined with chemical fertilizers significantly improved the height of plants, shoots and roots fresh weight of Napa Shak. The highest plant height was 18.15 cm at 15 DAS, followed by T<sub>5</sub>, T<sub>4</sub>, and T<sub>3</sub>. The lowest value was T<sub>1</sub> (11.59 cm). The highest plant height was achieved at 30 DAS, with T<sub>6</sub> reaching 27.00 cm, followed by T<sub>5</sub>, T<sub>4</sub>, and T<sub>3</sub>, and T<sub>2</sub> and T<sub>1</sub> having the smallest height of 15.40 cm. Move to the harvest, the highest plant height obtained from T<sub>6</sub> (52.70 cm) which was statistically similar to the T<sub>5</sub> (50.07 cm) followed by T<sub>4</sub> (42.37 cm). The smallest plant height was obtained from T<sub>1</sub> (control) (24.90) cm. The highest shoot fresh weight was obtained from T<sub>6</sub> (6.70 g), followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub>, and T<sub>2</sub> and lowest was T<sub>1</sub> (control) of 0.35 g. Root fresh weight was statistically similar for all treatments, but T<sub>3</sub> had the highest value (0.53 g) after harvest. The highest availability of N, P, S, pH, OC and OM were found 0.16%, 39.46 ppm, 15.32 ppm, 6.27, 0.67% and 1.17 % respectively in T<sub>6</sub> and the lowest from the T<sub>1</sub>. The study suggests further research on cow dung combined with chemical fertilizers for Napa Shak cultivation in different Agroecological zones (AEZ) of Bangladesh for regional adaptability.

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## LIST OF ABBREVIATIONS AND ACRONYMS

<i>et al.</i>	and others
%	Per cent
g	Gram
N	Nitrogen
P	Phosphorus
K	Potassium
pH	Potential of hydrogen
S	Sulphur
m <sup>2</sup>	Square
BBS	Bangladesh Bureau of Statistics
TSP	Tripple super phosphate
MOP	Muriate of potash
OC	Organic Carbon
OM	Organic Matter
RCBD	Randomized Complete Block Design
AEZ	Agroecological zone
@	At the rate
HSTU	Hajee Mohammad Danesh Science and Technology University
DAS	Days after sowing
FAO	Food and Agriculture Organization
UNDP	United Nations Development Program
°C	Degree Celsius
LSD	Least Significant Difference
AEZ	Agroecological Zone
CV	Co-efficient of variance
t ha <sup>-1</sup>	Ton per hectore

# CHAPTER I

## INTRODUCTION

*Malva verticillata*, also known as the Chinese mallow or cluster mallow and Napa Shak in Bengali, a species of the mallow genus *Malva* in the family of Malvaceae found in East Asia from Pakistan to China. This plant is used as a popular leafy vegetable (Ya *et al.*, 2007) in East Asia, Korea, and China for a long time (Odontuya, 2012). A total of 44 distinct species were found and classified into 33 different genera, which in turn belonged to 20 distinct families. Among the documented species, the majority (69.44%) were classified as herbs, while climbers accounted for 18.18% of the recorded species. Shrubs constituted 11.11% of the species, and trees represented a smaller proportion at 2.27%. Within the realm of investigation, it was observed that wild species constituted 34.09% of the overall sample, whereas farmed species accounted for the remaining 65.91% found from a consensus in the Rangpur city corporation of Bangladesh from October 2019 to December 2021 (Sumona *et al.*, 2022). The vegetable output in Bangladesh during the period of 2019-2020 amounted to 13.555 million tons, which is deemed insufficient to satisfy the prevailing demand. Consequently, in order to address this issue, the yield has been augmented by 14.616 million tons in the subsequent year of 2020-2021. The depletion of soil fertility in Bangladesh has been attributed to the progressive increase in agricultural intensity coupled with unbalanced fertilization (BBS, 2021). Bangladesh has experienced a consistent growth in vegetable production over the past 23 years, with an average yearly rate of 2.8 percent. Although there has been an increase in vegetable output, the consumption of vegetables remains relatively low in comparison to other nations (Haque, 2021).

*M. verticillata* is an annual or biennial. Two species of *Malva* are locally known as 'lapha' being used as a green leafy vegetable. Published literature refers to the same local name and use of *Malva parviflora*. The critical morphological study of the taxa has delineated two taxa as *Malva parviflora* L and *M. verticillata* L, former is a weed of wastelands whereas the latter is grown as vegetable in some parts of Assam, Bihar and West Bengal. *M. verticillata* preferred most by locals due to its easy-to-cultivate nature and having high nutritive/therapeutic value, which indicates its potential to cultivate during the lean period in those areas where few greens are grown (Kumar *et al.*, 2023).

Uses of these taxa as potherb and fodder (*M. verticillata* and *M. parviflora*) or used as medicinal (*M. pusilla* and *M. sylvestris*) are well known because these are nutritionally rich in calcium, iron and carotene. Ahmedullah and Sanjappa (2008) reported that seeds of *M. parviflora* contain 18% fatty oil and seeds of *M. neglecta* yield 7–8% fatty oil. Furthermore, its seed, commonly known as Dong-Kui-Zi, has long been used as traditional Chinese medicines for the treatment of diuretic, laxative, and galacto-poietic. So far, most of the studies on genus *Malva* were focused on chemical composition, biological activity, morphological taxonomy, and molecular phylogeny (Li *et al.*, 2020, Shim *et al.* 2016).

The leaves of *Malva verticillata* L. are commonly consumed as vegetables in the northern part of Bangladesh, locally known as Laffa or Napa Shak. Considering the importance of *Malva verticillata* L. Much work has been done on its seed and different polysaccharides have been isolated previously such as MVS-IIA and MVS-IIG as a neutral polysaccharide, MVS-V as the major pectic peptidoglycan, MVS-I also as a neutral polysaccharide, MVS-VI as a novel acidic polysaccharide. On the other hand, in the case of leaves antimicrobial activity and phytochemical analysis have been carried out for different solvent extracts. However, according to a literature survey, no report on phytochemical constituents of *Malva verticillata* L. (Shahabuddin *et al.*, 2017). In oral glucose tolerance tests, MEMV dose-dependent and significantly reduced blood glucose levels in glucose-loaded mice. At doses of 50, 100, 200 and 400 mg per kg body weight, MEMV lowered blood glucose levels by 20.4, 32.0, 37.2, and 46.6%, respectively, compared to control animals (Akter and Rahmatullah, 2018). Folk medicinal practitioners in Dhaka city reportedly use leaves and roots of the plant to strengthen heart, liver, and stomach functions and for treatment of helminthiasis and piles (Jahan, 2015). Antidiabetic activity has been reported for ethanol extract of seeds of the plant (Jeong and Song, 2011). Flavonoid 8-O-glucuronides have been isolated from aerial parts of the plant, which exhibited significant recovery effect on pancreatic islets of zebrafish larvae damaged by alloxan (Ko *et al.*, 2018).

The combination of cow dung and chemical fertilization is vital for Napa Shak cultivation. Cow dung provides essential organic matter and nutrients, enhancing soil structure and fertility. When synergistically paired with chemical fertilizers, this combination optimally supports Napa Shak growth, ensuring a balanced nutrient supply for robust and healthy crop development.

Therefore, the present study was undertaken with the following objectives:

1. To assess the impact of different doses of cow dung combined with chemical fertilizer on the growth parameters of *Malva verticillata* L.
2. To evaluate the nutritional content, retain after post-harvest under varying fertilization regimes.
3. To analyze soil fertility and microbial activity in response to different fertilization treatments.

## CHAPTER II

### REVIEW OF LITERATURE

Napa Shak, sometimes known as Chinese mallow, holds significant agricultural importance in Bangladesh, as well as in numerous other countries across the globe. The crop has been relatively neglected by researchers in terms of its many characteristics, likely due to its tendency to be grown with minimal care or management practises. Limited research has been conducted in our country regarding the growth, yield, and development of Napa Shak. This chapter provides an overview of significant works and research conducted both domestically and internationally on the management of organic and chemical fertilisers in relation to the production of various vegetable crops, especially Napa Shak. The following headings have been used to organise the discussion.

#### 2.1 Effects of Organic Fertilizers on Vegetable Growth

In their study, Miaha *et al.* (2020) conducted an experiment to assess the growth and yield outcomes of okra (*Abelmoschus esculentus* (L.) Monech) when exposed to several types of organic fertilisers. The researchers aimed to determine the fertiliser treatment that would optimise both the growth and production of okra. Data on various parameters including plant height (cm), number of leaves, total flower count, total number of fruits, fruit length (cm), and fruit weight (g) were collected to assess the growth and yield of the plant. Although the fruit weight was found to be higher in the FYM + Vermi-Compost treatment (72.78 g), the Integrated Nutrient Management treatment exhibited superior growth and yield results in terms of plant height, number of leaves, total flowers, total number of fruits, and fruit length compared to the other treatments.

A pot experiment was conducted to study the effect of arbuscular mycorrhiza, cowdung and P on red amaranth and Indian spinach in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh. The experiment was laid out in a Completely Randomized Design (CRD) with five replications and 8 treatment combinations comprised of T<sub>1</sub>: Control, T<sub>2</sub>: Arbuscular mycorrhiza (AM), T<sub>3</sub>: Cowdung (CD), T<sub>4</sub>: P, T<sub>5</sub>: AM + CD, T<sub>6</sub>: CD + P, T<sub>7</sub>: AM + P and T<sub>8</sub>: AM + CD + P. Red amaranth (*Amaranthus tricolor* L.) cv. BARI Lalshak-1 and Indian spinach (*Basella alba*) cv. BARI Puishak-1 were used as test crops for the

experiment. The experimental results showed that there were significant differences in growth and yield characters such as plant height, plant diameter, number of leaves per plant, shoot fresh and dry weights, root fresh and dry weights of red amaranth and Indian spinach due to the application of arbuscular mycorrhiza (AM), cow dung (CD) and P independently and combinedly. When arbuscular mycorrhiza, CD and P were applied combinedly, it exhibited a remarkably higher response in growth and yield of these vegetables (Ghosh *et al.*, 2017).

According to Makinde and Ayoola (2012) revealed in okra fruit production supported with application of organic manures, to reduce the use of chemical fertilizers to assess the growth and yield of okra (Variety: NH47-4) with cow dung (CD) and poultry manure (PM) applications at 0, 5, 10, 15 and 20 t ha<sup>-1</sup> in RCBD with four replicates in experiment. Plants were generally taller for PM than CD. But cow dung gave higher fruit yields.

A pot experiment was conducted by Uddin *et al.*, (2012) to investigate the effect of cow manure, city waste, chicken manure and TSP on the growth of water spinach (*Ipomoea aquatica* cv. Kankon) and the phytoavailability of P in soil. An air-dried sandy loam soil was mixed with cow manure, city waste, chicken manure and TSP at rates equivalent to 0, 200, 400 and 800 mg P kg<sup>-1</sup> soil based on total P. The number of leaves, maximum height, and dry weight of shoot and root of water spinach were influenced by these amendments and their different application rates. The highest leaf number, maximum height, dry weight of shoot and root were obtained with the cow manure treatment of 800 mg P kg<sup>-1</sup>. Among the amendments, TSP produced the least dry matter yield. After the plant harvest, Olsen P of the soil was measured and increased with P application rates. The extractability of P from different amendments was in the order: TSP > cow manure > chicken manure > city waste.

A study was undertaken by Ama *et al.* (2022) to investigate the impact of three varying rates of cattle dung treatment on growth characteristics, proximate and mineral content, weight loss, and shelf life of *Amaranthus cruentus* and *Corchorus olitorius*. The experimental treatments consisted of different rates of cattle dung manure application, specifically 0, 0.5, 0.8, and 1.1 t ha<sup>-1</sup>. The highest plant height on the 20th day after transplanting was seen when applying a rate of 1.1 t ha<sup>-1</sup> in *Amaranthus cruentus*. The application rate of 0.8 t ha<sup>-1</sup> resulted in the greatest number of leaves and shoots seen

in *Amaranthus cruentus*. The administration of manure resulted in higher rates of stem girth, which exhibited significant variation compared to stems that did not receive manure application. The findings of the study examining the impact of various rates of application on *Corchorus olitorius* indicate that, overall, there was no statistically significant distinction observed between the treatments with manure application and those without. The growth parameters experienced a drop as a consequence of the heightened rates of application. The findings on the shelf life of *Amaranthus cruentus* and *Corchorus olitorius* indicated that both experienced wilting after 24 hours and drying after 48 hours post-harvest. In summary, the research findings indicate that the heightened utilisation of bovine excrement resulted in favourable effects on the growth metrics of *Amaranthus cruentus*.

A greenhouse experiment was conducted to study the relative effect of organic and inorganic fertilizers on the growth of okra (*Abelmoschus esculentus*) in RCBD with three replications. The application of poultry droppings gave plants with the greatest plant height, leaf area and fresh weight, while cow dung application gave the greatest dry weight (Uka *et al.*, 2013).

The study conducted by Pohan *et al.* (2021) investigated the impact of organic fertilisers on the growth and yield of water spinach (*Ipomoea reptans* Poir) within the Green House of the Biology Department, Faculty of Mathematics and Natural Sciences at Universitas Negeri Medan. The experiment was conducted using a Completely Randomised Factorial Design, which consisted of two components and three repetitions. The initial component under consideration pertains to the specific type of fertiliser employed, namely chicken manure, cow manure, and compost. The subsequent aspect to be examined relates to the dosage of the fertiliser, specifically categorised as 1:1, 2:1, and 3:1 ratio. To assess plant development and yield, various parameters were examined, including plant height, number of shoots, number of leaves, fresh weight, dry weight, leaf's total chlorophyll content, and water content. The data collected was analysed using the General Linear Model in the SPSS 21 software. The findings of the study demonstrated a considerable enhancement in plant growth and output when cow dung was applied at a ratio of 2:1, indicating the most effective treatment. Subsequently, the application of cow manure at a ratio of 3:1 also resulted in notable improvements. The application of cow manure resulted in a significant increase in the overall chlorophyll content (8.0574c mg. L<sup>-1</sup>), with the optimal dosage being a

ratio of 2:1 (8.2807 mg. L<sup>-1</sup>). The water content of the plant was found to be relatively high in chicken dung, with a percentage of 93%. Conversely, cow manure with a dose ratio of 3:1 exhibited a lower water content of 87.5%.

Mohosina (2019) carried out an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh, during the period from October 2014 to February 2015 to study the effects of cow dung and boron on growth and yield of broccoli. The experiment consisted of two factors; Factor A: cow dung - 4 levels such as C0: no cow dung (control), C1: cow dung 10 t ha<sup>-1</sup>, C2: cow dung 15 t ha<sup>-1</sup> and C3: cow dung 20 t ha<sup>-1</sup>. Factor B: boron - 4 levels, such as B0- no boron (control), B1: boron 1 kg/ha, B2: boron 2 kg/ha and B3: boron 3 kg/ha. The experiment was laid out following a randomized complete block design (RCBD) with three replications. In case of cow dung the maximum plant height at 60 DAT (61.47 cm), spread of plant at 60 DAT (50.00 cm), number of leaves per plant at 60 DAT (11.39), length of the largest leaf at 60 DAT (57.69 cm), primary curd weight (374.58 g), yield per hectare (15.74 t ha<sup>-1</sup>) were recorded from C3 (cow dung 20 t ha<sup>-1</sup>) treatment and the lowest was recorded from the control (C0) treatment. In case of boron the maximum plant height at 60 DAT (57.69 cm), spread of plant at 60 DAT (48.44 cm), number of leaves per plant at 60 DAT (11.21), length of the largest leaf at 60 DAT (54.45 cm), primary curd weight (286.78 g), yield per hectare (12.03 t ha<sup>-1</sup>) and the minimum days required for curd initiation (51.17 DAT) were recorded from B2 (boron 2kg/ha) treatment and the lowest was recorded from control (B0) treatment. Regarding combination of cow dung and boron the maximum plant height at 60 DAT (63.11 cm), spread of plant at 60 DAT (52.33 cm), number of leaves per plant at 60 DAT (12.97), length of the largest leaf at 60 DAT (60.25 cm), primary curd weight (399.33 g), yield per hectare (16.71 t ha<sup>-1</sup>) and the minimum days required for curd initiation (50.10 DAT), were recorded from C3B2 (cow dung 20 t ha<sup>-1</sup> and boron 2 kg/ha) treatment and the lowest was recorded from C0B0 (no cow dung and no boron) treatment. The highest production of broccoli is obtained from 20 t ha<sup>-1</sup> cow dung and 2 kg/ha boron at Horticulture farm condition of Bangladesh Agricultural University, Mymensingh.

## 2.2 Effects of Chemical Fertilizers on Vegetable Growth

Zielewicz and Wróbel (2018) carried out to determine and analyze chemical and biological properties of fodder mallow and maize (Eurostar variety) as well as opportunities of their cultivation in pure sowing and when dedicated to fodder in the years 2011-2012 in Department of Grassland and Natural Landscape Sciences at Poznań University of Life Sciences located in Brody Experimental Farm (52°43' N, 16°30' E). The research material consisted of fodder mallow plants and maize cultivars Eurostar variety FAO 240 with three replications with three variants of N fertilization: 120 (control), 160 and 200 kg of N/ha. Larger doses of N enhanced the content of crude proteins both in the case of fodder mallow and maize. An advantage of fodder mallow over maize consists in a higher richness in mineral components (especially calcium, P and K). Fodder mallow and maize accumulated similar amounts of silicon, which is favorable for the nutritional value of the obtained fodder. Fodder mallow surpasses maize when the content of crude proteins is concerned.

The study conducted by Naher *et al.* (2014) aimed to investigate the impact of various macro and micronutrients (specifically N, P, K, S, zinc, boron, and molybdenum) on the growth and yield of cabbage in the calcareous soil of Chapai Nawabganj, located in the High Ganges River Floodplain. The experiment was carried out from November 2008 to March 2009, with nutrient application rates set at 150 kg/ha for N, 50 kg/ha for P, 100 kg/ha for K, 20 kg/ha for S, 3 kg/ha for zinc, 3 kg/ha for boron, and 1 kg/ha for molybdenum. The growth and yield of cabbage were significantly influenced by the application of various nutrients.

Chen *et al.* (2004) carried out an experiment to investigate the advanced N advisory systems that require target values of N supply for the crop. Two field experiments with different N supply levels were conducted in the Beijing region to determine the target values of N supply and N mineralization rates for optimization of N fertilization of Chinese cabbage (*Brassica campestris* L. ssp. *Pekinensis*). Crop yield, N uptake, and soil inorganic N was investigated during the crop growth periods. Marketable yields of the crop increased significantly with N application rate. The agronomically effective N supply levels for Chinese cabbage growth in Beijing region were 349 and 277 kg N ha<sup>-1</sup>, respectively, for target marketable yields of 120 t FW ha<sup>-1</sup> for Chinese cabbage.

Experiments were carried out by Wang and Li (2004) on a vegetable field with Peking cabbage (*Brassica pekinensis* Lour. Rupr.), cabbage (*Brassica chinensis* var. *oleifera* Makino and Nemoto), green cabbage (*Brassica chinensis* L.), spinach (*Spinacia oleracea* L.), and rape (*Brassica campestris* L.) to study the effects of N forms and rates, and P fertilization on their growth and nitrate accumulation. The results indicated that application of ammonium chloride, ammonium nitrate, sodium nitrate, and urea significantly increased the yields and nitrate concentrations of Peking cabbage and spinach. Although N forms had no significantly different effect on yields, input of nitrate N fertilizer increased nitrate accumulation in vegetables much more than did ammonium N. Vegetable yields were not increased continuously with N rate, and an excess input of N fertilizer more or less reduced plant growth, leading to yield decline for the earlier harvests. This trend was also true for nitrate concentrations in some vegetables and at some sampling times. However, as a whole, nitrate concentrations in vegetables were positively correlated with N rates. As a result, addition of N fertilizer to soil was the major cause for vegetables increasing their nitrate contents. Effects of P fertilization on vegetable growth and nitrate accumulation were species and sampling-time dependent. By addition of P fertilizer, yields of green cabbage and rape were increased, while those of spinach and cabbage had no significant changes. The nitrate concentration was significantly decreased in green cabbage, but significantly increased in cabbage and rape by P fertilization at the second harvest. Different organs had different amount in nitrate accumulation, and it was found that nitrate concentrations were much higher in roots, stems, and petioles than in blades at any N rate.

In their study, Shariful *et al.* (2019) did an experimental investigation on tomato plants in order to assess the impact of N and P on both the growth and yield components of the tomato crop. Four different levels of N were employed in this study, namely N0 (0 kg N/ha), N100 (100 kg N/ha), N150 (150 kg N/ha), and N200 (200 kg N/ha). Additionally, four levels of P were also utilised, namely P0 (0 kg/ha), P50 (50 kg/ha), P100 (100 kg/ha), and P150 (150 kg/ha) as P2O5 (205 kg/ha). It was observed that the quantity of flowers per plant, the number of fruits per plant, and the weight of fruits per plant exhibited a notable rise as the N level increased up to 200 kg N/ha. Additionally, the fruit yield also displayed a substantial increase up to 200 kg N/ha.

### 2.3 Combined effect of Organic and Chemical Fertilizers Vegetable Growth

Gudugi (2013) conducted a trial to examine the impact of cow dung and inorganic fertilizer in Teaching and Research Farm of Ibrahim Badamsi Babangida University on the growth and yield of Okra. The experiment involved two Okra varieties and four levels of cow dung. The inorganic fertilizer was applied at a rate of 200kg ha<sup>-1</sup>. The results showed that cow dung applied at 20 t ha<sup>-1</sup> and inorganic fertilizer significantly produced taller plants, more leaves, and more fruits. Non-application of fertilizer delayed flowering. The highest fruit weight was obtained in 2012 with cow dung at 20 t ha<sup>-1</sup>.

A study was conducted by Noor *et al.*, (2022) to investigate the effect of organic fertilizer, inorganic fertilizer, and compound fertilizer applications on the plant growth of water spinach (*Ipomoea aquatic*) under polyculture system. It was grown under a polyculture planting condition with okra (*Abelmoschus esculentus*) and yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) and treated with five different types of fertilizer regime (T<sub>1</sub>: without fertilizer, T<sub>2</sub>: organic fertilizer, T<sub>3</sub>: inorganic fertilizer, T<sub>4</sub>: compound fertilizer and T<sub>5</sub>: organic + inorganic fertilizer). For each treatment group, a total amount of 9 g m<sup>-2</sup> of N, P and K each were applied throughout the experiment. The present results showed that under polyculture condition, no significant difference was observed in the total weight, root weight, root length and leaf number of water spinach under different treatments. However, significant differences were found for plant height of water spinach among the five treatment groups. In addition to crop growth, the fertilizer application also influenced the soil pH, EC, OM and moisture content after one cropping season. In the study, the growth of water spinach following application of organic fertilizer was found comparable to the inorganic fertilizer treatment. Incorporation of organic and inorganic fertilizer (T<sub>5</sub>) served the best condition for the growth of water spinach under the polyculture system.

Singh *et al.* (2020) carried out an experiment with ten treatments having different combination of organic manures and inorganic fertilizers to find out the effect of integrated nutrient management (INM) on growth and yield of broccoli and found that the application of integrated nutrient management significantly increased the growth and yield of broccoli. The use of 10 t ha<sup>-1</sup> vermicompost + 50% RDF recorded the earliest days to head initiation (57.13 days) and first harvesting (80.07 days), maximum

head weight (190 g), head diameter (110.33 mm), yield/plot (4.50 kg) and yield/ha (50.29 q).

A study conducted by Tonoya (2014) the impact of varying N fertilizer levels, specifically urea, in conjunction with cow dung (CD), on the growth and yield of green amaranth cv. The BARI Data-I was examined at the Sher-e-Bangla Agricultural University Farm from April to May 2014. The growth and yield contributing parameters were increased with the increasing cow dung levels up to 5 t ha<sup>-1</sup> with N fertilizer combination. The highest green yield (69.74 t ha<sup>-1</sup>) was obtained from the interaction of N3C1 (125 kg N ha<sup>-1</sup> and 2.5 t CD ha<sup>-1</sup>) treatment.

In a study conducted by Yogita *et al.* (2022), it was observed that the application of a mixture of 50:25:25 kg NPK ha<sup>-1</sup>, 2.5t ha<sup>-1</sup> FYM, 1.65t ha<sup>-1</sup> vermicompost, 5kg ha<sup>-1</sup> Azatobacter, and 5 kg ha<sup>-1</sup> PSB resulted in the highest observed outcome for the treatment of bottle gourd.

Field trial was conducted by Awotoye *et al.* (2011) with the view to determining the ideal rock phosphate (RP) and the level of cow dung fertilizer combination with respect to heavy metal contamination of soil and crops. Soils amended with Ogun rock phosphate (ORP) were subjected to 1-4 t ha<sup>-1</sup> of cow dung on which maize (*Zea mays* (L)) and okra (*Abelmoschus esculentum*) were planted. The amended soils were found to be enriched with heavy metals (Pb, Zn, Cu and Cd) more than the unamended soil but were still within the tolerable level with the exception of Cd which had a high value of 5.30  $\mu\text{g g}^{-1}$  above the critical value of 3  $\mu\text{g g}^{-1}$ . The application of RP in combination with various levels of cow dung elevated the Pb, Zn and Cu content in the tissue of maize relative to the control. The Zn and Pb content of okra were not affected except for Cu and as in soil amended with RP and various levels of cow dung relative to the control. Transfer factor (TF) was higher in the treatment with RP supplemented with 2 t ha<sup>-1</sup> of cow dung particularly for Pb and Zn for both crops relative to other treatments. Except for Cu and Zn, increasing the level of cow dung while RP did not increase the TF value of the heavy metals to the crops.

In a study conducted by Seran *et al.* (2016), an experiment was carried out to assess the impact of the combination of NK chemical fertilisers and compost on the growth and yield characteristics of tomatoes. The marijuana trial was conducted using a complete randomised block design, consisting of eight treatments and four repetitions.

Significant variations were observed in fruit and seed weights, total soluble solids, pulp weight, 100 seed weight, pulp consistency, leaf area, and crop residue. Within the specified parameters, it was seen that chemical fertilisers combined with compost (2 kg per m<sup>2</sup>) yielded higher mean values compared to the application of chemical fertilisers alone (9.0 g N + 8 g K<sub>2</sub>O + 15 g P<sub>2</sub>O<sub>5</sub> per m<sup>2</sup> as the standard control). The chemical fertilisers used in combination consisted of 7.5 g N, 6 g K<sub>2</sub>O, and 15 g P<sub>2</sub>O<sub>5</sub> per m<sup>2</sup>.

A scientific investigation conducted by Rahman *et al.* (2012) to investigate the effects of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili the experiment in RCBD with three replications at Botanical Garden of Rajshahi University Campus, Bangladesh during August 2008 to February 2009. There were 15 treatments viz. T<sub>1</sub> = bio compost (3 kg/pot) + NPK, T<sub>2</sub> = bio compost (2 kg/pot) + NPK, T<sub>3</sub> = bio compost (1.5 kg/pot) + NPK, T<sub>4</sub> = bio compost (3 kg/pot), T<sub>5</sub> = bio compost (2 kg/pot), T<sub>6</sub> = bio compost (1.5 kg/pot), T<sub>7</sub> = cow dung compost 3 kg/pot + NPK, T<sub>8</sub> = cow dung compost (2 kg/pot) + NPK, T<sub>9</sub> = cow dung compost (1.5 kg/pot) + NPK, T<sub>10</sub> = cow dung compost (3 kg/pot), T<sub>11</sub> = cow dung compost (2 kg/pot), T<sub>12</sub> = cow dung compost (1.5 kg/pot), T<sub>13</sub> = NPK, T<sub>14</sub> = bacterial suspension, T<sub>15</sub> = control (only soil). Bio compost and NPK significantly (p=0.05) influenced the growth and yield of chili. The treatment bio compost (3kg/pot) +NPK (T<sub>1</sub>) produced the highest germination (%), vigor index, growth. The yield per plant of chili had significant and positive correlation with plant height, leaf number, number of primary branches, secondary branch, root number, root length, total number of flowers at maximum flowering time, total number of fruits, fruit length, fresh fruit weight, dry fruit weight, number of seed/ fruit and hundred seed weight.

According to Islam *et al.* (2021), the utilisation of organic manures has been found to be advantageous in the process of nutrient recycling within soil, offering a potential substitute for conventional mineral fertilisers. The simultaneous utilisation of organic manures and inorganic fertilisers resulted in a substantial enhancement in growth parameters, yield attributes, and overall yield of cauliflower. This combined approach also demonstrated notable positive impacts on the uptake of essential nutrients such as N, P, K, and S by the cauliflower curds, when compared to the control group that did not receive any fertilisation.

Tonny (2021) conducted a field experiment in Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2020 to March 2021 to evaluate the effect of different doses of organic and inorganic fertilizers on growth, yield and quality attributes of SAU yellow cherry tomato. The experiment was outlined in the Randomized Complete Block Design with 3 replications using 14 treatments. The treatments were T<sub>1</sub>=N 0 kg P 50 kg, K 80 kg, Vermicompost 6t ha<sup>-1</sup>, T<sub>2</sub>= N 60 kg, P 50 kg, K 80 kg, Vermicompost 6 t ha<sup>-1</sup>, T<sub>3</sub>= N 120 kg, P 50 kg, K 80 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>4</sub>= N 180 kg, P 50 kg, K 80 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>5</sub>= N 120 kg, P 50 kg, K 80 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>6</sub>= N 120 kg, P 25 kg, K 80 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>7</sub>= N 120 kg, P 75 kg, K 80 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>8</sub> = N 120 kg, P 50 kg, K 0 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>9</sub> = N 120 kg, P 50 kg, K40kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>10</sub> = N 120 kg, P 50 kg, K 120 kg, vermicompost 6 t ha<sup>-1</sup>, T<sub>11</sub> = N 120 kg, P 50 kg, K 80 kg, vermicompost 0 t ha<sup>-1</sup>, T<sub>12</sub> = N 120 kg, P 50 kg, K 80 kg, vermicompost 3 t ha<sup>-1</sup>, T<sub>13</sub> = N 120 kg, P 50 kg, K 80 kg, vermicompost 9 t ha<sup>-1</sup> and T<sub>14</sub> = N 0kg, P 0 kg, K 0 kg, vermicompost 0 t ha<sup>-1</sup> (control). N, P and K were supplied to the plants from inorganic sources of fertilizers and vermicompost (V) was applied as organic fertilizer. Significant variation was found with the treatments. Among the treatments, the maximum plant height (191.9 cm), flowers number (1347.1/plant), fruits number (1061.3/plant), fruit yield (4.8 kg/plant) and (108.6 t ha<sup>-1</sup>) were found from T<sub>4</sub> while minimum fruit yield (1.2 kg/plant) and (26.6 t ha<sup>-1</sup>) were found from T<sub>14</sub> treatment.

Nahar *et al.*, (2021) studied combined effect of organic and inorganic fertilizer on tomato for yield and yield contributing character of fruits using vermicompost and different types of inorganic fertilizers at the farms of Ishurdi Sub-station of Bangladesh Institute of Nuclear agriculture (BINA) during Rabi season, 2020. One variety (BINA tomato-11) and ten different treatments T<sub>1</sub> = control (no fertilizer), T<sub>2</sub> = 100% CF (Chemical Fertilizer), T<sub>3</sub> = 70% CF, T<sub>4</sub>= 70% CF + 1 t ha<sup>-1</sup> VC (Vermicompost), T<sub>5</sub> = 70% CF + 2 t ha<sup>-1</sup> VC, T<sub>6</sub> = 70% CF + 3 t ha<sup>-1</sup> VC, T<sub>7</sub>= 85% CF, T<sub>8</sub> = 85% CF+ 1 t ha<sup>-1</sup> VC, T<sub>9</sub> = 85% CF+ 2 t ha<sup>-1</sup> VC and T<sub>10</sub> = 85% CF + 3 t ha<sup>-1</sup> VC were used as experimental materials. Results showed that plant height (120.67 cm), number of fruits/plant (53.33), single fruit weight (95 g), fruit yield (63.33 t ha<sup>-1</sup>), number of fruit picking (5 times) were higher in T<sub>5</sub> (70% Chemical fertilizers + 2t ha<sup>-1</sup> VC) than control and other treatments. No significant difference was observed in days to 1st flowering

response to the treatments. The study revealed that the combined effect of vermicompost and inorganic fertilizers affected tomato plants significantly.

Biswas *et al.* (2021) conducted an experiment with ten combinations of inorganic fertilizers and organic manures with one control to investigate the effects of inorganic and organic fertilizers on broccoli and found that the application of 50% RDF + PM @ 6 t ha<sup>-1</sup> (T<sub>2</sub>) responded better with respect to the plant height, number of leaves per plant, head initiation, days to first harvest, head weight, number of secondary head per plant, lateral head weight, head diameter, head yield per plant, head yield, head yield. The stalk length and stalk diameter were observed to be the maximum in treatment in 100% RDF [NPK through chemical Fertilizer] (T<sub>10</sub>).

A scientific experiment was conducted by Sultana (2007) at Horticulture Farm of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2006 to January 2007 to study the effect of organic manure and N fertilizer on growth and yield of Chinese cabbage. The experiment had two factors viz. four levels of organic manure of cow dung and three levels of N. The experiment was laid out in the two factors Randomized Complete Block Design with three replications. Data on different yield components and yield of Chinese cabbage were recorded. Statistically significant variation was recorded in all characters due to the different cow dung used as organic manure. The highest values were recorded for plant height (26.21 cm), plant spread (47.27 cm), number of folded leaves per plant (32.22), head weight (1.50 kg) and gross (69.77 t ha<sup>-1</sup>) and marketable (62.55 t ha<sup>-1</sup>) yield for cow dung used as organic manure @ 20 ton per hectare (OMh) and the lowest value was recorded from OM as control. N fertilizer showed significant differences in all characters. The highest values were recorded for plant height (25.30 cm), plant spread (45.96 cm), number of folded leaves per plant (30.91), head weight (1.57 kg) and gross (65.44 t ha<sup>-1</sup>) and marketable (59.03 t ha<sup>-1</sup>) yield from N 150 kg per ha (N<sub>2</sub>) and the lowest value was recorded from control. Interaction effect between organic manure and N fertilizer also showed significant differences in yield and yield contributing characters in case of OM<sub>3</sub>N<sub>2</sub> (cow dung 20 ton and N 150 kg per ha), while the treatment OM<sub>0</sub>N<sub>0</sub> (no cow dung + no N) performed the lowest value. The highest gross and net return was obtained from the treatment combination of OM<sub>3</sub>N<sub>2</sub> and the lowest gross (Tk. 413,340) and net (Tk. 378, 360) return were obtained in treatment combination OM<sub>0</sub>N<sub>0</sub>. The highest (2.43)

benefit cost ratio was noted from the treatment combination OM3N2 and the lowest (1.72) obtained from the treatment OM<sub>0</sub>N<sub>0</sub>.

Yoldas *et al.* (2020) conducted an experiment with sheep and cattle manure and organic commercial fertilizer to determine the animal manures on yield, quality, and nutrient content of broccoli heads and found that manure rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli compared to control. The highest total yield (27.74 t ha<sup>-1</sup>) was obtained using sheep manure (30 t ha<sup>-1</sup>). At harvest, the highest amount of the total N in broccoli heads was measured at organic commercial fertilizer application. K, sodium (Na), iron (Fe) and manganese (Mn) content increased with higher doses but, P, calcium (Ca), copper (Cu) and zinc (Zn) contents were not influenced. Additionally, the highest nutrient removal for broccoli heads was obtained at 30 t ha<sup>-1</sup> sheep manure application rate.

Thy and Buntha (2005) carried out an experiment from May to August 2004 to evaluate the response of Chinese cabbage (*Drassica pekinensis*) to different forms of organic fertilizer. The four treatments (each replicated four times) were: raw cattle manure solids, composted cattle manure solids (in piles of 0.5 or 1.0 m<sup>3</sup> volume) and the effluent from a mixing indigested (20-day retention time) charged with the liquid and small particles from raw cattle manure. The fertilizers were applied at the same level of N (150 kg N/ha) at 7-day intervals with increasing quantities equivalent to 10, 20, 30, and 40% of the total amount over the first 28 days. A basal fertilization of 2 kg per m<sup>2</sup> of fresh cattle manure was applied to all plots one week before starting the trials. In Trial 2, when seeding was done directly in the field and the plots were protected with plastic sheet against the rain, biomass yield of the cabbage showed a 100% increase for use of indigested effluent (34 t ha<sup>-1</sup>) as compared of composted manure (14 to 17 t ha<sup>-1</sup>), with lowest results for fresh manure solids (9 t ha<sup>-1</sup>).

Akter (2021) carried out a field experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh, during November 2021 to March 2022 to find out the effect of organic and inorganic fertilizer managements for the growth and yield of broccoli (*Brassica oleracea* var. *italica*). The experiment comprised 9 different treatments of organic and inorganic fertilizer and their combination viz., T<sub>0</sub>: Control (without fertilizer); T<sub>1</sub>: Cow dung (CD) @ 15 t ha<sup>-1</sup>; T<sub>2</sub>: Recommend fertilizer dose @ CD10t N150kg P150kg K120kg/ha; T<sub>3</sub>: Vermicompost @ 10 t ha<sup>-1</sup> and

Trichoderma @ 22 kg/ha; T<sub>4</sub>: Vermicompost @ 10 t ha<sup>-1</sup> and biochar 150 kg/ha; T<sub>5</sub>: Kitchen compost @ 8 t ha<sup>-1</sup>; T<sub>6</sub>: Mushroom compost @ 5 t ha<sup>-1</sup>; T<sub>7</sub>: Vermicompost (50%) + Cow dung (50%) and T<sub>8</sub>: Mushroom Spent compost @ 5 t ha<sup>-1</sup> (60%) + Vermicompost (20%) + Trichoderma (20%) and experiment was setup in Randomized Complete Block Design (RCBD) with three replications. A positive impact of each fertilizer was observed on vegetative growth and yield of the crop. Early curd initiation (44.33 days after transplanting), maximum curd diameter (13.58 cm), maximum weight of primary curd (344.2 g), maximum number of secondary curd (6.67), maximum weight of secondary curd (210 g), maximum dry matter content (9.86%) of curd, highest yield plant<sup>-1</sup> (550 g), yield plot<sup>-1</sup> (4.95 kg) and yield ha<sup>-1</sup> (26.76 t) were found from T<sub>2</sub> treatment, while the control treatment gave the lowest. The highest benefit cost ratio (3.40) was noted from T<sub>2</sub> and the lowest (1.21) from T<sub>4</sub>. Considering the differences between different organic fertilizers with the recommended dose, the lowest differences of plant height (1.57 cm) at 60 DAT, diameter (0.33 cm) of primary curd, weight (26.1 g) of primary curd, per plant yield (21.9 g) and yield (1.07 t ha<sup>-1</sup>) of broccoli over the recommended dose was observed in T<sub>8</sub> treatment. Considering the sustainable yield, application of recommend fertilizer dose @ CD10t N150kg P150kg K120kg/ha seemed to be more promising for broccoli cultivation and among the organic fertilizers, the combination Mushroom Spent compost @ 5 t ha<sup>-1</sup> (60%) + Vermicompost (20%) + Trichoderma (20%) was best in respect of plant growth and yield.

#### **2.4 Post-harvest Soil Nutrients**

A study was carried out by Sanni (2016) under field condition at Teaching and Research Farms, Lagos State Polytechnic, Ikorodu to evaluate effects of compost, cow dung and NPK 15-15-15 fertilizer amendments on the growth and yield performances of *Amaranthus hybridus*. The obtained results indicated that all treatments significantly achieved an increment in morphological parameters (numbers of leaves stem girth, leaf area and plant height) and fresh weight yield comparing with the control. The best results in terms of these characters were obtained in the following order Cow dung > compost > NPK 15-15-15 and control. Post soil analysis shows that all the treatments reduced the soil pH from 6.20 to a range between 5.58- 5.68 and available P, magnesium, OC, total N and CEC increased significantly compared with control plot.

A field experiment was carried out Thingujam *et al.* (2016) at the Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India to study the effects of integrated nutrient management on the nutrient accumulation (dry weight recoveries) in brinjal and plant nutrient status of the post-harvest soil of brinjal under Nadia conditions. The results revealed that the treatment consisting of 75% RDF (RDF *i.e.* N:P:K:: 125:100:50) + *Azospirillum* + phosphate solubilising bacteria (PSB) + Borax @ 10 kg ha<sup>-1</sup> recorded the highest oxidizable OC (8.049 g kg<sup>-1</sup>), total N (1.05 g kg<sup>-1</sup>), available N (212.67g kg<sup>-1</sup>), available P (76.20g kg<sup>-1</sup>) and available K (177.59 g kg<sup>-1</sup>) in the post-harvest soils of brinjal. On the other hand, 75% RDF + *Azospirillum* + PSB + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> recorded the highest available iron (26.14 kg ha<sup>-1</sup>) and the treatment consisting of 75% RDF + *Azospirillum* + PSB + ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> recorded the highest soil available zinc (7.62 kg ha<sup>-1</sup>) while 75% RDF + *Azospirillum* + PSB + Borax @ 10 kg ha<sup>-1</sup> recorded the highest available Boron content (0.78 kg ha<sup>-1</sup>) of the post-harvest soil of Brinjal. Highest brinjal yield (14.96 t ha<sup>-1</sup>) was supported by the treatment consisting of 75% RDF + *Azospirillum* + PSB + Boron @ 10 Kg ha<sup>-1</sup>. Meager information was available regarding the performance of integrated application of organics and micronutrient on brinjal in the experimental location. The present study may enlighten this unexplored section of nutrient management in brinjal.

El-Ramady (2014) carried out to determine the effect of various soil water treatments applied to the test crop on the status of postharvest residual soil nutrient pools in an arid environment. Spring wheat (*Triticum aestivum* L.) was grown as test crop under conditions of full- (as control), high-, moderate-, and low-water conditions during jointing, booting-heading, and grain filling stages, in 2003 and 2004. Compared to the control, grain yield and water use efficiency (WUE) were significantly increased by subjecting the wheat crop to moderate-water conditions during various growth stages, and low-water conditions at jointing stage in both years. Soil C at harvest decreased linearly with increased grain yield of the test crop. Moderate- to high-water conditions during jointing stage resulted in 12–24% greater soil C in the top 40 cm depth in 2003, with a marginal difference in 2004. Water treatments impacted the status of residual soil nutrients in 2003; soil total N and available soil P in the top 40 cm depth were significantly higher in low- to moderate-water treatments compared to the control, while in 2004 significantly higher total N and P, available N, P and K were found only in the top 20 cm depth. Increased yield of wheat test crop with moderate water resulted

in increased postharvest residual soil nutrients, whereas the ratios of C/N, C/P, and C/K were largely influenced by years and were less related to water treatments. We conclude that the determination of postharvest soil C and nutrient elements may provide useful information in monitoring potential changes of soil nutrient status over time in the intensified cropping systems, and that the recommendation of fertilization for the crop to be grown immediately following the first crop can be established by simply analyzing the productivity of the first crop without intensive measurements of soil nutrients.

According to Zaman *et al.* (2017) organic manure as a source of plant nutrients for cultivation of field crops has received worldwide attention due to rising costs, rapid nutrient loss and adverse environmental impacts from inorganic fertilizers. A pot experiment was conducted in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh to observe the effects of cow dung on growth, yield of stevia along with post-harvest fertility status of soil. Four treatments of CD *viz.* 0, 5, 7.5 and 10 t ha<sup>-1</sup> in two contrasting soils (acid and non-calcareous) were examined following Completely Randomized Design (CRD) with three replications. Growth and yield attributes increased significantly with the advancement of growth period (60 DAP) and increased rate of CD up to 10 t ha<sup>-1</sup>. An overall performance of non-calcareous soil was better than acid soil. In non-calcareous soil, the leaf biomass yield was increased by 275% whereas in acid soil it was 268% over control. The acidity of both soils significantly decreased with the increased rate of CD. All essential plant nutrients *viz.* total N, available P exchangeable K, Ca, Mg, available S, Zn, B and OM content of soil were significantly increased with the increased levels of CD up to its highest dose (CD @ 10 t ha<sup>-1</sup>) in both soils. Thus, from the findings of the present research work it can be concluded that for getting optimum leaf biomass yield of stevia along with fertility of both soils CD should be applied @ 10 t ha<sup>-1</sup>.

## CHAPTER III

### MATERIALS AND METHODS

The field experiment was conducted during the period from November 2022 to January 2023 to evaluate the role of combinations of different amounts of cow dung with same amounts of chemical fertilizers in improving growth of Napa Shak. A brief of soil, climate, materials, and methods used for conducting the experiment is presented below.

#### 3.1 Location and Duration

The experiment was conducted in the soil science research field (next to the central masjid) of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh from December 2022 to February 2023. The geographic location of the area is between 25.69°N; 88.65° E and 40 m above sea level. The Agroecological Zone (AEZ) of the area is the Old Himalayan-Piedmont Plain.

#### 3.2 Soil

The soil of the experimental field belongs to the Old Himalayan Piedmont Plain (AEZ-1). The soil of the experimental plot was sandy loam with good drainage capacity. The experimental plot was medium high land. The soil of the experiment is described as loamy clay soil and characterized by a deep cracking. Moderately alkaline clays and low permeability.

#### A. Morphological Characteristics

Morphology	Characteristics
Location	Soil Science Research Field, HSTU, Dinajpur
AEZ	Old Himalayan Piedmont plain (AEZ-1)
General Soil Type	Non-calcareous brown floodplain soil
Parent material	Piedmont alluvium
Drainage	Well drained
Flood level	Above Flood level
Topography	High land

## B. Physical characteristics

	Characteristics	Value
Particle size (%)	Sand (2-0.02 mm)	58.0
	Silt (0.02-0.002mm)	28.0
	Clay (<0.002mm)	14.0
Textural class		Sandy loam

## C. Chemical characteristics of initial soil under field experiment

Characteristics	Content
pH	6.12
OC (%)	0.54
OM (%)	0.94
Total N (%)	0.11
Available P (ppm)	12.20
Exchangeable K (meq 100 g <sup>-1</sup> )	0.06
Available S (ppm)	16.08

### 3.3 Climatic Conditions

The experimental area is situated in a subtropical climate zone with two distinct seasons: Rabi (October–March) and Kharif (April–September). These seasons are characterized by high temperatures, high humidity, heavy rainfall, and comparatively long daytime hours. During the Rabi season, which ran from November 2022 to February 2023, the experiment was conducted.

### 3.4 Planting Materials

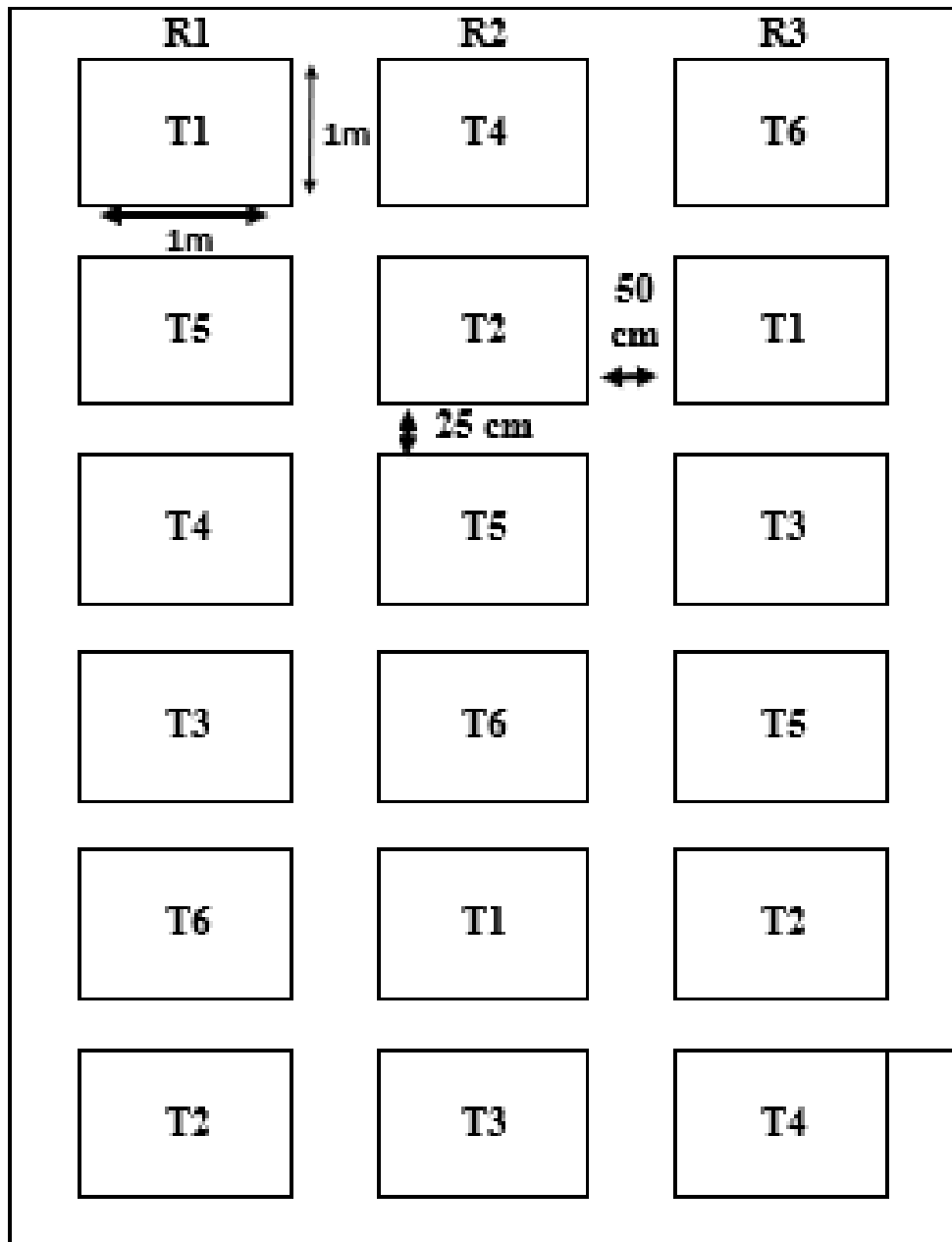
The plant material of the experiment of Napa Shak (*Malva verticillata* L.) seeds of local variety were collected from the local market named Paker Hat, Khanshama, Dinajpur, organic fertilizer, Cow dung from HSTU animal farm and chemical fertilizers from the local market of Basher hat, Dinajpur Sadar, Dinajpur.

### **3.5 Seeds and Fertilizer rates**

Seeds of Napa Shak were used at the rate of 200 g/ha and 20 g/plot. Organic fertilizer cow dung in case of T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> was applied at the rate of 1 t ha<sup>-1</sup>, 3 t ha<sup>-1</sup>, 5 t ha<sup>-1</sup>, 7 t ha<sup>-1</sup> and 10 t ha<sup>-1</sup> respectively. Chemical fertilizers were applied to urea, TSP and MOP @ 125 kg/ ha, 75 kg/ha and 100 kg/ha respectively.

### **3.6 Experimental design and Layout**

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The 6 treatments of the experiment were assigned at random into 18 plots, each treatment with three replications. The size of each unit plot 1m × 1m. The space between blocks and plots were 50 cm and 25 cm, respectively.



**Figure 1.** Experimental field layout

### **3.7 Treatments of the Experiments**

The experiment contains 6 treatments. These are-

T<sub>1</sub> = Control

T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

In T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> treatments, cow dung was applied at the rate of 1, 3, 5, 7 and 10 t ha<sup>-1</sup> with the combination of urea, TSP and MOP were 125, 75 and 100 kg ha<sup>-1</sup> respectively.

### **3.8 Details of the Field Operations**

#### **3.8.1. Preparation of the main field**

In the first week of November 2022, the experiment's chosen plot was tilled and left in the sun for a week at a decent slope. After eliminating stubble and weeds, the ideal soil slope for planting was attained.

#### **Application of fertilizers and manures**

Cow dung, TSP and MOP fertilizers were applied during final land preparation according to treatments and urea was applied in two splits i.e., first split after 15 DAS and rest of the amount as second split 30 days after planting (DAS).

### **3.8.2 Seed sowing**

The healthy seeds were selected for better germination and growth. Then the seeds were soaked in water for 24 hours and after that seeds were sown in broadcasting by hand.

### **3.9 Intercultural operation**

After the establishment of seedlings, various intercultural operations were accomplished for better growth and development of the crop.

#### **3.9.1. Irrigation and drainage**

The experimental plots required three irrigations during the crop growth and then when needed, and sometimes drainage was done due to remove the excess water.

#### **3.9.2. Thinning**

First gap filling was done for all of the plots at 10 days after sowing (DAS).

#### **3.9.3. Weeding**

Three weeding were done to keep the plots free from weeds, which ultimately ensured better growth and development. The first wedding was done at 15 days after sowing (DAS) and 2nd weeding were done at 30 DAS.

#### **3.9.4. Pest control**

At the early stage of growth root rot and aphid attacked plants during crop production. Root rot and aphid were successfully controlled by the application of Mancozeb and Imitaf.

### **3.10 Data collection**

#### **A. Growth parameter**

1. Plant height (cm)
2. Shoot weight per plant (g)
3. Root weight per plant (g)

## **B. Post Harvest Soil Analysis**

4. Available S (ppm)
5. Available P (ppm)
6. Exchangeable K (meq 100 g<sup>-1</sup> soil)
7. Total N (%)
8. pH
9. Available soil organic carbon (OC) (%)
10. Available soil organic matter (OM) (%)

### **3.11 Data collection procedure**

#### **3.11.1. Plant height (cm)**

The height of the plant was recorded in cm (cm) at 30, 45 and 60 DAS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves.

#### **3.11.2 Shoot fresh weight per plant**

At 60 DAS, selected plants fresh weight was measured in gram unit as fresh weight per plant

#### **3.11.3 Root fresh weight per plant**

Selected plants were air dried. After harvest the fresh weight was measured in gram unit as fresh weight per plant

#### **3.11.4 Post Harvest Soil Analysis**

##### **Soil sample preparation**

Following harvesting, soil samples were collected from each plot and allowed to air dry. After that, a 2 mm (10 mesh) sieve was used to filter the dried samples. For analysis, the soil was kept in a pristine plastic container.

### **Analysis of soil sample**

At the Department of Soil Science, Soil Science Laboratory-1, HSTU Dinajpur, the chemical characteristics of every soil sample were examined. The following common techniques were used to analyze the soil samples:

#### **Total N**

By digesting the soil with 30% H<sub>2</sub>O<sub>2</sub>, conc., the micro-Kjeldahl method was used to determine the total N content of the soil. H<sub>2</sub>SO<sub>4</sub> and catalyst mixture (100:10:1 K<sub>2</sub>SO<sub>4</sub>: CuSO<sub>4</sub>.5H<sub>2</sub>O: Se powder). By distilling with 40% NaOH and then titrating the distillate included in H<sub>3</sub>BO<sub>3</sub> with 0.01 N H<sub>2</sub>SO<sub>4</sub>, the amount of digested N was determined (Page *et al.* 1982).

The amount of N was calculated by using the following formula:

$$N (\%) = \frac{(T-B) \times N \times 0.014 \times D}{W} \times 100$$

Here,

T = Sample titration (ml) value of standard H<sub>2</sub>SO<sub>4</sub>

B = Blank titration (ml) value of standard H<sub>2</sub>SO<sub>4</sub>

N = Strength of H<sub>2</sub>SO<sub>4</sub>

W = Oven dry weight of supplied soil sample

D = Dilution factor

#### **Available P**

By shaking a 0.5 M NaHCO<sub>3</sub> solution with a pH of 8.5, available P was removed from the soil (Olsen *et al.* 1954). The phosphomolybdate complex's SnCl<sub>2</sub> reduction resulted in the development of a blue color, which was used to determine the P content of the extract. Using a spectrophotometer set to measure the blue color of molybdophosphate at 660 nm, the available P was computed by applying the standard P curve (Page *et al.* 1982).

### **Exchangeable K**

Exchangeable K was measured using flame photometry and 1N NH<sub>4</sub>OAc (pH 7) extraction techniques, and it was calibrated using a standard curve (Page *et al.* 1982).

### **Available S**

Available S was determined by extraction of the soil sample with 0.01 M Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>. The S content in the extract was estimated and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

### **Soil pH**

The pH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio being 1:2.5 (Jackson, 1973).

### **Soil OC and OM:**

OC in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the OM with an excess of 1N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in presence of conc. H<sub>2</sub>SO<sub>4</sub> and conc. H<sub>3</sub>PO<sub>4</sub> and to titrate the excess K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution with 1N FeSO<sub>4</sub>. To obtain the content of OM was calculated by multiplying the percent OC by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

### **3.12 Statistical analysis**

The Statistix 10 program was used to statistically test the collected data. The mean for every treatment was determined, and the Least Significant Difference (LSD) test was used to analyze variance and evaluate treatment differences at the five percent significance level (Gomez and Gomez, 1984).

## CHAPTER IV

### RESULTS AND DISCUSSION

Determining the effects of different amounts of cow dung combined with chemical fertilizers on Napa Shak (*Malva verticillate* L.) growth was the aim of the current study. It was determined which organic, chemical, or combination fertilizers were most beneficial for spinach development by measuring the influence of different morphological traits and nutrients available following the closed soil experiment. The experiment's results are presented and discussed in this chapter.

#### 4.1 Combined effect of Cow dung and Chemical Fertilizers on Plant Height (cm)

The plant height of all leafy vegetables is an important characteristic that can influence the overall growth, health, and yield of all leafy vegetables and also for the napa shak.

Significant variation was observed on plant height of Napa Shak at different days after sowing (DAS) due to the application of combinations of different levels of cow dung and same amounts of chemical fertilizers (Table 1). At 15 DAS, the highest plant height was 18.15 cm from T<sub>6</sub> which was statistically similar with T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> which were 17.33, 17.25 and 17.00 cm respectively followed by T<sub>2</sub> (14.77) cm. The smallest plant height was observed from T<sub>1</sub> (11.59 cm) which was in controlled condition.

In 30 DAS, the highest plant height was obtained from T<sub>6</sub> (27.00) cm which was statistically identical with T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> which were 25.63, 24.97 and 24.03 cm respectively which was followed by T<sub>2</sub> (23.40) cm. The smallest plant height was 15.40 cm obtained from T<sub>1</sub> (control).

Move to the harvest, the highest plant height obtained from T<sub>6</sub> (52.70 cm) which was statistically similar to the T<sub>5</sub> (50.07 cm) followed by T<sub>4</sub> (42.37 cm). The smallest plant height was obtained from T<sub>1</sub> (control) (24.90 cm). Ama *et al.* (2022) found same results for *Amaranthus cruentus* and *Corchorus olitorius* and by Pohan *et al.* (2021) in water spinach (*Ipomoea reptans* Poir). Tonoya (2014) also found relevant results which was the growth and yield contributing parameters were increased with the increasing cow dung levels up to 5 t ha<sup>-1</sup> with N fertilizer combination in green amaranth. Gudugi (2013) found also same results in okra.

**Table 1.** Combination effect of different cow dung levels fertilizer with chemical fertilizer on at 15 DAS, 30 DAS, harvest, RW and SW.

Treatment	Plant Height (cm) at			SW (g plant <sup>-1</sup> )	RW (g plant <sup>-1</sup> )
	15 DAS	30 DAS	Harvest		
T <sub>1</sub>	11.59c	15.40c	24.90d	3.12b	0.35a
T <sub>2</sub>	14.77b	23.40b	30.27cd	5.43ab	0.38a
T <sub>3</sub>	17.00ab	24.03ab	32.30c	5.93ab	0.41a
T <sub>4</sub>	17.25ab	24.97ab	42.37b	6.12a	0.42a
T <sub>5</sub>	17.33ab	25.63ab	50.07a	6.20a	0.46a
T <sub>6</sub>	18.15a	27.00a	52.70a	6.70a	0.53a
CV (%)	9.64	7.74	8.30	29.42	37.82
LSD (0.05)	2.81	3.29	5.85	2.99	0.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. PH at 15 DAS = Plant height at 15 DAS, PH at 30 DAS = Plant height at 30 DAS, PH at harvest = Plant height at harvest, RW = Root fresh weight at harvest, SW = Shoot fresh weight at harvest.

Treatment combinations were as follows:

T<sub>1</sub> = Control

T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

#### **4.2 Combined effect of Cow dung and Chemical Fertilizers on Plant Shoot Fresh Weight (g)**

The measurement of shoot weight in Napa shak plants holds significant importance in evaluating their development and overall well-being. The aforementioned statement highlights the significance of a particular indication that has value in assessing various aspects that have the potential to influence both the overall production and quality of Napa shak crops.

The shoot fresh weight was significantly different from the combination of different levels of cow dung with same amounts of chemical fertilizers (Table 1). The highest shoot fresh weight was obtained from T<sub>6</sub> (6.70 cm) which was statistically similar to the T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 6.20, 6.12, 5.93 and 5.43 cm respectively. The smallest shoot weight was obtained from T<sub>1</sub> (3.12 cm) which was statistically similar to the T<sub>3</sub> and T<sub>2</sub> were 5.93 and 5.43 cm respectively. Uddin *et al.*, (2012) found similar results in water spinach (*Ipomoea aquatica*).

#### **4.3 Combined effect of Cow dung and Chemical Fertilizers on Plant Root Fresh Weight (g)**

The root system of Napa Shak has a vital function in the uptake of necessary nutrients and water from the surrounding soil. An adequately nourished and robust root system is essential for facilitating the plant's acquisition of necessary nutrients, hence promoting optimal growth.

There were no statistically significant differences among the treatments (Table 1). All treatments gave statistically similar results. But the highest value was T<sub>3</sub> (0.53 cm) followed by T<sub>2</sub>, T<sub>5</sub>, T<sub>6</sub>, and T<sub>4</sub> (0.42, 0.41 and 0.42 cm respectively) and smallest was T<sub>1</sub> (control) of 0.35 cm. similar results found by Uddin *et al.* (2012).

## 4.4 Post-harvest Soil Nutrient Availability

### 4.4.1 Total N (%)

N is an essential element that plays a crucial role in facilitating the development of leaves and stems. The promotion of new foliage is conducive to the advancement of photosynthesis and the overall well-being of plants. Sufficient N concentrations have the potential to result in abundant and verdant foliage.

In initial soil N was 0.11 % which was statistically similar to T<sub>1</sub> (11 %) which was the smallest value (table 2). The highest N in post-harvest soil of Napa Shak was in T<sub>6</sub> (0.16 %) which was statistically similar to T<sub>5</sub> followed by T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 0.14 % for all treatments. In *Amaranthus hybrid*, Sanni (2016) also found the highest retaining post-harvest N present used combination cow dung with chemical fertilizers.

**Table 2.** Combination effect of different cow dung levels fertilizer with chemical fertilizer available N, P, K and S on post-harvest soil.

Treatment	Total N (%)	Available P (ppm)	Exchangeable K (meq 100 g <sup>-1</sup> )	Available S (ppm)
Initial	0.11c	12.26f	0.06a	16.08a
T <sub>1</sub>	0.11c	9.40g	0.06a	6.03g
T <sub>2</sub>	0.14b	17.80e	0.06a	8.30f
T <sub>3</sub>	0.14b	19.63d	0.06a	11.05e
T <sub>4</sub>	0.14b	33.12c	0.06a	12.31d
T <sub>5</sub>	0.16a	35.78b	0.06a	13.31c
T <sub>6</sub>	0.16a	39.46a	0.06a	15.32b
CV (%)	0.71	2.61	0.19	1.78
LSD (0.05)	1.74E-3	1.11	2.02E-4	0.37

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. N = Nitrogen (%), P = P (ppm), K = K (meq 100 g<sup>-1</sup>), S = Sulphur (ppm), OC = Organic carbon (%), OM = Organic matter (%).

Treatment combinations were as follows:

T<sub>1</sub> = Control

T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

#### **4.4.2 Available P (ppm)**

The various treatments used had a discernible favourable effect on the availability of S in the soil after the harvest period, as seen in Table 2. The initial P was 12.26 ppm in the soil of the experimental fields. All treatments of cow dung in combination with chemical fertilizers significantly have difference. The highest value was obtained from the treatment T<sub>6</sub> (39.46 ppm) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 35.78, 33.12 and 19.63 ppm respectively. Where, the lowest value obtained from T<sub>1</sub> (9.40 ppm). Zaman *et al.* (2017) revealed the similar results to increasing the cow dung amount increased P availability after harvest.

#### **4.4.3 Exchangeable K (meq 100 g<sup>-1</sup> soil)**

K availability in the soil can affect the uptake of other nutrients by plants. It plays a role in nutrient transport within the plant. Inadequate K levels can lead to deficiencies in other nutrients, even if they are present in the soil.

Different levels of cow dung and chemical fertilizers combination were statistically non-significant (Table 2). There was no significant change in post-harvest exchangeable K amount in the experimental field.

#### **4.4.4 Available S (ppm)**

Sulfur is one of the essential macronutrients required by plants. It is a critical component of amino acids, vitamins, and enzymes, and it plays a vital role in photosynthesis, root development, and overall plant growth. Significance difference was observed from the treatments used (Table 2). The Initial soil with available S was 16.08 ppm. The highest available S was obtained from T<sub>6</sub> (15.32 ppm) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 13.31, 12.31, 11.05 and 8.30 ppm respectively. The lowest value was observed in T<sub>1</sub> (control) (6.03 ppm). Zaman *et al.* (2017) revealed the same results to increasing the cow dung amount increased P availability after harvest.

#### **4.4.5 Soil pH**

The availability of critical nutrients to plants is influenced by soil pH. The availability of various nutrients to plants is influenced by the pH level of the soil.

The pH varied significantly due to the application of different organic fertilizers (Table 3). The initial soil pH was recorded as 6.12. After applying treatment, T<sub>6</sub> exhibited a maximum pH value of 6.27 which was statistically identical with T<sub>5</sub> (6.27) followed by T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 6.24, 6.20 and 6.18 respectively. On the contrary, T<sub>1</sub> displayed the lowest pH value of 6.12 which was identical with initial soil pH. Similar results were revealed by Sanni (2016).

**Table 3.** Combination effect of different cow dung levels fertilizer with chemical fertilizer available pH, OC and OM on post-harvest soil.

<b>Treatment</b>	<b>pH</b>	<b>OC (%)</b>	<b>OM (%)</b>
<b>Initial</b>	6.12e	0.53e	0.94f
<b>T<sub>1</sub></b>	6.12e	0.52g	0.91g
<b>T<sub>2</sub></b>	6.18d	0.54e	1.04e
<b>T<sub>3</sub></b>	6.20c	0.60d	1.07d
<b>T<sub>4</sub></b>	6.24b	0.62c	1.10c
<b>T<sub>5</sub></b>	6.27a	0.65b	1.13b
<b>T<sub>6</sub></b>	6.27a	0.67a	1.17a
<b>CV (%)</b>	0.06	0.50	0.42
<b>LSD (0.05)</b>	7.14 E-3	5.29 E-3	7.89 E-3

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. N = Nitrogen (%), P = P (ppm), K = K (meq 100 g<sup>-1</sup>), S = Sulphur (ppm), OC = Organic carbon (%), OM = Organic matter (%).

Treatment combinations were as follows:

T<sub>1</sub> = Control

T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP)

#### **4.4.6 Soil OC (%)**

The role of OC in soil health and its impact on vegetable cultivation has gained increasing attention in agricultural research. OC, a fundamental component of soil OM, plays a crucial role in nutrient cycling, water retention, and microbial activity. This thesis investigates the intricate relationship between OC levels and the growth, yield, and nutritional quality of vegetables. Understanding these dynamics is imperative for sustainable agriculture, as OC influences soil fertility and resilience. Through an exploration of current literature and empirical studies, this research aims to provide insights into optimizing OC management practices for the sustainable cultivation of vegetables.

Initial soil OC was 0.53 % (Table 3). The highest value of the OC found from T<sub>6</sub> (0.67 %) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 0.65, 0.62 and 0.60 % respectively. The lowest value was observed from T<sub>1</sub> (0.52 %).

#### **4.4.7 Soil OM (%)**

OM is a fundamental component of soil, influencing its physical, chemical, and biological properties. In the realm of vegetable cultivation, the impact of OM on soil health and crop performance is of paramount importance. This thesis delves into the multifaceted effects of OM on vegetables, exploring its role in nutrient availability, water retention, and microbial activity. As the global agricultural community strives for sustainable practices, understanding how OM influences the growth, yield, and quality of vegetables becomes pivotal. Through an amalgamation of existing literature and empirical studies, this research seeks to unravel the intricacies of OM dynamics, providing valuable insights for enhancing vegetable production in a sustainable and environmentally friendly manner.

Initial soil OC was 0.94 % (Table 2). The highest value of the OM found from T<sub>6</sub> (1.17 %) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 1.13, 1.10 and 1.07 % respectively. The lowest value was observed from T<sub>1</sub> (0.52 %). Sanni (2016) found that the increase in cow dung treatments used increased significantly compared with control plot.

## CHAPTER V

### SUMMARY AND CONCLUSION

#### 5.1 Summary

A field experiment was done from December 2022 to February 2023 at the research field of the Department of Soil Science, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur-5200, in order to evaluate the impact of various organic fertilizers on the growth of spinach. The experiment consists of six treatments, namely T<sub>1</sub> (Control), T<sub>2</sub> = Cow dung (1 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>3</sub> = Cow dung (3 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>4</sub> = Cow dung (5 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>5</sub> = Cow dung (7 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP), T<sub>6</sub> = Cow dung (10 t ha<sup>-1</sup>) + chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP). The experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications, resulting in a total of 18 plots. Data was gathered on various growth parameters, including plant height (measured in cm), number of leaves per plant, shoot weight per plant (measured in grammes), root weight per plant (measured in grammes), and post-harvest soil analysis. The soil analysis included measurements of available S (in parts per million), available P (in parts per million), exchangeable K (measured in milliequivalents per 100 grammes of soil), total N (expressed as a percentage), pH, OC and OM (%). The Statistix 10 program was employed for the purpose of conducting data analysis. In order to evaluate the disparities between treatments, the Least Significant Difference (LSD) test was utilized at a level of significance of 5%.

From the above results it can be concluded that combination of cow dung and recommended chemical fertilizer is more productive compared to sole use of control conditions. At 15 DAS, the highest plant height was 18.15 cm from T<sub>6</sub> which was statistically similar with T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> which were 17.33, 17.25 and 17.00 cm respectively followed by T<sub>2</sub> (14.77 cm). The smallest plant height was observed from T<sub>1</sub> (11.59 cm) which was in controlled condition. At 30 DAS, the highest plant height was obtained from T<sub>6</sub> (27.00 cm) which was statistically identical with T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> which were 25.63, 24.97 and 24.03 cm respectively which was followed by T<sub>2</sub> (23.40

cm. The smallest plant height was 15.40 cm obtained from T<sub>1</sub> (control). Move to the harvest, the highest plant height obtained from T<sub>6</sub> (52.70 cm) which was statistically similar to the T<sub>5</sub> (50.07 cm) followed by T<sub>4</sub> (42.37 cm). The smallest plant height was obtained from T<sub>1</sub> (control) (24.90 cm).

The shoot fresh weight was significantly different from the combination of different levels of cow dung with same amounts of chemical fertilizers (Table 1). The highest shoot fresh weight was obtained from T<sub>6</sub> (6.70 cm) which was statistically similar to the T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 6.20, 6.12, 5.93 and 5.43 cm respectively. The smallest shoot weight was obtained from T<sub>1</sub> (3.12 cm) which was statistically similar to the T<sub>3</sub> and T<sub>2</sub> were 5.93 and 5.43 cm respectively.

Root fresh weight for all treatments was statistically similar results. But the highest value was T<sub>3</sub> (0.53 cm) followed by T<sub>2</sub>, T<sub>5</sub>, T<sub>6</sub>, and T<sub>4</sub> (0.42, 0.41 and 0.42 cm respectively and smallest was T<sub>1</sub> (control) of 0.35 cm.

For N availability, T<sub>1</sub> (11 %) which was the smallest value. The highest N in post-harvest of Napa Shak was in T<sub>6</sub> (0.16 %) which was statistically similar to T<sub>5</sub> followed by T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 0.14 % for all treatments.

The highest value of P was obtained from the treatment T<sub>6</sub> (39.46 ppm) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 35.78, 33.12 and 19.63 ppm respectively. Where, the lowest value obtained from T<sub>1</sub> (9.40 ppm).

The highest available S was from T<sub>6</sub> (15.32 ppm) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 13.31, 12.31, 11.05 and 8.30 ppm respectively. The lowest value was observed in T<sub>1</sub> (control) (6.03 ppm).

T<sub>6</sub> exhibited a maximum pH value of 6.27 which was statistically identical with T<sub>5</sub> (6.27) followed by T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> were 6.24, 6.20 and 6.18 respectively. On the contrary, T<sub>1</sub> displayed the lowest pH value of 6.12 which was identical with initial soil pH.

The highest value of the OC found from T<sub>6</sub> (0.67 %) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 0.65, 0.62 and 0.60 % respectively. The lowest value was observed from T<sub>1</sub> (0.52 %). The highest value of the OM found from T<sub>6</sub> (1.17 %) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> were 1.13, 1.10 and 1.07 % respectively. The lowest value was observed from T<sub>1</sub> (0.52 %).

## 5.2 Conclusion

Based on the findings above, it may be concluded that:

- The effect of different organic fertilizers can influence the growth of Napa Shak.
- The overall results showed that T<sub>6</sub> fertilizer (cow dung = 10 t ha<sup>-1</sup>) combined with chemical fertilizers (125 kg ha<sup>-1</sup> urea, 75 kg ha<sup>-1</sup> TSP and 100 kg ha<sup>-1</sup> MOP) respectively produced the maximum growth of Napa Shak.

## 5.3 Recommendation

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

- i. Considering the observation farmers may be suggested the apply cow dung combined with chemical fertilizers to the field for Napa Shak cultivation.
- ii. This study also needed to conduct in different agroecological zone (AEZ) of Bangladesh for regional adaptability.

## REFERNCES

- Ahmedullah M and Sanjappa M. 2008. Oil yielding plants. Botanic Garden of Indian Republic. Botanical Survey of India. Kolkata. pp 104.
- Akter F and Rahmatullah M. 2018. Antihyperglycemic Activity Studies with *Malva verticillata* Leaves. World Journal of Pharmaceutical Research. 7(19), 107-113.
- Akter T. 2021. Effect of Organic and Inorganic Fertilizers on The Growth and Yield of Broccoli (*Brassica oleracea* Var. *italica* L). MS Thesis, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh.
- Ama S, Padi F, Serwaa G, Nyame B, Appiah F and Adu F. 2022. Effects of Three Different Rates of Application of Cattle Dung on the Growth and Quality of Two Traditional Leafy Vegetables (*Amaranthus Cruentus* and *Corchorus Olitorius*). Journal of Food Technology. 9(4): 176-193.
- Awotoye OO, Oyedele DJ and Anwadike BC. 2011. Effects of cow-dung and rock phosphate on heavy metal content in soils and plants. Journal of Soil Science and Environmental Management. 2(7):193-7.
- BBS. 2022. Statistical Yearbook of Bangladesh 2021. Bangladesh Bureau of Statistics. Ministry of Planning. Govt. of the People's Republic of Bangladesh. Dhaka.
- Biswas A, Upadhyay D and Rathiya PS. 2021. Effect of inorganic fertilizer and organic manures on growth and yield of broccoli (*Brassica oleracea* var. *italica*) cv. Palam Samridhi at Norther Hill of Chhattisgarh. Pharma Innovation Journal. 10(10): 1000-1003
- El-Ramady HR. 2014. Integrated nutrient management and postharvest of crops. Sustainable Agriculture Reviews. 13:163-274.
- Ghosh A, Tahjib-Ul-Arif M, Chamely SG, Haque MR, Rahman MM, Bhuiyan MA. 2017. Comparative effect of arbuscular mycorrhiza, cowdung and P on growth and yield contributing characters of red amaranth (*Amaranthus tricolor* L.) and Indian spinach (*Basella alba* L.). Tropical Plant Research. 4(2):254-63.

- Gomez KA. and Gomez AA. 1984. Comparison between treatment means. In: Statistical Procedures for Agricultural Research. Gomez KA and Gomez AA, (eds.). 2nd Edition. John Wiley and Sons, NY, USA. 187-240.
- Gudugi IA. 2013. Effect of cow dung and variety on the growth and yield of okra (*Abelmoschus esculentus* L.). European Journal on Experimental Biology. 3(2):495-8.
- Haque MM and Hoque M Z. 2021. Vegetable Production and Marketing Channels in Bangladesh: Present Scenario, Problems, and Prospects. [https://www.researchgate.net/publication/353343092\\_Vegetable\\_Production\\_and\\_Marketing\\_Channels\\_in\\_Bangladesh\\_Present\\_Scenario\\_Problems\\_and\\_Prospects](https://www.researchgate.net/publication/353343092_Vegetable_Production_and_Marketing_Channels_in_Bangladesh_Present_Scenario_Problems_and_Prospects).
- Islam MR, Hoque TS, Khan RNA, Farzana S, Ahmed M, and Khodabakhshloo N. 2021. Influence of different integrated nutrient management strategies on growth, yield and nutritional qualities of cauliflower. Agricultural Research. 10: 656-664.
- Jackson ML. 1973. Soil chemical analysis, pentice hall of India Pvt. Ltd, New Delhi, India. 498: 151-154.
- Jahan N, Islam S, Islam R, Onna SN, Tonny TA, Akter S, Islam MT, Das PR and Rahmatullah M. 2015. Ethnomedicinal practices of an urban folk medicinal practitioner of Dhaka city, Bangladesh. Journal of Chemistry and Pharmaceutical Research. 7: 414-420.
- Jeong YT and Song CH.2011. Antidiabetic activities of extract from *Malva verticillata* seed via the activation of AMP-activated protein kinase. Journal of Microbial Biotechnology. 21: 921-929.
- Ko JH, Nam YH, Joo SW, Kim HG, Lee YG, Kang TH and Baek NI. 2018. Flavonoid 8-O-glucuronides from the aerial parts of *Malva verticillata* and their recovery effects on alloxan-induced pancreatic islets in zebrafish. Molecules. 23: 833.
- Kumar Malav P, Pandey A, Pamarthi RK, Bhatt KC, Nivedhitha S, Pradheep K, Singh K and Ahlawat SP 2023. Less-known leafy vegetable “Lapha” (*Malva*

*verticillata* L.; family Malvaceae) in India and study on genetic resources. <https://www.researchsquare.com/article/rs-2722323/v1>.

- Li R, Liu J, Xu L, Duan B and Qian J. 2020. The complete chloroplast genome of *Malva verticillata* (Malvaceae). *Mitochondrial DNA Part B*. 5(2):1609-10.
- Makinde EA and Ayoola OT. 2012. Comparative growth and yield of okra with cow dung and poultry manure. *American-Eurasian Journal of Sustainable Agriculture*. 18-24.
- Miaha R, Methelaa NJ, and Ruhib RA. 2020. Effect of Integrated Nutrient Management on Growth and Yield of Okra. *Tropical Agro biodiversity (TRAB)*. 1(2), 72-76.
- Mohosina F. 2019. Effect of cow dung and boron on growth and yield of broccoli (*Brassica oleracea*). *Journal of Bioscience and Agriculture Research*. 22(2):1845-51.
- Nahar K, Haque MA, Chowhan S, Ali MKJ, Husain MM, and Rahman MM. 2021. Combined Effect of Vermicompost and Inorganic Fertilizer on Yield and Yield Contributing Characters of Tomato Plant. *Asian Journal of Soil Science and Plant Nutrition*. 7(4):76-82.
- Naher MNA, Alam MN and Jahan N. 2014. Effect of nutrient management on the growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.) in calcareous soils of Bangladesh. *The Agriculturists*, 12(2), 24-33.
- Noor NM, Ropi NA and Leong HY. 2022. Effects of Organic, Inorganic and Compound Fertilizer on Growth and Quality of Water Spinach (*Ipomoea aquatica*) under Polyculture Condition. *Journal of Agrobiotechnology*. 13(1):1-2.
- Odontuya G. 2012. Pharmacological activities of a mongolian medicinal plant, *Malva mohileviensis* Down. *European Journal of Medicinal Plants*. 3(2):230–241.
- Olsen SR, Cole CV, Watanabe FS, and Dean LA. 1954. Estimation of available P in soils by extraction with sodium bicarbonate. US Department of Agriculture, Circ. 939, Washington, DC.
- Page AL, Miller RH. and Keency DR. 1982. In: *Methods of soil analysis. Part II*. (2nd Edn.). American Society of Agronomy Inc. Madison, Wisconsin, USA.

- Pohan SD. 2021. The Effect of Organic Fertilizers on Growth and Yield of Water Spinach (*Ipomoea reptans* Poir). JERAMI Indonesian Journal of Crop Science. 3(2): 37-44.
- Rahman MA, Rahman MM, Begum MF and Alam MF. 2012. Effect of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili. International Journal of Biosciences. 2(1):51-5.
- Sanni KO. 2016. Effect of compost, cow dung and NPK 15-15-15 fertilizer on growth and yield performance of Amaranth (*Amaranthus hybridus*). International Journal of Advances in Scientific Research. 2(3):76-82.
- Seran TH, Saleem M and Imthiyas M. 2016. Effect of different doses of NK chemical fertilizers and compost on growth and yield attributes of tomato. Turkish Journal of Agriculture - Food Science and Technology. 4(6): 481-485.
- Shahabuddin M, Hossain MS, Rahman MM, Muslim T and Begum SA. 2017. Phytochemical constituents from the leaves of *Malva verticillata* L. Journal of Pharmacognosy and Phytochemistry. 6(1):16-22.
- Shariful I, Fatema A, Hossain MM and Sayem A. 2019. Effects of nitrogen and phosphorous use efficiency on the growth and yield of tomato. Journal of Biodiversity and Environmental Sciences. 14(4):21-26.
- Shim KS, Lee CJ, Yim NH, Ha H and Ma JY. 2016. A water extract of *Malva verticillata* seeds suppresses osteoclastogenesis and bone resorption stimulated by RANK ligand. BMC Complem Altern Med.1(16):332.
- Singh S, Chamroy T, Malik S and Kundu S. 2020. Integrated nutrient management (INM) studies on growth and yield of broccoli (*Brassica oleracea* var. *italica*). Plant Arc. 20(2): 9651-9654.
- Sultana N. 2007. Effect of organic and inorganic fertilizers on growth and yield of Chinese cabbage (*Brassica campestris* var. *pekinensis*). MS Thesis, Dept. of Horticulture, Sher-e Bangla Agricultural University, Dhaka, Bangladesh.
- Sumona SA, Khatun L, Khatun S, Ame MA, Rahman AM. 2022. Leafy vegetables in Rangpur city corporation area of Bangladesh focusing on potential medicinal values. GSC Biological and Pharmaceutical Sciences.21(1):160-74.

- Thingujam U, Pati S, Khanam R, Pari A, Ray K, Phonglosa A and Bhattacharyya K. 2016. Effect of integrated nutrient management on the nutrient accumulation and status of post-harvest soil of brinjal (*Solanum melongena* L.) under Nadia conditions (West Bengal), India. *Journal of Applied and Natural Science*. 8(1):321-8.
- Thy S and Buntha P. 2005. Evaluation of fertilizer of fresh solid manure, composted manure or biodigester effluent for growing Chinese cabbage (*Brassica pekinensis*). *Livestock-Research for Rural Development*. 17(3): 26
- Tonny FA. 2021. Effect of Integrated Organic and Inorganic Fertilizers on Growth, Yield and Quality Attributes of SAU Yellow Cherry Tomato. MS Thesis, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.
- Tonoya TZ. 2014. Effects of Urea and Cow Dung on The Growth and Yield of Green Amaranth. MS Thesis, Department of Agricultural Chemistry, Sher-E-Bangla Agricultural University, Dhaka-1207, Bangladesh.
- Uddin M, Kashem A and Osman KT. 2012. Effect of organic and inorganic fertilizers on phytoavailability of P to water spinach (*Ipomoea aquatica* cv. Kankon). *Journal of Agricultural and Biological Science*. 7(3):152-6.
- Uka UN, Chukwuka KS and Iwuagwu M. 2013. Relative effect of organic and inorganic fertilizers on the growth of okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Agricultural Sciences, Belgrade*. 58(3):159-66.
- Wang Z and Li S. 2004. Effects of nitrogen and P fertilization on plant growth and nitrate accumulation in vegetables. *Journal of plant nutrition*. 27(3):539-56.
- Ya T, Gilbert MG and Dorr LJ. 2007. *Flora of China*. Vol. 12. Beijing: Science Press; Louis (MI): Missouri Botanical Garden Press.
- Yogita P, Prasad V M and Bahadur V. (2022). Effect of inorganic fertilizers, organic manures and trichoderma on growth, quality and yield of ridge gourd (*Luffa acutangula*) cv. Kashi Shivani. *The Pharma Innovation Journal*. 11(6): 1793-1797
- Yoldas F, Ceylan S and Elmaci OL. 2020. Effects of animal manures on yield quality and nutrient content in organic broccoli (*Brassica oleracea* L. var. *italica*). M.

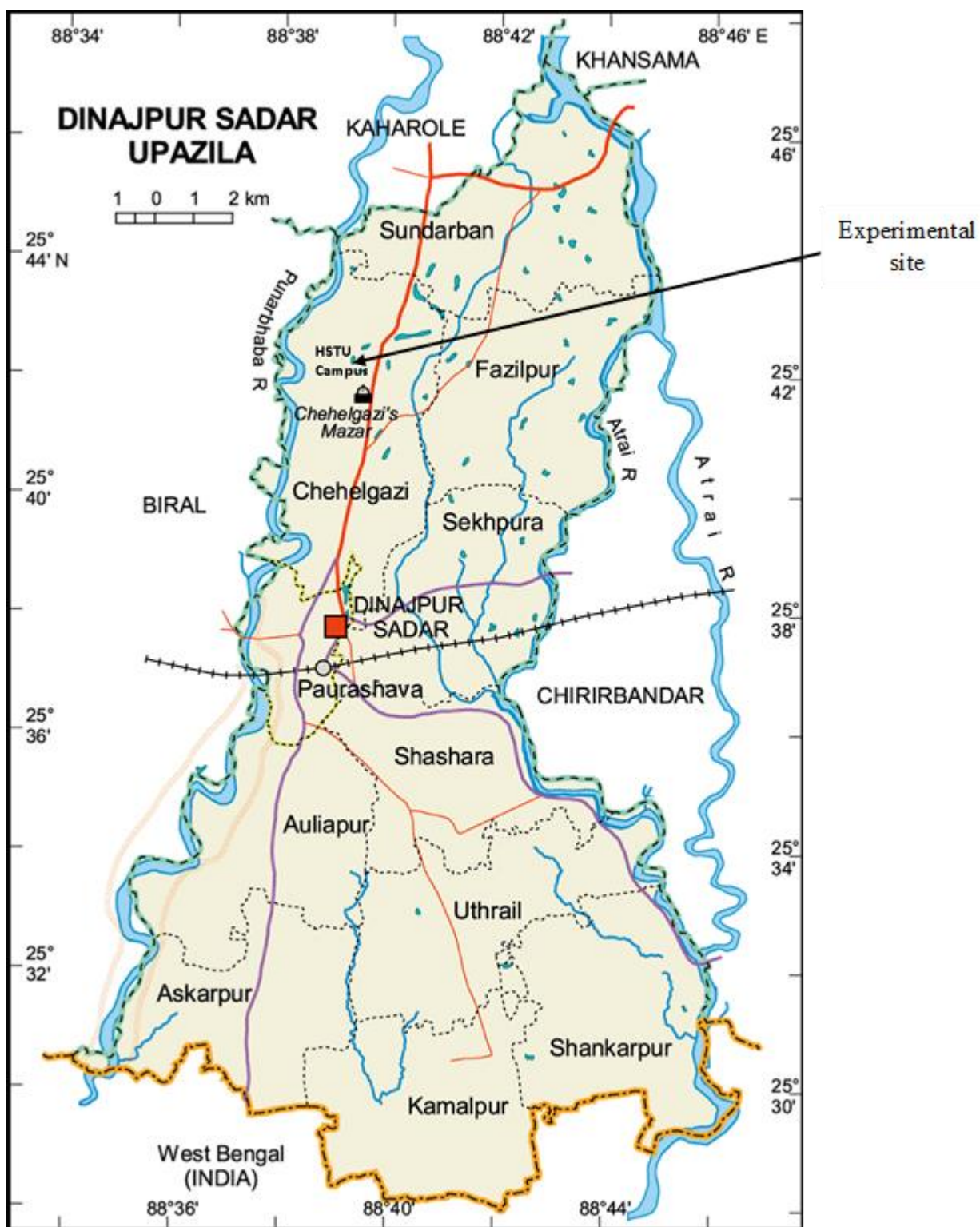
S. Thesis. Soil Sci. Dept. Odemis Technical Training College, Ege University, Izmir, Turkey. pp.: 21-23.

Zaman MM, Chowdhury T, Nahar K, Chowdhury MA. 2017. Effect of cow dung as organic manure on the growth, leaf biomass yield of *Stevia rebaudiana* and post-harvest soil fertility. *Journal of the Bangladesh Agricultural University*. 2017;15(2):206-11.

Zielewicz W and Wróbel B. 2018. Effect of differential nitrogen fertilization on the nutritive value of fodder mallow (*Malva verticillata* L.) and maize (*Zea mays* L.) Eurostar variety. *Journal of Research and Applications in Agricultural Engineering*.63(3):151-6.

## APPENDICES

Appendix I. Experimental Field location on map



**Appendix II.** Some pictorial view of the experimental field

