

**PERFORMANCE OF INDIAN SPINACH (*Basella alba* L.) UNDER
DIFFERENT COMBINATION OF ORGANIC AND INORGANIC
FERTILIZERS**

A THESIS

BY

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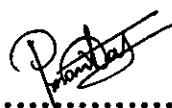


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DEDICATED TO

***THE FARMERS WHO ARE SOLELY DEVOTED TO MEET
THE INCREASING DEMAND OF FOOD AND MY
BELOVED PARENTS***

LIST OF ACRONYMS

BioF= Biofertilizer

BPR = Biogas Plant Residues

CD = Cow Dung

CV = Coefficient of Variation

DAP = Days After Planting

DAP= Diammonim Phosphate

DAS = Days After Sowing

DAT = Days After Transplanting

DMRT = Duncan Multiple Range Test

FYM = Farm Yard Manure

GM= Goat Manure

HW = Household Waste

MoP = Muriate of Potash

PL = Poultry Litter

PM = Poultry Manure

RDF = Recommended Dose of Fertilizer

TSP = Triple Super Phosphat

VC= Vermicompost

WAT = Weeks After Transplanting

WH = Water Hyacinth



ABSTRACT

A field experiment was conducted in the Germplasm centre of Agrotechnology Discipline of Khulna University, Khulna during May 2014 to September 2014 to investigate the performance of Indian spinach under different combination of organic and inorganic fertilizers. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 11 treatments, viz. T_0 = Control (no manures and fertilizers was used), T_1 = NPK (Recommended dose), T_2 = 100% Water Hyacinth (WH), T_3 = 50% Water Hyacinth + 50% Farm Yard Manure (FYM), T_4 = 50% Cow Dung (CD) + 50% Water Hyacinth (WH), T_5 = 50% Poultry Litter + 50% Water Hyacinth (WH), T_6 = 100% Poultry Litter (PL), T_7 = 50% Poultry Litter + 50% Farm Yard Manure (FYM), T_8 = 50% Poultry Litter + 50% Cow Dung (CD), T_9 = 100% Farm Yard Manure (FYM), T_{10} = 100% Cow Dung (CD) and T_{11} = 50% FYM+50% Cow Dung (CD), respectively. Data were collected regularly on number of branch plant⁻¹, number of leaves plant⁻¹, plant height (cm), length of leaves (cm), breadth of leaves (cm), diameter of plant (mm) and yield (t ha⁻¹). Though effect of recommended NPK fertilizers (T_1) was observed to be more effective as produced highest number of branches plant⁻¹, number of leaves plant⁻¹, length of leaves, breadth of leaves and harvested yield but T_{11} (50% FYM + 50% CD) and T_8 (50% PL + 50% CD) gave the highest plant height and diameter, respectively. In context of yield parameter, the highest yield of *Basella alba* L. (28.9 t ha⁻¹) was found at recommended NPK fertilizers followed closely by T_{11} (50% FYM + 50% CD) (28.5 t ha⁻¹), T_7 (50% PL + 50% FYM) (27.1 t ha⁻¹) and T_8 (50% PL + 50% CD) (26.5 t ha⁻¹), respectively. Application of organic manures in combination 50% FYM + 50% CD (5 t ha⁻¹ + 5 t ha⁻¹), 50% PL + 50% FYM (2.5 t ha⁻¹ + 5 t ha⁻¹) and 50% PL + 50% CD (2.5 t ha⁻¹+5 t ha⁻¹), respectively showed better performance in terms of yield parameters and yield of Indian spinach after NPK fertilizers.

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Chapter I

INTRODUCTION

Indian spinach (*Basella alba* L.) also known as Red vine spinach, Creeping spinach, Climbing spinach is a perennial vine found in the tropics where it is widely used as a leafy vegetable. It belongs to the family *Basellaceae* and order *Caryophyllales*. *Basella alba* L. is a fast-growing, soft stemmed vine, reaching 10 m in length. It's thick, semi-succulent, heart-shaped leaves have a mild flavour and mucilaginous texture (Olanrewaju, 2011).

It grows best in sandy loam soils rich in organic matter with pH ranging from 5.5 to 8.0. Typical of leafy vegetables, Indian spinach is high in vitamin A, vitamin C, iron and calcium. It is low in calories by volume, but high in protein per calorie (Grubben and Denton, 2004).

Basella alba L. grows well under full sunlight in hot, humid climates and in areas lower than 500 meters (1,600 ft) above sea level. The plant is native to tropical Asia. Growth is slow in low temperatures resulting in low yields. Flowering is induced during the short-day months of November to February (<http://www.wikipedia.org>).

Fertilizers are materials added to the soil to enrich and compliment the nutrient status of the soil. Fertilizers can either be organic or inorganic in nature. Inorganic fertilizers dissolve quickly and are made available to the plants for their use within a short time. Organic fertilizers on the other hand release their nutrients slowly to the plants and make these nutrients available to plants for a longer period of time. Inorganic fertilizers leach

faster than organic fertilizers. The best fertilizer for soils found in the humid tropics is a mixture of organic and inorganic fertilizers (Agboola and Sobulo, 1981).

A complimentary application of manure and mineral fertilizer has shown tremendous increase in the nutrient efficiency of plants (Murwira and Kirchmann, 1993) and organic manure is usually required in large quantities to sustain crop production which may not readily be available to small scale farmers. Nitrogen is an essential plant nutrient which is needed mainly for vegetative growth. Phosphorus serves to store energy in the plants as well as in photosynthesis processes, all these are contained in fertilizers. The use of fertilizers is inevitable and bulkiness of organic manure is laborious. High cost and the toxicity arising from the missuse of inorganic fertilizers have been creating barriers for their use by farmers (Olanrewaju, 2011).

Manure is a valuable fertilizer for any farming operation and has been used for centuries to supply needed nutrients for crop growth. Manure and compost not only supply many nutrients for crop production, including micronutrients, but they are also valuable sources of organic matter. Increasing soil organic matter improves soil structure or tilth, increases the water-holding capacity of coarse-textured sandy soils, improves drainage in fine-textured clay soils, provides a source of slow release nutrients, reduces wind and water erosion, and promotes growth of earthworms and other beneficial soil organisms. Most vegetable crops return small amounts of crop residue to the soil, so manure, compost, and other organic amendments help to maintain soil organic matter levels (Rosen and Bierman, 2005).

Proper use of manure and compost is essential from both production and environmental standpoint. Applying rates that are too low can lead to nutrient deficiency and low yields.

On the other hand, too high a rate can lead to nitrate leaching, phosphorus runoff, accelerate eutrophication of lakes, and excessive vegetative growth of some crops. Thus, understanding how to manage manure is important for any farming operation with livestock that relies on manure as a major source of nutrients, as well as for vegetable producers who have access to an economical supply of manure, compost, or other organic nutrient sources. This discussion addresses differences between the composition of fresh and composted manure, nutrient availability from manure/compost, and calculation of how much manure/compost to apply. Although focused on manure or composted manure, much of the discussion and the methods for calculating rates are generally applicable to effective use of different types of compost, biosolids and similar organic nutrient sources (Rosen and Bierman, 2005).

For sustainable crop production soils should have at least 5% organic matter. Unfortunately, though, most of the Bangladeshi soil has 1 to 1.8% organic matters. The low organic matter content in the soils reduces soil fertility and limits water-holding capacity. This combination of factors contributes to severe production constraints in the drought and saline prone areas of North West and South West Bangladesh. The use of compost for soil enrichment is a suitable way for farmers to reduce the limitations (FAO, 2000).

In Bangladesh where limited cultivable land is forced to maximize crop yields per unit area through intensive use of land and soil resources. Due to the present land ownership and tenureship the farmers of Bangladesh have the tendency to exploit the soils for maximum profit and little attention is given for maintaining sustainable soil health. The soil fertility and productivity of soils of Bangladesh has been declining day by day due to

continuous mining of nutrients, crop intensification and imbalanced use of chemical fertilizers with little or no addition of organic fertilizers. Organic matter content in Bangladesh soil is alarmingly low around 1% in most and 2% in few soils, where it should be maintained at least 3% that is conducive to high productivity. Under such situation to increase soil fertility and sustain crop productivity, there is no alternative besides to add organic fertilizer into the soil. Organic fertilizer can serve as a substitute to mineral fertilizers. Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity. Organic fertilizers play a vital role in restoring fertility as well as organic matter status of the soils (Hossain *et al*, 2014).

Basella alba L. is a nutritious indigenous vegetable but it is under- utilized mainly because it is not usually cultivated conventionally but grows spontaneously in non-hygienic places without using fertilizers or unconscious use of fertilizers and manures. This affects the demand of the vegetable negatively. Therefore, this study is designed to evaluate the type of fertilizers and manures and their combinations that will enhance the growth and yield of the Indian spinach.

Objectives

1. To identify the impact of organic matter and fertilizers on growth and yield of Indian spinach.
2. To find out optimum dose of organic manures and fertilizers for production of Indian spinach.



Chapter II

REVIEW OF LITERATURE

Different scientists and researchers have found several results on different parameters in their research by using fertilizers and manures for Indian spinach production. Some of the literature pertaining to the present study is reviewed below.

2.1 Effect of fertilizers and manures on growth and yield of Indian spinach

Islam *et al.* (2011) conducted an experiment at Gazipur District, Bangladesh with eight treatments such as poultry manure (PM) @ 5 t ha⁻¹ (T₁), cow dung (CD) @ 10 t ha⁻¹ (T₂), household waste (HW) @ 10 t ha⁻¹ (T₃), PM @ 2.5 t ha⁻¹ + reduced RDF (recommended dose of fertilizer) (T₄), CD @ 5 t ha⁻¹ + reduced RDF (T₅), HW @ 5 t ha⁻¹ + reduced RDF (T₆), 100% RDF (T₇) and Control (T₈) for Indian spinach and result represented that treatment T₆ gave the maximum number of leaves plant⁻¹ (15.1 in 2007-08 and 14.8 in 2008-09) followed by T₅ and T₄ treatment. The minimum numbers of leaves plant⁻¹ (7.57 in 2007-08 and 7.1 in 2008-09) were found in the control. It was observed that organic manure or chemical fertilizers alone did not produce higher number of leaves plant⁻¹. In case of stem length, ranged from 21.4 to 76.7 cm in 2007-08 and 18.8 to 72.2 cm in 2008-09 having the longest size with HW (Household waste) @ 5 t ha⁻¹ + rest from RDF (Recommended dose of chemical fertilizers) which was significantly higher than all other treatments. The shortest stem length was found in the Control. Three types of organic manure alone produced moderate plant height and they were statistically similar with each other. The maximum stem circumference (4.21 cm in 2007-08 and 4.14 cm in 2008-09) was found in T₆ and the minimum was in the control, but the integrated effect had no significant influence on stem circumference. In case of leaf length and

breadth the highest was in HW @ 5 t ha⁻¹ + rest from RDF (T₆) application followed by CD @ 5 t ha⁻¹ + rest from RDF (T₅) application and PM @ 2.5 t ha⁻¹ + rest from RDF (T₄). Minimum leaf length and breadth was found in case of control. In case of Indian spinach result shows that highest yield was found in T₆ for both first year and second year where as lowest yield was found in control.

Hossain *et al.* (2014) also conducted another experiment at the Department of soil science, University of Chittagong, Bangladesh. There were seven treatments comprising of control, recommended NPK fertilizer and biogas plant residues (BPR) @ 10, 20, 30, 40 and 50 ton ha⁻¹. The treatments were arranged in a randomized complete block design with three replications. Results indicated that number of leaves; plant height and root length and dry weight of shoot and root obtained with recommended NPK fertilizer were statistically similar to those with control treatment except for number of leaves at 60 DAS. Application of biogas plant residues up to 30 ton ha⁻¹ produced similar number of leaves and plant height compared to control and recommended NPK fertilizer at 30 DAS. At 60 DAS, a significantly higher number of leaves and root length was found with above 20 ton ha⁻¹ biogas plant residues and plant height with above 10 ton ha⁻¹ biogas plant residues than control and recommended NPK fertilizer. Fresh weight of shoot and root found with recommended fertilizer dose were significantly higher than that with the control but lower than that with biogas plant residues above 30 ton ha⁻¹ and 10 ton ha⁻¹, respectively. Biogas plant residues at 30 ton ha⁻¹ and above gave higher shoot and root dry weight than control and recommended NPK fertilizer. However, there were no significant differences between BPR40 and BPR50 for growth parameters of Indian spinach. The study recommends 40 ton ha⁻¹ of biogas plant residues for enhanced growth of Indian spinach.

An experiment conducted by Olanrewaju (2011) in Africa showed that the effect of fertilizers on number of leaves of *Basella alba* L. was not significant from 2WAT (Weeks After Transplanting) to 6WAT. However, there was a significant difference at 7WAT, the plants treated with NPK, poultry manure and tithonia had mean values of 46.77, 43.10 and 46.77, respectively. The differences were significant at $P \leq 0.5$. Plants that received NPK performed better than those raised with poultry manure and tithonia based compost. The highest mean value (5.87cm) of vine length while plants treated with Tithonia based compost had the lowest mean value (4.87cm) of vine length. At 5WAT, NPK had the highest mean value of vine length (13.53cm) while plants on the control plot had the lowest mean value (9.21cm) of vine length of Indian spinach (*Basella alba* L.). The differences were significant at $P \leq 0.5$. There was no significant difference on the leaf area from 3WAT to 7WAT. At 2WAT, plants treated with poultry manure had the highest mean value (16.7cm²) of leaf area while plants treated with Tithonia had the lowest mean value of leaf area (7.0cm²). NPK had the highest effect on the harvested yield 61893.2 kg ha⁻¹ of *Basella alba* L. followed closely 56213.2 kg ha⁻¹ by poultry manure.

Melton and Dufault (1991) conditioned tomato (*Lycopersicon esculentum* Mill.) seedlings nutritionally with solutions containing factorial combinations of N at 25, 75 and 225 mg liter⁻¹, P at 5, 15, and 45 mg liter⁻¹, and K at 25, 75, and 225 mg liter⁻¹ to determine the effect of nutritional regimes on tomato transplant growth and quality. As N increased from 25 to 225 mg liter⁻¹, fresh shoot weight, plant height, stem diameter, leaf number, leaf area, shoot and root dry weights, and total chlorophyll increased. Nitrogen accounted for the major source of variation. Phosphorus effects were significant only in 1988; Phosphorus at 45 mg liter⁻¹ increased fresh shoot weight, plant height, stem

diameter, leaf number, and leaf area in comparison to 5 and 15 mg liter⁻¹. Potassium did not significantly influence any of the growth variables measured in the study. For quality transplant production, nutrient solutions should contain at least N at 225 mg liter⁻¹, P at 45 mg liter⁻¹, and K at 25 mg liter⁻¹.

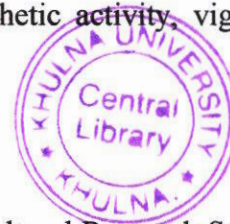
Ahammad *et al.* (1999) conducted an experiment in Gazipur, Bangladesh, during November 1996 March 1997 to determine the optimum rates of mustard oilcake and urea per pot for pot culture of grafted tomato cv. Ratan on roof gardens. The pots were supplied with different organic residues, i.e. cow dung and poultry droppings, and mustard oilcake and urea, at 11 different treatment combinations. There were significant differences among the treatments with respect to vegetative growth, flowering and fruiting, fruit characteristics and yield of grafted tomato. The maximum number of fruits per plant (82.1) was obtained in treatments where urea and mustard oilcake were applied at 4.66 and 350 g pot⁻¹, respectively. The lowest number of fruits per plant (37.3) was obtained in treatment where urea and mustard oilcake were applied at 9.33 and 7.00 g pot⁻¹, respectively. The highest fruit yield per plant (4.41 kg) was also obtained in the same treatment where the highest number of fruits per plant was obtained.

Ghimire (2013) also conducted an experiment to know the effectiveness of different nitrogen sources on growth and yield of sweet pepper cv. California Wonder. The treatments were : FYM 100%- (33 t FYM), FYM 50% + urea 50%- (16.5 t FYM + 163 kg urea), GM 100%- (26.8 t goat manure), GM 50% + urea 50%- (13.4 t goat manure + 163 kg urea), VC 100%- (28.8 t vermicompost), VC 50% + urea 50%- (14.4 t vermicompost + 163 kg urea) and NPK chemicals- (262.3 kg urea + 163 kg DAP + 83.3 kg MOP). However, application of FYM 50% + urea 50% significantly increased the

plant height (33.02 cm), number of leaves per plant (61.20). Number of primary branches (4.267), fresh shoot weight (193.5 g) at 60 days after planting where application of only chemicals represented lower vegetative growth. On the other hand, days to first flowering did not differ significantly among the treatments but numerically the highest number of days to first flowering (48.75 days) was seen with only chemicals. Per cent fruit set (45.85%), fruit length (8.80 cm), fruit weight (96.54 g) and fruit yield was the highest (13.524 MT ha⁻¹) with application of FYM 50% + urea 50%. While, lower percent of fruit set was observed with the application of vermicompost 50% + urea 50% and goat manure 50% + urea 50% may have been due to more availability of nitrogen at the time of flowering.

Ojeniyi *et al.* (2007) conducted an experiment in which combined use of crop and animal wastes is necessary in order to obtain adequate amount of organic manure for use in crop production. Hence field experiments were conducted at two sites in Akure, Southwest Nigeria to compare effect of NPK (15-15) fertilizer (200 kg ha⁻¹) and each of Spent Grain (SG) and ground Cocoa Husk (CH) amended with Cattle Dung (CD), Poultry Manure (PM) and Goat Manure (GM) at equal rates (12.5 : 12.5 t ha⁻¹). The effects of treatments on leaf N, P and K concentrations, growth and fruit yield of tomato were studied. Compared with control, NPK and animal manure amended SG and CH increased leaf N and K, plant height, number of branches, leaf area, number and weight of fruits significantly ($P > 0.05$). Fruit yields given by CD, PM and GM amended CH and M and GM amended SG were similar. Among eight treatments compared, CH and SG amended with PM gave height fruit yield, compared with control, NPKF, amended SG and CH increased fruit yield by 268, 342 and 397%, respectively.

On another study Prativa and Bhattarai (2011) also noticed the impact of integrated use of vermicompost, farmyard manure and NPK on tomato (*Lycopersicon lycopersicum* L. cv. Yash). 9 different treatments were considered in this study : $T_1 = 20 \text{ mt/ha}$, $T_2 = \text{Half of the recommended NPK} + 30 \text{ mt/ha FYM}$, $T_3 = \text{Three fourths of the recommended NPK} + 25 \text{ mt/ha}$, $T_4 = 10 \text{ mt/ha Vermicompost}$, $T_5 = \text{Half of the recommended NPK} + 15 \text{ mt/ha Vermicompost}$, $T_6 = \text{Three fourths of the recommended NPK} + 12.5 \text{ mt/ha Vermicompost}$, $T_7 = 16.66 \text{ mt/ha FYM} + 8.33 \text{ mt/ha Vermicompost} + \text{NPK}$, $T_8 = \text{Recommended NPK (100: 80: 60 kg/ha)}$, $T_9 = \text{Control (no organic manures and inorganic fertilizers)}$. Although the earliness in days to 50% flowering (26.33) was recorded in treatment 20 mt/ha FYM , (may be due to the faster enhancement of vegetative growth and storing sufficient reserved food materials for differentiation of flower buds) but the overall good performance in case of highest plant height (116.16 cm), number of leaves per plant (105.50), number of fruit clusters/plant (6.90), fruit weight (52.8 g) and fruit yield (25.74 mt/ha) was observed in T_7 $16.66 \text{ mt/ha FYM} + 8.33 \text{ mt/ha Vermicompost} + \text{NPK}$ might be due to the fact that the application of NPK, FYM and vermicompost provided adequate N which is associated with high photosynthetic activity, vigorous vegetative growth and solubilization effect of plant nutrients.



Mehdizadeh *et al.* (2013) carried out a field experiment in Agricultural Research Station, Ferdowsi University of Mashhad, Iran during the season, 2011 to evaluate the vegetative growth and yield of tomatoes as affected by different organic fertilizers addition. The experiment was a randomized complete block design with three replications. The results showed that addition of organic fertilizers at rate of 20 t ha^{-1} significantly ($P < 0.05$) increased tomato growth and yield compared to control (no fertilizer application). Also obtained results proved that tested treatments could be arranged in decreasing order

following: municipal waste compost > poultry manure > cow manure > sheep manure > no fertilizer. Compost and poultry manure had a synergistic effect on both fresh and dry weights of tomato shoots and roots and compared to other treatments. As a general result using of organic fertilizers especially in composted form had positive effect on soil health and fertility, which consequents increase yield in long term can be expected.

In another experiment, Osumah and Tijani (2010) found that 100 kg ha⁻¹ NPK (15:15:15) significantly improved the growth and quality attributes of chilli (*Capsicum frutescens* L.). This experiment was conducted in 2005 by taking 7 different treatments: control (No soil additive), 50 kg ha⁻¹ NPK, 100 kg ha⁻¹ NPK, 150 kg ha⁻¹ NPK, 2.5 t ha⁻¹ OMF + 50 kg ha⁻¹ NPK and 2.5 t ha⁻¹ OMF + 100 kg ha⁻¹ NPK. Among the treatments, 100 kg ha⁻¹ NPK performed best and from 6-10 weeks after planting the highest plant height (29.42 cm - 49.64 cm), number of leaves (60.50 - 150.25), number of branches (8.75 - 17.75) and fruit yield (0.8 kg) was found in case of NPK at 100 kg ha⁻¹ that clearly emphasized fertilizer use as a key factor in soil fertility management and yield increase in crop production. Also the nutrient composition of the NPK at 150 kg ha⁻¹ were available for plant utilization which greatly influence the quality parameters and yield of chilli indicated that rapid supply of nutrient is the main reason for highest growth and yield compared to that of other treatments.

Khalid *et al.* (2010) conducted the study in Bara locality during 2009-2010 to assess the impact of using different types of organic fertilizers on tomato yield growing in a sandy soil. Five treatments were compared, i.e., compost, fresh chicken manure, fresh cattle manure, fresh chicken + cattle manure and untreated control. The design of experiment was Randomized Complete Block Design (RCBD) with three replications. All treatments

resulted into higher tomato yield compared to the control. Compost fertilizer gave the highest tomato yield of 13.58 t ha⁻¹.

Kisetu and Heri (2014) convened a study to compared the effects of poultry manure and NPK (23:10:5) fertilizer to the performance of tomato. Poultry manure was applied at 2, 4 and 8 t ha⁻¹ and NPK fertilizer at 20, 40 and 80 kg ha⁻¹. Results showed that the highest number of leaves (70) and shoot length (93 cm) were recorded at 8 t ha⁻¹ and lowest (46 and 57 cm, respectively) at 2 t ha⁻¹ of poultry manure. These variables were far small (18 and 55 cm, respectively) for absolute control. In addition, 40 kg NPK ha⁻¹ recorded the highest shoot length (91 cm) and 20 kg NPK ha⁻¹ lowest (60 cm). Many tomato fruits (31) were produced at 8 t ha⁻¹ poultry manure compared with 22 in 40 kg NPK ha⁻¹ and differed significantly ($p < 0.001$) with absolute control (5) and among treatments. The smallest (823 g) and highest (2338 g) weights of fruits recorded per plant at 2 and 8 t ha⁻¹ poultry manure, respectively, differed significantly ($p < 0.01$) among treatments and absolute control (341 g). The smallest (676 g) and highest (1668 g) weights recorded at 20 and 40 kg NPK ha⁻¹, respectively, also differed significantly ($p < 0.01$). It was concluded that poultry manure at 8 t ha⁻¹ and NPK (23:10:5) fertilizer at 40 kg ha⁻¹ are sufficient for tomato plants but the former outweighs the latter.

Kodally (2006) conducted an experiment by taking 7 different combination of fertilizers on two varieties of chilli (*Capsicum annum* L.) treatments namely, T₁ – Control (RDF-100:50:50 kg NPK ha⁻¹), T₂ – RDF + FYM (25 t ha⁻¹), T₃ – RDF + Vermicompost (5 t ha⁻¹), T₄ – RDF + VAM (2 kg ha⁻¹), T₅ – RDF + *Azospirillum* (500 g ha⁻¹), T₆ – RDF + NAA (40 ppm), T₇ – RDF + Ethrel (250 ppm) and 2 varieties namely, V₁ – Byadagikaddi and V₂ – Byadagidabbi. Among the treatments, RDF + FYM 25 t ha⁻¹ recorded

significantly higher (92.8 cm) plant height and higher (31.1) number of branches over all other treatments at all the stages followed by RDF + vermicompost 5 t ha⁻¹ (85.3 cm and 28 respectively) while lower was recorded in control (75.1 cm and 23.5). However, the days to 50 per cent flowering, number of fruits per plant, fruit length, fruit diameter and fruit yield per plant was differed significantly due to treatments and varieties but not with interaction of these two factors. The maximum number of days to attain 50 % flowering was noticed in control (32.2) and the minimum was in RDF + FYM (25 t ha⁻¹) (27.6) in both genotypes. Higher number of fruits per plant (105.3), fruit length (11.2 cm), fruit diameter (2.53 cm) and fruit yield per plant (104.8 g) was observed in T₂ – RDF + FYM (25 t ha⁻¹) followed by T₃ – RDF + Vermicompost (5 t ha⁻¹)– 97.7, 10.2 cm, 2.36 cm and 98.8 g, respectively which may be attributed to the increased solubilization effect and availability of nutrients by the addition of FYM and increased physiological activity leading to the buildup of sufficient food reserves for the developing sinks and better portioning towards the developing fruits. While lowest was found in the control (only RDF).

Dorji *et al.* (2009) conducted an experiment to find out the combined effect of farmyard manure and inorganic fertilizers on chilli (*Capsicum annum* L.). This study was conducted over four consecutive years (2001-2004) by taking four different levels of FYM (0, 2, 4 and 8 t ha⁻¹) and N: P: K (0:0:0, 8:6:6, 16:8:8 and 24:18:18 kg acre⁻¹). This experiment revealed that when quantity of fruits increases the quality of fruit tended to decrease with increasing NPK and FYM applications. The highest crop yield of 5.17 t ac⁻¹ and 4.78 t ac⁻¹, highest yield per plant 256 g and 229 g, highest number of fruits per plant 22 and 19 as well as highest number of rejected fruits per acre (664 and 529) was observed with highest rate of NPK (24:18:18 kg acre⁻¹) and FYM (8 t ha⁻¹) and the author stated that the integrated use of these organic and inorganic fertilizers is benefitted

than with the use of either of these separately although their combination effect on the quantity and quality of the fruits was not statistically significant.

Malik *et al.* (2011) observed that the various combinations of inorganic fertilizers and FYM rate significantly affected on growth and yield attributing traits of sweet pepper (*Capsicum annuum* L. var. *grossum*). The experiment was conducted on two different locations by 9 different combinations of FYM and inorganic fertilizers treatments, e.g: T₁ (N=90 kg ha⁻¹; P₂O₅= 60 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 20 t ha⁻¹), T₂ (N=90 kg ha⁻¹; P₂O₅ = 60 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 30 t ha⁻¹), T₃ (N=90 kg ha⁻¹; P₂O₅ = 60kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 40 t ha⁻¹), T₄ (N=120 kg ha⁻¹; P₂O₅ = 90 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 20 t ha⁻¹), T₅ (N=120 kg ha⁻¹; P₂O₅ = 90 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 30 t ha⁻¹), T₆ (N=120 kg ha⁻¹; P₂O₅ = 90 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 40 t ha⁻¹), T₇ (N=150 kg ha⁻¹; P₂O₅ = 120 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 20 t ha⁻¹), T₈(N=150 kg ha⁻¹; P₂O₅ = 120 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 30 t ha⁻¹), T₉ (N=150 kg ha⁻¹; P₂O₅ = 120 kg ha⁻¹; K₂O = 60 kg ha⁻¹; FYM = 40 t ha⁻¹), T₁₀ (control = no chemical fertilizers or FYM). However, Treatment 9 recorded a maximum of plant height (57.14cm and 54.16cm), number of branches (6.70 and 6.53), plant spread (46.00 and 43.00 cm), number of fruits per plant (20.45 and 19.00), fruit length (8.40 and 8.20cm), fruit diameter (8.09 and 7.70cm), average fruit weight (94.85 and 93g), average fruit yield plot⁻¹ (38.79 and 35.34 kg) and average fruit yield ha⁻¹ (718.47 and 686.39 kg) at Wadura and Shalimar respectively where as lowest found in the control. The increase in growth in this treatment might be due to increase in fertilizer and FYM application may be ascertained to increase amount of nutrients such as nitrogen, phosphorus and potassium in plants, leading to increase formation of plant metabolites that helped to build the plant tissue and the increase in yield and yield contributing characters may be

due to balanced C/N ratio, decomposition, mineralization, availability of native and applied macro and micro-nutrients. The combination of Farmyard manure and inorganic fertilizers were also proved to be effective in case of improving the growth and yield of Cucumber (*Cucumis sativus* L.cv. Ashley) (Eifediyi and Remison, 2010). Three different rates of farmyard manure (0, 5 and 10 t ha⁻¹) and 5 rates of inorganic fertilizers (0, 100, 200, 300 and 400 kg ha⁻¹) were used in this trial. Although the vine length and no. of leaves were not significantly differ among the treatments but numerically at 8 weeks after planting (WAP), the highest vine length (276.93 cm) and no. of leaves (61.73) were observed in the combined rates of farmyard manure at 10 t ha⁻¹ x 400 kg ha⁻¹ fertilizers. However, the yield attributing characters of cucumber significantly differed among the treatments except fruit length (highest was found 15.71 cm in highest rate of farmyard manure and inorganic fertilizers). The highest fruit weight (2.43 kg) per plant and fruit weight per hectare (43,259.24 kg ha⁻¹) was observed in the treatment 10 t ha⁻¹ x 400 kg ha⁻¹ fertilizer. Also this treatment fertilizer gave a yield of 166.42% over the control which indicated that response to FYM was more at higher rates of NPK application and nutrients were more readily available when organic and inorganic fertilizer were combined.

Ibrahim and Fadni (2013) conducted the study in Bara locality of North Kordofan state, for two consecutive winter seasons (2009/2010). The objective of the study was to investigate the effect of different types of organic fertilizers on soil chemical and physical properties, and on growth, yield and quality of tomato fruits. The experiment consisted of five treatments. The treatments were laid in a randomized complete block designed (RCBD) with three replications. Soil analysis showed that the experimental area is dominated by sandy soil texture. Tomato seeds were planted in the nursery and then transplanted into the field after five weeks. Data collected Soil sampling and

analysis, Results of soil samples analysis showed significant ($p \leq 0.05$) change in the soil chemical and physical properties and increase in the amount of organic matter content especially. The production indicators showed that the tomatoes Agronomic parameters were significantly ($P \leq 0.05$), affected by the addition of different sources of organic fertilizers.



In a study Haque *et al.* (2012) proposed that *Trichoderma*-enriched biofertilizer could save at least 50% N fertilizer uses for mustard and tomato which indicates reduction of excessive uses of NPK for crop cultivation. Treatments were T₁ - control (without biofertilizer and chemical fertilizers), T₂ - NPK fertilizer, T₃ - BioF/compost (618 g plot⁻¹), T₄ - BioF/pellets (5 g plant⁻¹ for tomato and 25 g/row for mustard), T₅ - BioF/suspension (5 ml plant⁻¹ for tomato and 25 ml/row for mustard), T₆ - 50% N-fertilizer + 50% BioF/compost, T₇ - 50% N fertilizer + 50% BioF/pellets and T₈ - 50% N fertilizer + 50% BioF/suspension. The authors observed that combined application (supplemented with N) of *Trichoderma*-enriched biofertilizer such as the treatments T₆, T₇ and T₈ significantly increased the growth and yield attributes of Mustard (*Brassica rapa* L. cv. BARI mustard) and Tomato (*Lycopersicon esculentum* Mill. Cv. Ratan). In case of Mustard, highest plant height, number of branches plant⁻¹, number of leaves plant⁻¹, Flower (per cluster), Silique (no./plant), Silique length (cm) and yield were observed in the treatment of only inorganic fertilizers and the other three combined treatments. In case of tomato although plant height and branch number were not significantly differ among the treatments, highest leaf number plant⁻¹ (T₆ - 69.73, T₈ - 73.77), Flower cluster/ plant (T₇ - 21.00, T₈ - 18.73, T₆ - 16.42), Flower no./cluster (T₇ - 7.75, T₆ - 6.45), Fruit no./plant (T₇ - 41.03, T₈ - 39.43, T₆ - 35.97) and Fruit yield plant⁻¹ (T₈ - 1.67, T₇ - 1.41, T₆ - 1.24) were observed in the combined treatments.

Adekiya and Agbede (2009) conducted four field trials during the years 2006 and 2007 at Owo, the forest- savanna transition zone in southwest Nigeria, to study the effect of poultry manure (PM), NPK 15-15-15 fertilizer and NPK 15-15-15 fertilizer + poultry manure on the growth and yield of tomato. Seven treatments were applied to the soil: 0, 10, 20, 30, 40 t ha⁻¹ poultry manure , 300 kg ha⁻¹ NPK 15-15-15 fertilizer and 150 kg ha⁻¹ NPK 15-15-15 fertilizer + 10 t ha⁻¹ poultry manure. These were laid out in a randomized complete block design and replicated three times. The treatments were compared on the basis of their effect on soil chemical properties, leaf nutrient content, growth and yield of tomato. All levels of poultry manure and NPK 15-15-15 fertilizer + poultry manure increased leaf N, P, K, Ca and Mg levels. The soil chemical properties except pH increased with amount of poultry manure. NPK 15-15-15 fertilizer alone did not increase the soil and leaf Ca and Mg. All levels of poultry manure, NPK 15-15-15 fertilizer alone and NPK 15-15-15 fertilizer + poultry manure increased the number of leaves, plant height, leaf area, number of fruits and fruit weight significantly. Among poultry manure levels, 30 t ha⁻¹ poultry manure gave the highest fruit yield. Among the seven treatments, NPK 15-15-15 fertilizer + poultry manure gave the highest yield. On an average over the two years, 10, 20, 30, 40 t ha⁻¹ poultry manure, 300 kg ha⁻¹ NPK 15-15-15 fertilizer alone and 150 kg ha⁻¹ NPK 15-15-15 fertilizer + 10 t ha⁻¹ poultry manure treatments increased fruit weight by 19, 36, 51, 14, 20 and 83%, respectively. Results revealed that poultry manure is a suitable source of nutrients for tomato especially if applied at 30 t ha⁻¹ in the forest-savanna transition zone of southwest Nigeria. The combined use of NPK 15-15-15 fertilizer and poultry manure increased tomato yield compared to the application of NPK 15-15-15 fertilizer or poultry manure alone and is therefore recommended for sustainable productivity. In addition, lesser quantities of poultry manure and NPK 15-15-15 fertilizer would be required, therefore, reducing the amount of money spent on chemical fertilizer.

Ayeni *et al.* (2010) conducted field experiments in two locations at Owo in early and late crop seasons (2007) to compare the effects of poultry manure at 0, 10, 20, 30, 40 t ha⁻¹ and 300 kg ha⁻¹ NPK 15:15:15 fertilizer on nutrient uptake and yield of tomato. The sites were located within the forest savannah transition zone of southwest Nigeria. The experiments were replicated three times in randomized complete block design. The test soil was slightly acidic, low in OM, N and P. Application of poultry manure and 300kg ha⁻¹ NPK fertilizer significantly ($P<0.05$) increased plant N, P and K. Poultry manure at 20, 30 and 40 t ha⁻¹ and NPK 15:15:15 fertilizer significantly ($P<0.05$) increased plant leaf, area height, number of leaves, branches fruits and fruit yield. Application of 10 t ha⁻¹ poultry manure gave similar values of plant N, P and K and yield components compared with 300 kg ha⁻¹ NPK fertilizer. The cumulative yield for the two seasons at 0, 10, 20, 30 and 40 t ha⁻¹ and 300 kg ha⁻¹ NPK were 9.6, 12.0, 18.1, 19.3, 14.4 and 13.5 t ha⁻¹, respectively.

2.2 Nutrient Contents and Use of Organic Manures

2.2.1 Cow Dung

Cow dung one of the most important and valuable organic matter rich in different nutrients which improve soil health and increase plant growth and yield. Composting cow manure has several benefits. In addition to eliminating harmful ammonia gas and pathogens (like *Escherichia coli*), as well as weed seeds, composted cow manure will add generous amounts of organic matter to your soil. By mixing this compost into the soil, you can improve its moisture-holding capacity. This allows you to water less frequently, as the roots of plants can use the additional water and nutrients whenever needed. Additionally, it will improve aeration, helping to break up compacted soils. Composted cow manure also contains beneficial bacteria, which convert nutrients into easily

accessible forms so they can be slowly released without burning tender plant roots. Composting cow manure also produces about a third less greenhouse gases, making it environmentally friendly (Phipps, 2014).

Cattle manure is basically made up of digested grass and grain. Cow dung is high in organic materials and rich in nutrients. It contains about 3 percent nitrogen, 2 percent phosphorus, and 1 percent potassium (3-2-1 NPK) (Phipps, 2014).

It also contains Fe (1134 to 1884 mg kg⁻¹), Cu (31 to 234 mg kg⁻¹), Zn (110 to 143 mg kg⁻¹), Total Calcium (1.87 to 2.0 g kg⁻¹), Total Potassium (2.8 to 7.8 g kg⁻¹) and Total Na (1.38 to 5.8 g kg⁻¹) (Yadav *et al*, 2013).

2.2.2 Farmyard Manure

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 percent P₂O₅ and 0.5 per cent K₂O. The present method of preparing farmyard manure by the farmers is defective. Urine, which is wasted, contains one percent nitrogen and 1.35 per cent potassium. Nitrogen present in urine is mostly in the form of urea which is subjected to volatilization losses. Even during storage, nutrients are lost due to leaching and volatilization. However, it is practically impossible to avoid losses altogether, but can be reduced by following improved method of preparation of farmyard manure. Trenches of size 6 m to 7.5 m length, 1.5 m to 2.0 m width and 1.0 m deep are dug. All available litter and refuse is mixed with soil and spread in the shed so as to absorb urine. The next morning, urine soaked refuse along with dung is collected and placed in the trench. A section of the trench from one end should be taken up for filling with daily collection.

When the section is filled up to a height of 45 cm to 60 cm above the ground level, the top of the heap is made into a dome and plastered with cow dung earth slurry. The process is continued and when the first trench is completely filled, second trench is prepared. The manure becomes ready for use in about four to five months after plastering. If urine is not collected in the bedding, it can be collected along with washings of the cattle shed in a cemented pit from which it is later added to the farmyard manure pit. Chemical preservatives can also be used to reduce losses and enrich farmyard manure. The commonly used chemicals are gypsum and superphosphate. Gypsum is spread in the cattle shed which absorbs urine and prevents volatilization loss of urea present in the urine and also adds calcium and sulphur. Superphosphate also acts similarly in reducing losses and also increases phosphorus content. Partially rotten farmyard manure has to be applied three to four weeks before sowing while well rotten manure can be applied immediately before sowing. Generally 10 to 20 t ha⁻¹ is applied, but more than 20 t ha⁻¹ is applied to fodder grasses and vegetables. In such cases farmyard manure should be applied at least 15 days in advance to avoid immobilization of nitrogen. The existing practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. These losses can be reduced by spreading the manure and incorporating by ploughing immediately after application (<http://www.teca.fao.org>).

The entire amount of nutrients present in farmyard manure is not available immediately. About 30 percent of nitrogen, 60 to 70 percent of phosphorus and 70 percent of potassium are available to the first crop (<http://www.teca.fao.org>).

2.2.3 Poultry Litter

The excreta of birds ferment very quickly. If left exposed, 50 percent of its nitrogen is lost within 30 days. Poultry litter contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrient content is 3.03 percent N; 2.63 percent P_2O_5 and 1.4 percent K_2O (<http://www.teca.fao.org>).

The nutrient content of poultry litter varies quite a bit. Fertilizer value depends on the type of birds, age of the litter, and litter moisture content. It is always a good idea to take a sample and test the litter for nutrients prior to cleaning out a poultry house. Use the test results to calculate how much litter to apply to fields (Hamilton, 2006).

2.2.4 Water Hyacinth as Green Manure

Water hyacinth can be used on the land either as a green manure or as compost. As a green manure it can be either ploughed into the ground or used as mulch. The plant is ideal for composting. After removing the plant from the water it can be left to dry for a few days before being mixed with ash, soil and some animal manure. Microbial decomposition breaks down the fats, lipids, proteins, sugars and starches. The mixture can be left in piles to compost, the warmer climate of tropical countries accelerating the process and producing rich pathogen free compost which can be applied directly to the soil. The compost increases soil fertility and crop yield and generally improves the quality of the soil. In developing countries where mineral fertilizer is expensive, it is an elegant solution to the problem of water hyacinth proliferation and also poor soil quality. It contains many trace elements, seldom found in synthetic fertilizers, so it helps plants to be more disease resistant. The nutrients in the compost are not leached out by rain-water and all available to the plants (Vidya and Girish, 2014).

Fresh water hyacinth plant contains 95.5% moisture, 0.04% N, 1.0% ash, 0.06% P_2O_5 , 0.20% K_2O , 3.5% organic matter. On a zero-moisture basis, it is 75.8% organic matter, 1.5% N, and 24.2% ash. The ash contains 28.7% K_2O , 1.8% Na_2O , 12.8% CaO , 21.0% Cl , and 7.0% P_2O_5 . The CP contains, per 100 g, 0.72 g methionine, 4.72 g phenylalanine, 4.32 g threonine, 5.34 g lysine, 4.32 g isoleucine, 0.27 g valine, and 7.2 g leucine (Jafari, 2010).

From the above discussion it is revealed that beside fertilizers, manures are rich source of nutrients which give higher growth and yield of different crops and vegetables. In case of Indian spinach production proper management and application of manure should give beneficiary results in terms of growth and yield. Most of the works have been done in abroad and other parts of the country, but no such types of work has done in the south western region of Bangladesh. So, the present study was undertaken.

Chapter III

MATERIALS AND METHODS

This chapter contained the materials used and methodology followed in the experiment to find the effect of different combination of manures and fertilizers on the performance of Indian spinach.

3.1 Experimental location

The experiment was carried out at the field in the Germplasm centre of the Agrotechnology Discipline, Khulna University which is located at latitude 22°48'35" N, longitude 89°33'51" E and altitude 8 m above sea level during May 2014 to September 2014.

3.2 Soil

The experimental field was medium high land of clay-loam with gray colored having pH of about 8.0. Soil samples of 0-15 cm depth from surface were collected from the experimental field. Chemical compositions of the soil samples were examined at SRDI laboratory, Daulatpur, Khulna and have been presented in Appendix I.

3.3 Planting

Plant spacing used was 50 cm × 50 cm with a 50cm space between plot to plot and block to block distance was one meter. Each plot size was about 2m × 1.5m = 3m². Seeds of Indian spinach were sown in a seedbed and germinated and proper care was taken before being transplanted on the experimental plot after two weeks.

3.4 Treatments

For the experiment following 12 treatments were used-

T₀= Control (no manures and fertilizers was used)

T₁= NPK (Recommended dose)

T₂= 100% Water Hyacinth (WH)

T₃= 50% Water Hyacinth + 50% Farm Yard Manure (FYM)

T₄= 50% Cow Dung (CD) + 50% Water Hyacinth (WH)

T₅= 50% Poultry Litter + 50% Water Hyacinth (WH)

T₆= 100% Poultry Litter (PL)

T₇= 50% Poultry Litter + 50% Farm Yard Manure (FYM)

T₈= 50% Poultry Litter + 50% Cow Dung (CD)

T₉= 100% Farm Yard Manure (FYM)

T₁₀= 100% Cow Dung (CD)

T₁₁= 50% FYM+50% Cow Dung (CD)



Manure and fertilizer doses as applied in different treatments given below:

T₁ (Recommended dose of NPK) = Urea 350 kg ha⁻¹, TSP 200 kg ha⁻¹ and MoP 220 kg ha⁻¹, T₂ (100% Water Hyacinth) = 10 t ha⁻¹, T₃ (50% Water Hyacinth + 50% Farm Yard Manure) = 5 t ha⁻¹ + 5 t ha⁻¹, T₄ (50% Cow Dung + 50% Water Hyacinth) = 5 t ha⁻¹ + 5 t ha⁻¹, T₅ (50% Poultry Litter + 50% Water Hyacinth) = 5 t ha⁻¹ + 5 t ha⁻¹, T₆ (100% Poultry Litter) = 10 t ha⁻¹, T₇ (50% Poultry Litter + 50% Farm Yard Manure) = 5 t ha⁻¹ + 5 t ha⁻¹, T₈ (50% Poultry Litter + 50% Cow Dung) = 5 t ha⁻¹ + 5 t ha⁻¹, T₉ (100%

Farm Yard Manure) = 10 t ha⁻¹, T₁₀ (100% Cow Dung) = 10 t ha⁻¹, T₁₁ (50% FYM+50% Cow Dung) = 5 t ha⁻¹ + 5 t ha⁻¹. The fertilizers Urea, triple superphosphate (TSP), muriate of potash (MoP) and gypsum were used as sources of N, P, K and S, respectively. One-half N and K for Indian spinach were applied during final land preparation and the remaining N and K were supplied at 10 and 25 DAP (days after planting).

3.5 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The selected field was firstly divided into three equal blocks and each block was further divided into twelve unit plots. The size of unit plot was 3 m² (2 m × 1.5 m). The distance between block to block was 1.0 m and plot to plot distance was 50 cm.

3.6 Cultivation practices

3.6.1 Seedbed preparation

A piece of medium high land was selected for seed bed preparation at the Germplasm centre of Agrotechnology Discipline of Khulna University, Khulna. Seed bed was made ready by spading four times with a spade followed by breaking clods and leveling.

3.6.2 Raising of the seedlings

Before sowing in the seed bed, seeds were soaked for 12-15 hours and were sown in the seedbed on May, 2014. Incentive care was taken to ensure that there was no infestation of pests and diseases and no damage by animals. Irrigation was given as and when required. The seeds were collected from registered seed dealers raised in the seed bed in proper way.

3.6.3 Field and plot preparation

Soils of main field was prepared for planting with spade. Dry roots, grasses and other particulate materials were removed from the soil. For the study, some organic matter and fertilizers were collected from local market and others were made manually.

3.6.4 Transplanting

Transplanting was done on last week of may 2014 maintaining plant spacing 50 cm × 50 cm. Immediately after transplanting watering was done and it was continued consecutive 3 days.

3.6.5 Weed management

To keep the experimental field free from the weed infestation proper measure was taken timely. Weed infestation appeared to be a severe problem during the early stages of crop establishment such as- *Cypentsrotundus* (mutha), *Cypermesculentus* (haldemutha), and *Cynodondactylon* (*Durba*) etc. Weeding operation was done whenever it required.

3.6.6 Water management

Irrigation was given as and when needed.

3.6.7 Plant protection measures

The crop was almost free from diseases and pest. During the experiment a minor incidents of some pest and grasshopper were noticed in the field. Insecticide 'Melathion' was used to control them.

3.7 Harvesting

The crop was harvested at the right stage of growth depending on the nature of the crop in installment. The edible part of Indian spinach was harvested from August to September 2014 by installments.

3.8 Data collection

Data were recorded on different parameter at 15 days intervals. The following data were recorded regularly:

1. Number of branch plant⁻¹
2. Number of leaves plant⁻¹
3. Plant height (cm)
4. Length of leaves (cm)
5. Breadth of leaves (cm)
6. Diameter of plant (mm)
7. Yield (t ha⁻¹)

3.9 Economic analysis

Economic analysis was done in order to find out the most profitable treatment.

3.9.1 Total cost of production of Indian spinach

Total material input costs, non-material input costs, interests on fixed capital of land and miscellaneous costs were considered for calculation of total cost of production. Interest was calculated at the rate of 12% for six months and miscellaneous cost was considered as 5% of the total input cost.

3.9.2 Gross income

Gross income was calculated based on the sale price (BDT –Tk/kg) of marketable Indian spinach.

3.9.3 Net return

Net return was calculated by deducting the total production cost from the gross return for each treatment.

3.9.4 Benefit cost ratio

The economic indicator BCR was calculated using following formula for each treatment.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income}}{\text{Total cost of production}}$$

3.10 Statistical analysis

The collected data on different parameters were analyzed following analysis of variance (ANOVA) technique by using MSTAT-C computer program and differences among means were adjudged by Duncan new Multiple Range Test (DMRT) test (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to observe the performance of Indian spinach under different manures and fertilizers and their combination. The data was analyzed and presented in tables and the analysis of variance was presented in Appendix II. The findings of the study have been described under the following headings.

4.1 Number of leaves plant⁻¹

The number of leaves of Indian spinach was recorded at 15 days after transplanting (DAT) and it was maintained at 15 days interval up to 90 DAT. Significant variation in number of leaves was observed among the treatments (Appendix II). The highest number of leaves (62.67) was obtained from T₁ (recommended dose of NPK fertilizers) followed by T₁₁ (50% Farm Yard Manure + 50% Cow Dung) (60.33) and the lowest number of leaves was found with control treatment at every date of data collection (Table 1). Similar result was also found by Islam *et al.* (2011), Hossain *et al.* (2014) and Olanrewaju (2011) in their research with fertilizers (recommended dose) and manures. The maximum number of leaves per plant was at recommended dose of fertilizer because there was fast release of nitrogen and other plant nutrients (phosphorus and potassium) than organic manures and available nitrogen was high at root zone. We know nitrogen initiate higher growth of stem and leaves of plant.

4.2 Plant height

The growth of Indian spinach in terms of plant height in different treatments is shown in table 2. The highest plant height (84.33 cm) was observed in T₁₁ (50% FYM + 50% Cow Dung) followed by T₁ (Recommended dose of NPK) (82.33 cm) and T₇ (50% Poultry Litter + 50% Farm Yard Manure) (80.33cm) at 90 DAT while the lowest plant height was found with control treatment at every stage of data collection except 15 and 30 DAT. However, there were no significant differences in plant height among the treatments at 15 DAT but it was found significant at 30 DAT to 90 DAT (Appendix II). This result may compare with the results of Hossain *et al.* (2014), Malik (2011) and Ghimire (2013) as they found that manures showed highest plant height during experiment. The highest plant height was found at T₁₁ (50% Farm Yard Manure + 50% Cow Dung) because FYM and CD are huge source of nitrogen and other plant nutrients which increase the plant height of Indian spinach. Not only that but also organic manures increase soil aeration which helps more nitrogen uptake from the soil.

Table 2. Effect of fertilizers and manures on plant height (cm) of Indian spinach

Treatments	Plant height (cm)					
	15 DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T ₀	15.33a-d	27.33b-d	41.67d	52.00e	59.00e	66.67i
T ₁	16.33a-c	30.33a-d	51.67a	64.00a	74.67a	82.33b
T ₂	16.00a-c	29.00a-d	44.33b-d	54.00de	63.33d	72.00bh
T ₃	14.67a-d	32.33a	47.00a-d	57.33bc	65.67cd	76.33e
T ₄	15.33a-d	31.67ab	47.00a-d	59.00b	66.33cd	77.33de
T ₅	14.33a-d	30.00a-d	46.33a-d	60.00b	69.00bc	78.33d
T ₆	14.33cd	26.67cd	45.00a-d	52.00e	63.67d	72.33g
T ₇	15.33a-d	30.67a-d	49.67a-d	58.00bc	73.00ab	80.33c
T ₈	14.00cd	27.67b-d	47.00a-d	54.00de	65.67cd	75.67e
T ₉	12.67d	26.33d	43.67cd	53.00e	64.00d	74.33f
T ₁₀	17.67a	31.00a-c	46.33a-d	56.00cd	67.00cd	77.67de
T ₁₁	17.33ab	31.00a-c	51.00ab	64.00a	76.00a	84.33a
Level of significance	*	*	**	**	**	**
CV (%)	9.90	7.40	5.25	5.81	6.53	4.72

**= Significant at 1% level and *= Significant at 5% level. Means followed by common letter(s) in a column do not differ significantly by DMRT

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)



4.3 Leaf length

The highest leaf length (25.67 cm) was observed in T₁ (Recommended dose of NPK) followed by T₃ (50% Water Hyacinth + 50% Farm Yard Manure) (24.67 cm) at 90 DAT, T₄ (50% Cow Dung + 50% Water Hyacinth) (23.33 cm) and T₉ (100% Farm Yard Manure) (24.33 cm) at both 75 and 90 DAT, respectively. While the lowest leaf length was found in the control treatment at every stage of data collection (Table 3). However, there were significant differences in leaf length among the treatments (Appendix II).

Table 3. Effect of fertilizers and manures on leaf length (cm) of Indian spinach

Treatments	Leaf length (cm)					
	15 DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T ₀	14.00c	16.00e	17.33d	18.33c	19.00d	19.00d
T ₁	16.67ab	21.00a	23.00a	24.33a	25.00a	25.67a
T ₂	14.33c	17.33de	18.33d	19.33c	20.00cd	20.67cd
T ₃	17.67a	21.00a	23.00a	24.00ab	24.33ab	24.67ab
T ₄	16.67ab	21.33a	22.33a-c	23.33ab	23.33ab	23.33ab
T ₅	17.67a	20.00a-c	22.33a-c	23.67ab	24.33ab	24.33ab
T ₆	14.33c	18.67cd	20.33c	21.67b	22.00bc	22.33bc
T ₇	15.33bc	18.67cd	20.67bc	22.00ab	23.33ab	24.00ab
T ₈	16.67ab	21.00a	22.67ab	23.67ab	24.00ab	24.00ab
T ₉	16.33ab	20.67ab	22.33a-c	23.33ab	24.33ab	24.33ab
T ₁₀	14.33c	19.00a-c	20.67bc	22.00ab	22.67ab	23.00bc
T ₁₁	14.33c	20.33a-c	22.33a-c	23.67ab	24.00ab	24.33ab
Level of significance	**	**	**	**	**	**
CV (%)	6.31	5.33	6.46	5.67	6.98	6.31

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

4.4 Leaf breadth

In case of leaf breadth of Indian spinach data presented in table 4 showed that the highest leaf breadth (18.67 cm) was observed in T₁ (Recommended dose of NPK) followed by T₃ (50% Water Hyacinth + 50% Farm Yard Manure) (18.00 cm) and T₄ (50% Cow Dung + 50% Water Hyacinth) (17.33 cm) at 90 DAT, respectively. While the lowest leaf breadth (7.33 cm) was found in T₁₀ (100% Cow Dung) at 15 DAT but after that the lowest leaf breadth was found in control treatment from 30 to 90 DAT. However, there were significant differences in leaves breadth among the treatments (Appendix II).

Table 4. Effect of fertilizers and manures on leaf breadth (cm) of Indian spinach

Treatments	Leaf breadth (cm)					
	15DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T ₀	8.33ab	10.67c	13.33a-c	13.00c	13.67d	14.00d
T ₁	8.67a	12.67a	14.67a	16.33a	17.67a	18.67a
T ₂	7.67ab	10.67c	12.67c	14.00bc	15.33b-d	16.67a-c
T ₃	8.67a	12.33ab	14.33ab	16.00a	17.33ab	18.00ab
T ₄	8.33ab	12.33ab	14.33ab	15.33ab	16.33a-c	17.33a-c
T ₅	7.67ab	10.67c	12.67c	14.67b	15.67a-d	16.67a-c
T ₆	7.67ab	11.33a-c	13.00bc	14.00bc	14.67cd	16.00b-d
T ₇	8.67a	11.33a-c	13.33a-c	14.67b	15.67a-d	16.00b-d
T ₈	7.67ab	11.33a-c	13.33a-c	15.00ab	16.00a-c	16.33a-d
T ₉	8.00ab	11.00bc	13.00bc	14.00bc	14.67cd	16.00b-d
T ₁₀	7.33b	10.67c	12.67c	14.00bc	15.33b-d	15.33cd
T ₁₁	9.33a	11.33a-c	13.33a-c	15.00ab	16.00a-c	16.33b-d
Level of significance	**	*	*	**	**	**
CV (%)	5.38	6.66	5.58	4.24	4.69	5.18

**= Significant at 1% level and *= Significant at 5% level. Means followed by common letter(s) in a column do not differ significantly by DMRT

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

4.5 Number of branches plant⁻¹

The results presented in table 5 showed the trend observed in the number of branches produced by Indian spinach at different stages of growth. At 15 DAT and 30 DAT, there were no significant differences in the number of branches per plant among the treatments. At 45, 60 and 75 DAT, number of branch per plant were significantly affected by the application of different fertilizers and manures (Appendix II). In case of 90 DAT there were no significant differences for other treatments except T₀ and T₂. The highest number of branches was (11.00) obtained in T₁ (Recommended dose of NPK) followed by T₁₁ (50% Farm Yard Manure + 50% Cow Dung) 10.67 at 90 DAT and the lowest number of branches was found in the control treatment at every date of data collection except 15 and 30 DAT. This result may compare with the results of Kodally (2006), Malik (2011) and Haque *et al.* (2012). The maximum number of branches per plant was at recommended dose of fertilizer because there was fast release of nitrogen and other plant nutrients (Phosphorus and Potassium) than organic manures and available nitrogen was high at root zone.

Table 5. Effect of fertilizers and manures on number of branches plant⁻¹ of Indian spinach

Treatments	Number of branches plant ⁻¹					
	15 DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T ₀	2.00	2.67	4.00cd	5.00c	5.67	5.33b
T ₁	2.33	3.67	6.00a	8.33a	10.33a	11.00a
T ₂	1.33	2.33	4.33a-c	6.33a-c	7.67a-c	8.00ab
T ₃	1.67	2.67	4.67a-d	6.67a-c	8.67ab	9.33a
T ₄	1.67	2.33	3.67d	6.00bc	7.00bc	8.33a
T ₅	2.67	3.33	5.33a-c	7.00a-c	9.00ab	9.67a
T ₆	2.00	3.33	4.67a-d	6.33a-c	8.00a-c	8.33a
T ₇	2.67	3.67	5.67ab	7.33ab	8.67ab	10.00a
T ₈	2.67	3.33	5.33a-c	7.33ab	8.67ab	9.33a
T ₉	2.00	3.00	5.00a-d	7.33ab	9.00ab	10.33a
T ₁₀	1.67	2.67	4.33b-d	6.33a-c	8.00a-c	9.33a
T ₁₁	2.67	3.67	5.67ab	7.33ab	9.33ab	10.67a
Level of significance	Ns	Ns	*	**	**	**
CV (%)	17.76	16.43	15.69	11.32	11.49	11.73

**= Significant at 1% level, *= Significant at 5% level and ns= non significant. Means followed by common letter(s) in a column do not differ significantly by DMRT

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

4.6 Diameter of stem

The data presented in table 6 showed the effect of fertilizers and manures on diameter of Indian spinach. Plant diameter differed significantly almost all the DATs. The highest plant diameter (22.67 mm) was recorded from T₈ (50% Poultry Litter + 50% Cow Dung) followed by T₁ (Recommended dose of NPK) (22.33 mm) and T₁₁ (50% FYM + 50% Cow Dung) (22.00 mm) at 90 DAT while the lowest plant diameter was found in the control treatment at every stage of data collection. However, there were significant differences in plant diameter among the treatments (Appendix II). Olanrewaju (2011) also found similar effect of manures and fertilizers on growth and yield of Indian spinach as the results showed a significant difference on the vine girth of *Basella alba* L. The highest plant diameter was found at T₈ (50% Poultry Litter + 50% Cow Dung) because FYM and CD are huge source of nitrogen and other nutrients which increase the plant diameter of Indian spinach. Not only that but also organic manures increase soil aeration which helps in more nitrogen uptake by the plants from the soil and increase the activities of soil microorganism.



Table 6: Effect of fertilizers and manures on diameter of plant of Indian spinach

Treatments	Diameter of Plant (mm)					
	15 DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T ₀	11.67f	12.67f	13.33e	14.00e	14.67d	15.00c
T ₁	19.67ab	20.67a	21.00ab	22.00a	22.33ab	22.33a
T ₂	15.33c-e	16.33de	17.33cd	18.00cd	19.33bc	19.67ab
T ₃	17.00b-e	17.33b-e	18.67b-d	20.00a-d	21.00a-c	21.33ab
T ₄	15.00de	15.67ef	17.00cd	18.67b-d	19.33bc	20.00ab
T ₅	15.67c-e	16.67b-e	17.33cd	18.67b-d	20.00a-c	20.67ab
T ₆	14.33e	15.33ef	16.33d	17.00d	18.33c	18.33d
T ₇	17.00b-e	18.00a-c	19.00a-d	20.00a-d	20.67a-c	21.00ab
T ₈	19.33ab	19.67a-c	21.00ab	22.00a	22.67ab	22.67a
T ₉	18.00bc	19.33a-d	20.67ab	21.33ab	22.00ab	22.00a
T ₁₀	17.33bd	17.67b-e	19.33a-c	20.33a-c	21.33a-c	21.33ab
T ₁₁	21.33a	20.33ab	21.67a	22.33a	23.00a	22.00a
Level of significance	**	**	**	**	**	**
CV (%)	5.76	6.64	5.28	5.63	5.83	5.71

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

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4.7 Yield of Indian spinach

The results presented in appendix III shows a significant difference on the harvested yield of Indian spinach. Recommended NPK fertilizer (T_1) had the highest effect on the harvested yield of Indian spinach. The highest yield (28.9 t ha^{-1}) was found in T_1 (Recommended dose of NPK) followed closely by T_{11} (50% FYM+50% Cow Dung) (28.5 t ha^{-1}), T_7 (50% Poultry Litter + 50% Farm Yard Manure) (27.1 t ha^{-1}) and in T_8 (50% Poultry Litter + 50% Cow Dung) (26.5 t ha^{-1}), respectively (Figure 1). The differences were significant at $P \leq 0.5$ (Appendix II). Similar result was also found by Islam *et al.* (2011) and Olanrewaju (2011) in their research with fertilizers and manures where NPK (Recommended Dose) fertilizers gave the highest yield for Indian spinach. The cause of this type of results may be because of huge and available nitrogen in recommended dose of fertilizers, cow dung, farm yard manure and poultry manure as Indian spinach is a leafy vegetable.

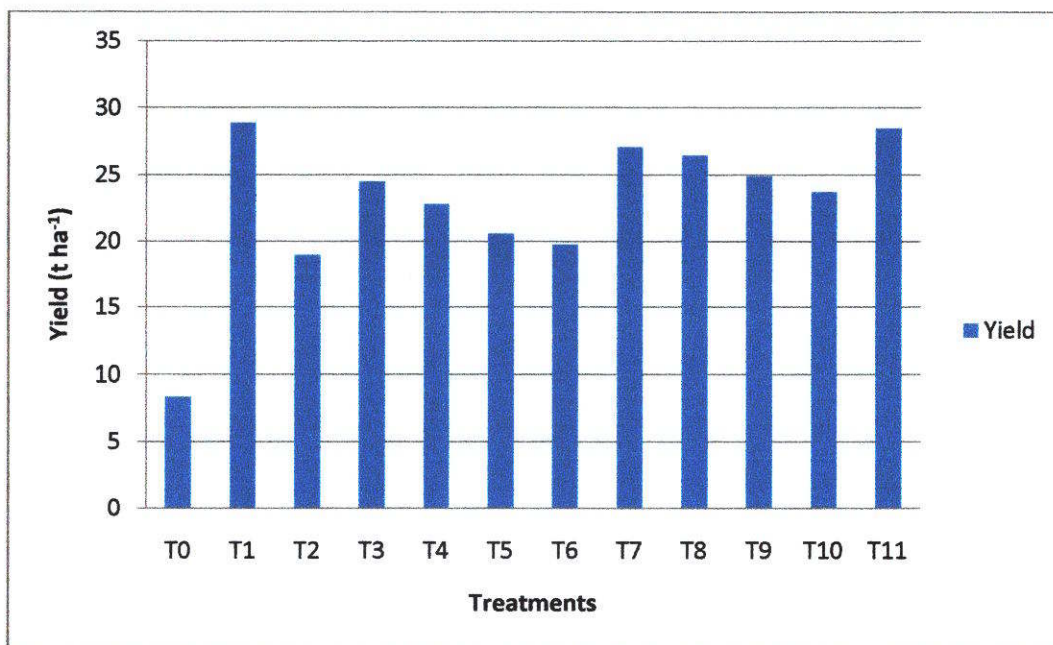


Fig.1: Effect of fertilizers and manures on yield (t ha⁻¹) of Indian spinach

Here, CV = Coefficient of variation, DAT = Days after transplanting, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

4.8 Economic analysis and benefit cost ratio of Indian spinach

The highest cost of production (TK. 187730 per hectare) was involved with the treatment T₆ (100% Poultry Litter) and the lowest (TK. 157440 per hectare) was involved with the treatment T₁₀ (100% Cow Dung). The highest net return (Tk. 265980) was obtained from T₁₁ (50% FYM + 50% Cow Dung). But the lowest net return (Tk. 109270) was obtained from T₆ (100% Poultry Litter). The benefit cost ratio was found the highest (2.65) in T₁₁ (50% FYM + 50% Cow Dung) followed by T₇ (50% Poultry Litter + 50% Farm Yard

Manure) (2.44) and the lowest (1.58) was recorded from T₆ (100% Poultry Litter) (Table 7).

Table 7: Economic analysis and Benefit Cost Ratio of Indian spinach

Treatments	Yield (t ha ⁻¹)	Total cost of production (Tk. ha ⁻¹)	Gross Return (Tk. ha ⁻¹)	Net return (Tk. ha ⁻¹)	BCR
T ₁	28.9	179656	433500	253844	2.41
T ₂	19.0	159760	285000	125240	1.78
T ₃	24.5	158040	367500	209460	2.33
T ₄	22.8	163590	342000	178410	2.09
T ₅	20.6	162330	309000	146670	1.90
T ₆	19.8	187730	297000	109270	1.58
T ₇	27.1	170450	416500	246050	2.44
T ₈	26.5	178970	397500	218530	2.22
T ₉	24.9	168780	373500	204720	2.21
T ₁₀	23.7	157440	355500	198060	2.26
T ₁₁	28.5	161520	427500	265980	2.65

Note: Sale of Indian spinach at the rate of TK. 15 per Kg

Here, T₀= Control (no manures and fertilizers was used), T₁= NPK (Recommended dose), T₂= 100% Water hyacinth (WH), T₃= 50% Water hyacinth + 50% Farm yard manure (FYM), T₄= 50% Cow dung (CD) + 50% Water hyacinth (WH), T₅= 50% Poultry litter + 50% Water hyacinth (WH), T₆= 100% Poultry litter (PL), T₇= 50% Poultry litter + 50% Farm yard manure (FYM), T₈= 50% Poultry litter + 50% Cow dung (CD), T₉= 100% Farm yard manure (FYM), T₁₀= 100% Cow dung (CD) and T₁₁= 50% FYM+50% Cow dung (CD)

Chapter V

SUMMARY AND CONCLUSION

The study was conducted at the field in the Germplasm centre of the Agrotechnology Discipline, Khulna University, Khulna to find the effect of manures and fertilizers on the performance of Indian spinach. There were twelve treatments and three replications. The experiment was laid out in a Randomized Complete Block Design. Data were recorded on different parameter at 15 days interval on number of branch plant⁻¹, number of leaves plant⁻¹, plant height (cm), length of leaves (cm), breadth of leaves (cm), diameter of plant (mm) and yield (t ha⁻¹). The effect of recommended NPK fertilizers affected the number of branches plant⁻¹, number of leaves plant⁻¹, length of leaves, breadth of leaves and harvested yield of *Basella alba* L. and was observed to be more effective than those of other treatments except of T₁₁ (50% Farm Yard Manure + 50% Cow Dung) which produced the highest plant height and T₈ (50% Poultry Litter + 50% Cow Dung) gave the highest plant diameter. This study indicated that growth and yield of *Basella alba* L. was significantly affected by fertilizers and manures. Effect of recommended NPK fertilizers (T₁) was observed to be more effective as produced the highest number of branches plant⁻¹, number of leaves plant⁻¹, length of leaves (cm), breadth of leaves (cm) and harvested yield (t ha⁻¹) than those of other treatments. But in case of T₁₁ (50% Farm Yard Manure + 50% Cow Dung) the highest plant height was observed and T₈ (50% Poultry Litter + 50% Cow Dung) gave the highest plant diameter. In context of yield parameter, the highest yield of *Basella alba* L. (28.9 t ha⁻¹) was recorded from recommended NPK fertilizers followed closely by T₁₁ (50% FYM + 50% CD) (28.5 t ha⁻¹), T₇ (50% PL + 50% FYM) (27.1 t ha⁻¹) and T₈ (50% PL + 50% CD) (26.5 t ha⁻¹), respectively. Application of organic manures in combination like 50% FYM + 50% CD (5 t ha⁻¹ + 5 t ha⁻¹), 50% PL + 50% FYM (2.5 t ha⁻¹ + 5 t ha⁻¹) and 50% PL + 50% CD (2.5 t ha⁻¹ + 5 t

ha⁻¹) showed better performance in terms of yield parameters and yield of Indian spinach after NPK fertilizers. This may have happened due to higher nitrogen content and other plant nutrients by cow dung, farm yard manure and poultry litter. These manures also increase soil aeration and activities of microorganisms of soil which are helpful for growth and production of plants. So, these combinations of manures should be better replacement of chemical fertilizers for Indian spinach production.

In context of economic analysis and benefit cost ratio (BCR) combination of organic manures showed better results as the highest cost of production (TK. 187730 per hectare) was involved with the treatment T₆ (100% Poultry Litter) and the highest net return (Tk. 265980) was obtained from T₁₁ (50% FYM + 50% Cow Dung). The benefit cost ratio was found the highest (2.65) in T₁₁ (50% FYM + 50% Cow Dung) followed by T₇ (50% Poultry Litter + 50% Farm Yard Manure) (2.44) and the lowest (1.58) was recorded from T₆ (100% Poultry Litter).

Though recommended NPK fertilizer performed better in terms of some growth parameters and yield but considering the long term residual side effect of chemical fertilizers and higher price, the cheapest and easily available manures and good combination of those could be better replacement of chemical fertilizers for Indian spinach production as they are environment friendly.

It can be concluded from the experiment that

- Recommended dose of NPK and T₁₁ was found to be better for growth and production of Indian spinach.
- The recommended optimum dose of NPK was (Urea 350 kg ha⁻¹, TSP 200 kg ha⁻¹ and MoP 220 kg ha⁻¹) and combination of manures was 50% FYM + 50% CD (5 t ha⁻¹ + 5 t ha⁻¹).

REFERENCES

- Adekiya, A. O. and T. M. Agbede. 2009. Growth and yield of tomato (*Lycopersicon esculentum* Mill) as influenced by poultry manure and NPK fertilizer. Emirates Journal of Food and Agriculture, 21 (1): 10-20.
- Agboola, A. A. and Sobulo R. A. 1981. Soil Fertility in Southwestern Zone of Nigeria. F.D.L.A.R. Kaduna. pp. 12-15.
- Ahammad, K., Ali M., Islam M. S. and Karim A. A. M. S. 1999. Optimization of organic residues and urea for pot culture of tomato. Ann. Bangladesh Agriculture, 9 (2): 99-104.
- Ayeni, L. S., Omole T. O., Adeleye E. O. and Ojeniyi S. O. 2010. Integrated Application of Poultry Manure and NPK Fertilizer on Performance of Tomato in Derived Savannah Transition Zone of Southwest Nigeria. Science and Nature, 8 (2): 50-54.
- Dorji, K. D., Dema E. and Uden T. 2009. Effect of Different Rates and Combinations of Farm Yard Manure and Inorganic Fertilizers on Chilli (*Capsicum annum*) Yield. Journal of Renewable natural resources, 5(1): 1-14.
- Eifediyi and Remison. 2010. Growth and Yield of Cucumber (*Cucumis sativus* L.) as Influenced by Farmyard Manure and Inorganic Fertilizers. Journal of Agricultural technology, 5(2):1217-1248.
- Food and Agriculture Organization (FAO). 2000. Farm yard manure and water hyacinth compost applications to enhance organic matter and water holding capacity of soils in drought prone areas of Bangladesh. Natural Resources Management and Environment Department, FAO [20].

- Ghimire, 2013. Sweet pepper production using different nitrogen sources in subtropical climate. *Journal of Agriculture and Food Science*, 1 (1): 6-10.
- Gomez, K. A. and Gomez A. A. 1984. *Statistical Procedures for Agricultural Research* (Second edition). A Wile Inter Science Publication, John Wiley and Sons. New York. P. 680.
- Grubben, G. H. and Denton O. A. 2004. *Plant Resources of Tropical Africa vegetable 2*. Prota Foundation, Wageningen, 4:103-111.
- Hamilton, W. D. 2006. Area Animal Waste Management Specialist Using Poultry Litter as Fertilizer Oklahoma Cooperative Extension Service. Oklahoma Cooperative Extension Service. P. 2246.
- Haque, M., Islam M. and Hossain N. 2012. Impact of *Trichoderma*-enriched Biofertilizer on the Growth and Yield of Mustard (*Brassica rapa* L.) and Tomato (*Solanum lycopersicon* Mill.). *The Agriculturists*, 10(2): 109-119.
- Hossain, N., Islam M., Alamgir M. and Kibria M. G., 2014. Growth Response of Indian Spinach to Biogas Plant Residues. *IOSR-Journal of Pharmacy and Biological Sciences*, 9: 01-06.
- Ibrahim, Kh. H. M. and Fadni O. A. S. 2013. Effect of Organic Fertilizers Application on Growth, Yield and Quality of Tomatoes in North Kordofan (sandy soil) western Sudan. *Greener Journal of Agricultural Sciences*, 3 (4): 299-304.
- Islam, M. M., Karim A. J. M. S., Jahiruddin M., Majid M. Nik, Miah M. G., Mustaque Ahmed M. and Hakim M. A. 2011. Effects of Organic Manure and Chemical Fertilizers on Crops in the Radish-Stem amaranth-Indian spinach Cropping Pattern in Homestead Area. *Australian Journal of Crop Sciences*, 5(11): 1370-1378.

- Jafari, N. 2010. Ecological and Socio-Economic Utilization of Water Hyacinth (*Eichhorniacrassipes* Mart. Solms). *Jornal of Applied Science for Environment Management*, 14 (2):43 – 49.
- Khalid, H., Mustak I. and Fadni O. E. 2010. Effect of different types of organic fertilizers on growth, quality and yield of tomatoes in sandy soil. Second RUFORUM Biennial Meeting, Entebbe, Uganda. pp. 12-18.
- Kisetu, E. and Heri P. 2014. Effects of Poultry Manure and NPK (23:10:5) Fertilizer on Tomato Variety Tanya Grown on Selected Soil of Morogoro Region, Tanzania. *Asian Journal of Crop Science*, 6: 165-175.
- Kodally, S. H. 2006. Studies on Integrated Nutrient Management on Seed Yield and Quality of Chilli. MS thesis. Department Of Seed Science and Technology College Of Agriculture, Dharwad University of Agricultural Sciences, Dharwad. India. pp. 12-18.
- Malik, 2011. Growth, Yield and Fruit Quality of Sweet Pepper Hybrid SH-SP-5 (*Capsicum annuum* L.) as Affected by Integration of Inorganic Fertilizers and Organic Manures (FYM). *Journal of Agricultural technology*, 7(4):1037-1048.
- Mehdizadeh, M., Darbandi E. I., Rad H. N. and Tobeh A. 2013. Growth and yield of tomato (*Lycopersicon esculentum* Mill.) as influenced by different organic fertilizers. *International Journal of Agronomy and Plant Production*, 4 (4): 734-738.
- Melton, R. R. and Dufault R. J. 1991. Nitrogen, Phosphorus, and Potassium Fertility Regimes Affect Tomato Transplant Growth. *Hortscience*, 26(2): 141-142.

- Murwira, H. K. and Kirchmann H. 1993. Carbon and Nitrogen Mineralization of Cattle Manures Subjected to Different Treatments in Zimbabwean and Swedish Soils. In: Mulongoy K and Merckx R (eds) Soil organic matter dynamics and sustainability of tropical agriculture. pp. 189-198.
- Ojeniyi, S. O., Awodun M. A. and Odedina S. A. 2007. Effect of animal manure ammended spent grain and cocoa husk on nutrient status, growth and yield of tomato. International Journal of Agricultural Research, 2: 406-410.
- Olanrewaju, O. O. 2011. The Effects of Fertilizers on the Growth and Yield of Indian Spinach (*Basella alba*). University Of Agriculture, Abeokuta, Ogun State, Nigeria. Matric no: 2006 / 1607.
- Osumah L. and Eniola S. 2010. Influence of NPK (15:15:15) and organomineral fertilizer on the performance of Pepper. Journal of Agriculture and Veterinary Sciences, 2:1-7.
- Phipps, N. 2014. Cow Dung Fertilizer: Learn the Benefits of Cow Manure Compost. (www.gardeningknowhow.com).
- Prativa S. and Bhattarai N. 2010. Effect of Integrated Nutrient Management on the Growth, Yield and Soil Nutrient Status in Tomato. Nepal Journal of Science and Technology, 12: 23 – 28.
- Rosen, J. C. and Bierman Peter M. 2005. Nutrient Management for Fruit and Vegetable Crop Production. University of Minnesota Extension Service. pp. 1-3.
- Tanu Agritech Portal; Organic Farming: Organic Inputs and Techniques. Web (URL) address: (<http://www.teca.fao.org>)
- Vidya, S. and Girish L. 2014. Water Hyacinth as a Green Manure for Organic Farming. Indian Journal of Agronomy, 2(6): 65-72.

Wikipedia, 1986. The Free Encyclopedia. Indian Spinach: A Green Leafy Vegetables.

Web (URL) address: (<https://www.wikipedia.org>)

Yadav, A., Gupta R. and Garg V. K. 2013. Organic Manure Production from Cow Dung and Biogas Plant Slurry by Vermicomposting Under Field Conditions. Indian Journal of Agronomy, 2:21-22.



APPENDICES

Appendix I. Chemical characters of the soil of selected site

Analyzed result and class of fertility						
pH	Salinity (EC)	Organic matter	Potassium	Total Nitrogen	Phosphorus	Sulpher
	(dsm^{-1})	(%)	$\mu\text{m}/100\text{g soil}$	(%)	(Microgram/g soil)	Zinc
8.0	5.3	2.02	0.37	0.117	9.44	143.23
						0.20

Source: SRDI office; Daulatpur, Khulna

Appendix II (Continuation):

Analysis of variance table for growth and yield contributing characters of Indian spinach

Source of variance	Degrees of freedom	Mean sum square (MS)
		Yield (t ha ⁻¹)
Replication	2	15.42
Factor A (Treatments)	11	857.14*
Error	22	13.04

*= Significance at 5% level, DAT= Days after transplanting