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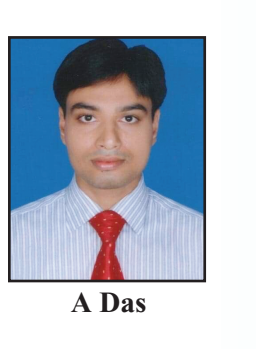
PERFORMANCE OF INDIAN SPINACH UNDER DIFFERENT COMBINATIONS OF ORGANIC AND INORGANIC FERTILIZERS



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Abstract

Soil health is deteriorate due to excessive use of inorganic fertilizer during crop production. Moving crop production to sole inorganic to organic and inorganic combination may improve soil health. Solely organic crop production in Bangladesh presents some challenges, however, including the stunting, and lower crop growth and yield. In order to address the problem of excessive use of inorganic fertilizer, different combinations of organic or inorganic fertilizer were tested in Indian spinach production. There is no recommended ideal combination of organic and inorganic fertilizer for Indian spinach production in Bangladesh. For that reason, the goal of the present research was to identify the effect of organic and inorganic fertilizer in Indian spinach production. The specific objective was to determine the ideal combination of organic and inorganic fertilizer for Indian spinach production. A field experiment was conducted in the Germplasm center of Agrotechnology Discipline of Khulna University, Khulna (AEZ-13) during May to September, 2014 in a Randomized Complete Block Design (RCBD) with three replications. There were eleven treatments combination tested for this experiments. Water hyacinth (WH), farm yard manure (FYM), cow dung (CD) and poultry liter (PL) were used as an organic manure source in different combination and Urea, TSP and MoP (NPK) was used for inorganic source of fertilizer. Effect of recommended NPK fertilizers 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 although which is not good for soil health. However, (50% FYM + 50% CD) and (50% PL + 50% CD) gave the highest plant height and diameter, respectively. In context of yield parameter, the highest yield of Indian spinach was found at recommended NPK fertilizers followed by (50% FYM + 50% CD), (50% PL + 50% FYM) and (50% PL + 50% CD), respectively. Therefore, application of organic manures in combination of (50% FYM + 50% CD), (50% PL + 50% FYM) and (50% PL + 50% CD), respectively showed better performance in terms of yield parameters and yield of Indian spinach after recommended NPK fertilizers.

Key words: Organic, Inorganic, Indian spinach,Yield.

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 vegetables. It is 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. Indian spinach is high in vitamin A, vitamin C, iron and calcium (Grubben and Denton 2004).

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 soil 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 of view. 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 deutrophication 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, 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. Soil organic matter 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).

Indian spinach 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. It is hypothesized that organic and inorganic combination of manure and fertilizer may improve soil health. 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. So, specific objectives-

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

Materials and Methods

Description of experimental site

A field experiment was conducted in the Germplasm center of Agrotechnology Discipline of Khulna University, Khulna during May to September, 2014. The experimental area was in the Agro Ecological Zone (AEZ) 13, or the Ganges Tidal Flood Plain. Geographical location of the experimental site was 22⁰47′ North latitude, 89⁰34′ East longitude. The experimental site is a subtropical humid climate and is characterized by moderately high temperature and heavy rainfall during the Kharif season (April-September) and moderately low temperature with low rainfall during the Rabi season (October-March). The soil of the experimental area belongs to the sandy loam soil type. The texture of the soil was clay loam to clay and it contained low N and Zn, very low P, and high amounts of K and S. In addition, B, Ca, Mg, Cu, Fe, and Mn were present in high amounts in the soil (SRDI 2010).

Layout of experiment and treatments description

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Eleven combination of organic and inorganic manure and fertilizer were used as treatments. The following manure and fertilizer doses was applied in different treatments-

T_1 (Recommended dose of NPK)= Urea 350 kg ha^{-1}, TSP 200 kg ha^{-1} and MoP 220 kg ha^{-1}; T_2 (100% water hyacinth) = 10 t ha^{-1}; T_3 (50% water hyacinth + 50% farm yard manure) = 5 t ha^{-1}+ 5 t ha^{-1}; T_4 (50% cow dung + 50% water hyacinth) = 5 t ha^{-1}+ 5 t ha^{-1}; T_5 (50% poultry litter + 50% water hyacinth) = 5 t ha^{-1}+ 5 t ha^{-1}; T_6 (100% Poultry Litter) = 10 t ha^{-1}; T_7 (50% poultry litter + 50% farm yard manure) = 5 t ha^{-1} + 5 t ha^{-1}; T_8 (50% poultry litter + 50% cow dung) = 5 t ha^{-1} + 5 t ha^{-1}; T_9 (100% farm yard manure) = 10 t ha^{-1}, T_{10} (100% cow dung) = 10 t ha^{-1}; T_{11} (50% FYM + 50% cow dung) = 5 t ha^{-1} + 5 t ha^{-1}. No fertilizer and manure treatment (T_0) consider as control. 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 of 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).

Management of the experiment

A piece of medium high land was selected for seed bed preparation at the Germplasm center of Agrotechnology Discipline of Khulna University, Khulna. Before sowing in the seed bed, seeds were soaked in water for 12-15 hours and were sown in the seedbed on May, 2014. The seeds were collected from registered seed dealers. 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. 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. To keep the experimental field free from the weed infestation proper measure was taken timely. Irrigation was given as and when needed. 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. 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.

Data collection procedure

Data were recorded on different parameters such as number of branch plant^{-1}, number of leaves plant^{-1}, plant height (cm), length and breadth of leaves (cm), diameter of plant (mm), yield (t ha^{-1}) at 15 days intervals.

Economic analysis

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

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.

Gross income

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

Net return

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

Benefit cost ratio

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

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

Statistical analysis

Data was analyzed with the help of SAS JMP 12.2.0 software and mean separation by the Tukey HSD test at p ≤0.05.

Results and Discussion

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 (p ≤0.05) in number of leaves was observed among the treatments (Table 1). The highest number of leaves was obtained from T_1 (recommended dose of NPK fertilizers) followed by T_{11} (50% farm yard manure + 50% cow dung) and the lowest number of leaves was found with control treatment throughout the study period (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. However, nitrogen initiated higher growth of stem and leaves of plant.

Table 1. Effect of fertilizers and manures on number of leaves per plant of Indian spinach.

Treatments	Number of leaves plant^{-1}					
	15DAT	30DAT	45DAT	60DAT	75DAT	90DAT
T_0	9.00e	16.00f	27.00f	35.67d	40.00c	43.67c
T_1	15.00a	27.67a	41.67a	53.67a	59.67a	62.67a
T_2	9.67de	19.67e	35.33de	46.67bc	52.67b	55.67b
T_3	12.67b	24.67a-c	38.67a-e	50.33a-c	55.33ab	59.33ab
T_4	11.00cd	22.33c-e	36.67b-e	48.33bc	53.33b	55.67b
T_5	10.00de	20.67e	35.00e	45.67c	51.33b	54.00b
T_6	12.00bc	24.33b-d	38.33a-e	49.33a-c	54.67ab	57.67ab
T_7	12.33bc	24.33b-d	39.33a-c	51.00ab	56.33ab	60.00ab
T_8	13.33b	26.33ab	40.33ab	51.00ab	55.33ab	58.00ab
T_9	11.00cd	21.33de	36.00c-e	46.33bc	51.33b	57.67ab
T_{10}	10.00de	20.67e	35.00e	45.67c	51.67b	56.33ab
T_{11}	13.00b	26.33ab	39.00a-d	49.67a-c	56.33ab	60.33ab
Level of significance	**	**	**	**	**	**
CV(%)	7.21	6.22	5.78	5.86	6.54	7.27

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level ** means significant at 1%. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Plant height

There were significant differences (p ≤0.05) in plant height observed among the treatments (Table 2). The highest plant height was observed in T_{11} (50% FYM + 50% cow dung) followed by T_1 (Recommended dose of NPK) and T_7 (50% poultry litter + 50% farm yard manure) at 90 DAT while the lowest plant height was found with control treatment at every stage of data collection (Table 2). 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 T_{11} (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

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level **, * means significant at 1%, 5%, respectively. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Leaf length

There were significant differences (p ≤0.05) in leaf length among the treatments (Table 3). The highest leaf length was observed in T_1 (Recommended dose of NPK) followed by T_3 (50% water hyacinth + 50% farm yard manure) at 90 DAT, T_4 (50% cow dung + 50% water hyacinth) and T_9 (100% farm yard manure) at both 75 and 90 DAT, respectively. While the lowest leaf length was found in the control (Table 3).

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

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level ** means significant at 1%. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Leaf breadth

Leaf breadth was significantly different (p ≤0.05) among the treatments (Table 4). In case of leaf breadth of Indian spinach data presented in table 4 showed that the highest leaf breadth was observed in T_1 (Recommended dose of NPK) followed by T_3 (50% water hyacinth + 50% farm yard manure) and T_4 (50% cow dung + 50% water hyacinth) at 90 DAT, respectively. While the lowest leaf breadth was found in T_{10} (100% cow dung) at 15 DAT but after that the lowest leaf breadth was found in control treatment throughout the study period.

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

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level **, * means significant at 1%, 5%, respectively. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

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 (p ≤0.05) in the number of branches per plant among the treatments. At 45, 60 and 75 DAT, number of branch per plant were significantly (p ≤0.05) affected by the application of different fertilizers and manures (Table 5). In case of 90 DAT there were no significant differences for other treatments except T_0 and T_2. The highest number of branches was obtained in T_1 (Recommended dose of NPK) followed by T_{11} (50% farm yard manure + 50% cow dung) 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 Haqueet *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.

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

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level **, * and NS means significant at 1% and 5%, or and insignificant, respectively. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Diameter of stem

Plant diameter differed significantly (p ≤0.05) almost all the DATs (Table 6). The highest plant diameter was recorded from T_8 (50% poultry litter + 50% cow dung) followed by T_1 (Recommended dose of NPK) and T_{11} (50% FYM + 50% cow dung) (22.00 mm) at 90 DAT while the lowest plant diameter was found in the control treatment. 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 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.

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

Table values with the same letters in a column do not differ significantly whereas column having dissimilar letter differ significantly as per Tukey HSD test. Significance level ** means significant at 1%. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Yield of Indian spinach

The results presented in Table 7 shows a significant difference (p ≤0.05) on the harvested yield of Indian spinach. The highest yield was found in T_1 (Recommended dose of NPK) followed closely by T_{11} (50% FYM + 50% cow dung), T_7 (50% poultry litter + 50% farm yard manure) and in T_8 (50% poultry litter + 50% cow dung), respectively (Fig. 1). 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 which facilitated to maintain leafy vegetative growth of Indian spinach.

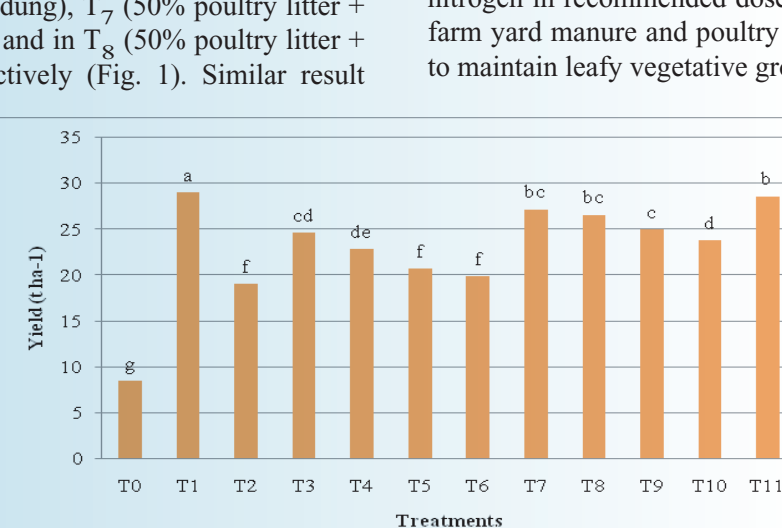

Fig.1. Effect of fertilizers and manures on yield (t ha^{-1}) of Indian spinach.

Figure having the same letters in a bar do not differ significantly whereas bar having dissimilar letter differ significantly as per Tukey HSD test. Significance level ** means significant at 1%. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Economic analysis and benefit cost ratio of Indian spinach

The highest cost of production was involved with the treatment T_6 (100% poultry litter) and the lowest was involved with the treatment T_{10} (100% cow dung). The highest net return was obtained from T_{11} (50% FYM + 50% cow dung). However, the lowest net return was obtained from T_6 (100% poultry litter). The benefit cost ratio was found the highest in T_{11} (50% FYM + 50% cow dung) followed by T_7 (50% poultry litter + 50% farm yard manure) (2.44) and the lowest was recorded from T_6 (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_0	8.4	89250	126000	36,750	1.41
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

Sale of Indian spinach at the rate of TK. 15 per Kg. Treatments (T_0-T_{11}) acronyms are described in Materials and Methods.

Conclusion

Organic manure incorporation increases soil aeration and activities of microorganisms of soil which helpful for growth and production of Indian spinach. Effect of recommended NPK fertilizers 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 although which is not good for soil health. However, (50% FYM + 50% CD) and (50% PL + 50% CD) produced the highest plant height and diameter, respectively. In context of yield parameter, the highest yield of Indian spinach was found at recommended NPK fertilizers followed by (50% FYM + 50% CD), (50% PL + 50% FYM) and (50% PL + 50% CD), respectively. Therefore, application of organic manures in combination of (50% FYM + 50% CD), (50% PL + 50% FYM) and (50% PL + 50% CD), respectively showed better performance in terms of yield parameters, yield, and benefit cost ratio of Indian spinach after NPK fertilizers. 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. Further trials is needed with including more cultivars and manure and fertilizer combination before final recommendation at farmer's level.

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