EFFECT OF SOWING TIME AND FERTILIZERS ON GROWTH AND YIELD OF INDIAN SPINACH (*Basella alba* L.)

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EFFECT OF SOWING TIME AND FERTILIZERS ON GROWTH AND YIELD OF INDIAN SPINACH (*Basella alba* L.)

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Sowing Time and Fertilizers on Growth and Yield of Indian Spinach (*Basella alba* L.)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **Kazi Abdul Quader**, Registration No. **02182** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: 31.12.07
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TO

MY BELOVED PARENTS

LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
Agro-Ecological Zone	AEZ
and others	*et al.*
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Degree Celsius	°C
Date After Seeding	DAS
Etcetera	etc
Food and Agriculture Organization	FAO
Gram	g.
Hectare	ha
Hour	hr
Kilogram	kg
Meter	M
Millimeter	mm
Month	mo
Muriate of Potash	MP
Number	No.
Percent	%
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Square meter	m2
Triple Super Phosphate	TSP
United Nations Development Program	UNDP

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ABSTRACT

A field experiment was conducted in the experimental field of Sher-e- Bangla Agricultural University, Dhaka, Bangladesh during the period from February to May 2007 to study the effect of sowing time and fertilizers on growth and yield of Indian spinach. The experiment considered two factors. Factor A: Sowing time (3 levels) i.e. Sowing on 19 February 2007 (T_1); Sowing on 06 March 2007 (T_2) and Sowing on 21 March 2007 (T_3) and Factor B: Fertilizers (4 levels) i.e. Control (F_0); Cowdung (25 t/ha)(F_1); Poultry litter (15 t/ha) (F_2) and Inorganic fertilizers (F_3)–Urea (400 kg/ha), TSP (120 kg/ha), and MP (180 kg/ha). Data were collected in respect of plant growth characters and yield at different days after sowing. At 60 DAS the longest plant height (87.32 cm) was recorded from T_2 (sowing on 06 March, 2007), while the shortest (83.66 cm) was recorded from T_1 (Sowing on 19 February 2007). The maximum number of leaves (73.45) per plant was recorded from T_2, while the minimum number of leaves (70.95) per plant was recorded from T_1. The maximum dry matter content (13.69%) was recorded from T_2, while the minimum dry matter content (11.90%) was recorded from T_1. The maximum yield (19.86 t/ha) was recorded from T_2, while the minimum yield (16.37 t/ha) was recorded from T_1. At 60 DAS the longest plant height (92.11 cm) was recorded from F_3 and the shortest (67.56 cm) was recorded from F_0 (Control).The maximum number of leaves (78.89) per plant was recorded from F_3 and the minimum (52.19) was recorded from F_0. The maximum dry matter content (13.63%) was recorded from F_3 and the minimum (10.86%) was recorded from F_0. The maximum yield (19.71 t/ha) was recorded from F_3 and the minimum (14.12 t/ha) was recorded from F_0. Interaction between sowing time and fertilizers for all the recorded characters showed significant differences for different days after sowing. The maximum net return (Tk. 366,426/ha) was obtained from the treatment combination of T_2F_3 and the minimum net return (Tk. 142.360/ha) was obtained in T_1F_0. The maximum benefit cost ratio (5.41) was attained from the combination T_2F_3 and the minimum benefit cost ratio (2.78) was obtained from T_1F_0.

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Introduction

INTRODUCTION

Indian spinach (*Basella alba* L.), commonly known as *poi,* belongs to the family Basellaceae. It is a popular summer leafy vegetable widely cultivated in Bangladesh, India, in Tropical Asia and Africa. Indian spinach is a fleshy annual or biennial, twining much branched herb with alternate leaves. Leaves are broadly ovate and pointed at the apex. Flowers are white or pink, small sessile in cluster on elongated thickened peduncles in an open branched inflorescence. Fruit is enclosed in fleshy perianth.

There are mainly two distinct types, *Basella alba* and *Basella rubra,* one with green petioles and stems and the other with reddish leaves, petioles and stems. Both the green and red leaved cultivars are consumed as vegetables but green-leaved cultivars are commercially cultivated. All the cultivars are trained on poles, pandals or trellis or grown on ground (Bose and Som, 1990). The fresh tender leaves and stems are consumed as leafy vegetable after cooking. As half of the water soluble substance may be lost by boiling in water, it is preferable to cook the leaves in soups and stews. Indian spinach is popular for its delicate, crispy, texture and slightly sweeter taste in fresh condition.

The nutritive value of Indian spinach is very high with a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and water (Ghosh and Guha, 1933). The plant is reported to contain moisture -93%, protein -1.2%, iron – 1.4%, calcium – 0.15%, vitamin A – 3250 IU/100g. In addition to these, *Basella alba* contains 16g fluoride/100g and nitrate content is 764 ppm on dry weight basis (Sanni, 1983). There was no loss of nitrate even after 48hrs of cold storage. Moreover, it is anadyne, sedative, diuretic and expectorant (Kallo, 1986).

The colouring matter present in the red cultiver is reported to have been used in China as a dye. The ripe fruits also contain a deep violet colouring matter which is also used for colouring food. On account of the presence of mucilagenous substances in the leaves and stems, it is used as poultice. The juice of leaves is prescrived in cases of constipation, particularly for children and pregnant woman (Burkill, 1935). The crop grows in well manured sandy loam soil provided it is wall drained and well aerated. Adequate moisture and partial shade result in better growth of the plant and formation of bigger succulent leaves. Cultivation of the crop should be avoided in regions affected by frost. The crop is usually grown during warm and moist seasons.

Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of *Basella alba* requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both. Only organic manure applicatoin can replace the requirement of inorganic fertilizer. Organic manure improves soil structure as well as increase its water holding capacity. Moreover, it facilitates aeration in soil. Recently, organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Now a days people are willing to get the vegetable without the inorganic fertilizer, because they are suffering from serious diseases which are due to the bad affect of inorganic fertilizer.

A number of agronomic practices have been found to affect the yield of vegetable crops (Boztok, 1985). Sowing time had a marked effect on growth and development of crops (Mittel and Srivastava, 1964). Effect of sowing time on growth and development has significnat influence in Indian spinach (Schoenemann *et al.*, 1982). Earlier sowing provides more time for the growth and development of plant which is favorable for higher yield.

Like many other vegetables such as root and tuber crops as well as spices, the growth and yield of Indian spinach is influenced by growing time and organic and inorganic fertilizer. A number of factors like temperature, soil moisture are involved with organic and inorganic fertilizer as well as sowing time which ultimately influence the growth and yield of the crop. Still to day there is few research works done on the effects of sowing time and fertilizer management for the growth and yield of Indian spinach production in Bangladesh. Considering the above facts, therefore the present study was undertaken with the following objectives:

- To findout the optimum sowing time for Indian spinach production;
- To find out the effect of different fertilizers on growth and yield of Indian spinach;
- To find out the benefit cost ratio for production of Indian spinach by using different sowing time and fertilizers.

Chapter 2

Review of literature

REVIEW OF LITERATURE

Indian spinach (*Basella alba* L.) is one of the most popular leafy vegetable in Bangladesh. Like many other vegetables such as root and tuber crops as well as spices, the growth and yield of *Basella alba* are influenced by organic and inorganic fertilizer. A number of factors like sowing time, temperature, soil moisture are involved with organic and inorganic fertilizer to influence the growth and yield of this crop. *Basella alba* is also known to be a heavy absorber of soil moisture which should be ensured through proper water management such as irrigation. There is a little or no combined research work to the effect of organic and inorganic fertilizer on growth and yield of *Basella alba* in Bangladesh. The literature related to the present study are reviewed in this chapter.

Zhu *et al*. (1994) were studied Plants were grown in solution culture and the effects of N supply (1-15 mmol NO_3/litre) and light intensity on nitrate accumulation, nitrate reeducates activity (NRA), and metabolic pool size (MPS) of nitrate reduction in the leaves. MPS and NRA in situ increased with increasing NO_3 concentration in the nutrient solution. When the NO_3 concentration was >10 mmol/litre, MPS was only slightly increased but the NO_3 accumulation in the vacuoles was increased. Under low light intensity, NO_3 accumulation in the leaves was increased; it was mostly stored in the vacuoles, as the NO_3 in the metabolic pool was not affected. Under low light intensity, the soluble sugar content of the leaves was significantly reduced. Accumulation of NO_3 in the vacuoles may be involved in osmoregulation.

Laxman *et al*. (1990) conducted an experiment with *Basella alba* collected from 3 districts of eastern Uttar Pradesh, India in 1988 were found to be infected by *Alternaria alternata*. This is the first report of *Alternaria alternata* causing leaf spot on *Basella alba* in India.

Busuioc *et al.* (2000) studied by Chlorophyll and carotene contents of *Basella alba* plants grown in greenhouse conditions at Iasi, Romania, from April to July, and at Targovise from June to September where Chlorophyll content was highest during the summer. Chlorophyll b content was highest during the last phenological phase. Carotene content was highest during the spring.

Miura *et al.* (1997) carried out an experiment with individual seeds of Malabar spinach (*Basella alba*) were sown in plastic cells of flats in a commercial potting mixture (Shinkenbyokun type 140) with 3 different water regimes. The moisture levels were adjusted by adding 16, 52 and 100 g of water to 500 g of potting mixture. After sowing, the plastic flats were stored for different periods at 15 or 25^0C. They were then watered and transferred to growth chambers at 30^0C (day) and 20^0C (night), with 8-hour photoperiod to induce emergence. Seeds in flats with 52 g water stored at 150^0C for 10 days began to emerge 2 days after transfer to the growth chambers, and attained 63-70% emergence within 5 days. Control seeds emerged 5-6 days after transfer. These seeds emerged gradually, and reached 23-24% emergence 20 days after transfer. Seed emergence was high in the post-sowing treatment of 52 g water at 25^0C for 5 days. The emergence rate was faster and the length of the hypocotyl was less variable in the post-sowing treatment of 52 g water at 15^0C for 10 days. It was suggested that optimal emergence of *B. alba* seeds could be obtained by sowing in a potting mixture with a moisture content equivalent to 52 g water/500 g mixture (water content of 41-45%), and chilling at 15^0C for 10 days.

Rosu *et al.* (2004) suggests that the vitamin A equivalency of beta-carotene from plant sources is lower than previously the effect of 60 d of daily supplementation with 750 microgram retinol equivalents (RE) of either cooked, pureed sweet potatoes; cooked, pureed Indian spinach (*Basella alba*); or synthetic sources of vitamin A or beta-carotene on total-body vitamin A stores in men. Total-body vitamin A stores in men (n = 14/group) were estimated by using the deuterated-retinol-dilution technique before and after 60 d of supplementation with either 0 microgram RE/d (white vegetables) or 750 microgram RE/d as sweet potatoes, Indian spinach, retinyl palmitate, or beta-carotene (RE = 1 microgram retinol or 6 microgram beta-carotene) in addition to a low-vitamin A diet providing approximately equal to 200 microgram RE/d. Mean changes in vitamin A stores in the vegetable and beta-carotene groups were compared with the mean change in the retinyl palmitate group to estimate the relative equivalency of these vitamin A sources. Initial vitamin A stores were 0.108 ⅄ 0.067 mmol. Relative to the low-vitamin A control group, the estimated mean changes in vitamin A stores were 0.029 mmol for sweet potato (P = 0.21), 0.041 mmol for Indian spinach (P = 0.033), 0.065 mmol for retinyl palmitate (P<0.001), and 0.062 mmol for beta-carotene (P < 0.002). Vitamin A equivalency factors (beta-carotene : retinol, wt : wt) were estimated as approximately equal to 13:1 for sweet potato, approximately equal to 10:1 for Indian spinach, and approximately equal to 6:1 for synthetic beta-carotene. Daily consumption of cooked, pureed green leafy vegetables or sweet potatoes had positive effect on vitamin A stores in population at risk of vitamin A deficiency.

Smith (2004) carried out a pot experiments in a screen house to evaluate pendimethalin effectiveness in pre-emergence weed control in Indian spinach (*Basella alba* L.). In the first trial, pendimethalin was applied at higher doses (0.33, 0.66, 0.99, 1.32, 1.98 kg ai ha^{-1}), while in the second trial, lower doses (0.066, 0.132, 0.198, 0.264, 0.330 kg ai ha^{-1}) were used. The treatments were arranged in a completely randomized design using three replications. Crop emergence, growth and biomass were not adversely affected by the lower doses. Seedlings emerging from doses higher than 0.33 kg (ai ha^{-1}) were significantly stunted, dark-green, mottled and produced shrunken, deformed, thickened and brittle leaves.

Leaves per plant were not markedly reduced by herbicide application but control (untreated) seedlings had higher number. Control and seedlings treated with the lowest doses of pendimethalin had longer, larger leaves than other treatments. Crop biomass decreased significantly with increasing herbicide dose. Higher doses (above 0.99 kg ai $ha^{-1)}$, reduced weed emergence over time. Weed emergence was comparable in the lower rates. These findings suggested judicious use of pendimethalin and/or integrated pendimethalin-based weed management in *B. alba*, might be possible.

Ravindra *et al*. (1998) reported that seeds of *B. rubra* [*B. alba*] were treated with KNO_3 (0.1 or 0.3 M), GA_3 (100 or 200 ppm), brassinosteroid (0.5 or 2.0 ppm) or distilled water for 24 h. Treating seeds with KNO_3 at 0.3 M resulted in the highest percentage of germination (60.8%), germination vigour index (1.27) and seedling FW (1.16 g). The seedlings from seeds treated with GA_3 were vigorous, with the greatest total seedling length (21.04 cm) at 200 ppm GA_3, and the longest root (14.36 cm) and highest (2.09) root: shoot ratio at 100 ppm GA_3. The seedlings from seeds treated with brassinosteroid at 2 ppm had the longest shoot length (10.45 cm).

Kanno *et al*. (1999) reported that new diseases occurred on *P. ocymoides* [*P. frutescens*, *C. olitorius* and *Basella rubra* [*B. alba*] in Miyagi Prefecture, Japan. The causal organism was isolated and identified as *Verticillium dahliae* and its pathogenicity was confirmed. This is the first report of Verticillium wilt of these plants in Japan.

Kanno and Ohkubo (1999) observed new diseases of *Basella rubra [B. alba*], *Lapsana apogonoides*, *Ammi majus*, *Didiscus caeruleus* and *Portulaca oleracea* occurred in Miyagi Prefecture, Japan, in 1997, 1996, 1997, 1997 and 1997, respectively. The pathogenicity of isolates from all the diseased plants to each host plant was confirmed and the isolates were identified as *Sclerotinia sclerotiorum* on the basis of morphological and cultural characteristics. This is the first report on Sclerotinia rot of these plants in Japan.

Busuioc, *et al* (1998) respiration and the activity of catalase and peroxidases were determined in leaves of *B. alba* and *B. rubra*, collected in June-September from plants grown in the field or in the greenhouse in Romania. Differences were found between field and greenhouse cultivated plants, and between species. In all cases, respiration was highest during August and was higher in field-grown plants. Peroxidase and catalase activities tended to be the lowest in August, and higher in field-grown plants.

Bolognesi *et al*. (1997) reported that new single-chain ribosome-inactivating proteins (RIPs) were isolated from the seeds of *Basella rubra* [*B. alba*] (two proteins) and from the leaves of Bougainvillea spectabilis (one protein). These RIPs inhibit protein synthesis both in a cell-free system, with an IC_{50} (concentration causing 50% inhibition) in the 10-10 M range, and by various cell lines, with IC_{50}s in the 10-8-10-6 M range. All three RIPs released adenine not only from rat liver ribosome but also from Escherichia coli rRNA, polyadenylic acid, herring sperm DNA, and artichoke mottled crinkle virus (AMCV) genomic RNA, thus being polynucleotide: adenosine glycosidases. The proteins from *B. rubra* had toxicity to mice similar to that of most type 1 RIPs with an LD_{50} (concentration that is 50% lethal) 8 mg kg^{-1} body weight, whilst the RIP from *B. spectabilis* had an $LD_{50} > 32$ mg kg^{-1}. The N-terminal sequence of the two RIPs from *B. rubra* had 80-93% identity, whereas it differed from the sequence of the RIP from *B. spectabilis*. When tested with antibodies against various RIPs, the RIPs from *B. rubra* gave some cross-reactivity with sera against dianthin 32, and weak cross-reactivity with momordin I and momorcochin S, whilst the RIP from

B. spectabilis did not cross-react with any antiserum tested. An RIP from *B. rubra* and one from *B. spectabilis* were tested for antiviral activity, and both inhibited infection of *Nicotiana benthamiana* by AMCV.

Glassgen *et al.* (1993) were identified betanidin monoglucoside, gomphrenin I (15S-betanidin 6-O-beta-glucoside), and its 4-coumaroyl and feruloyl derivatives, gomphrenin II (15S-betanidin 6-O-(6'-O-(4-coumaroyl)-beta-glucoside)), isogomphrenin I and II, and gomphrenin III (15S-betanidin 6-O-(6'-O-feruloyl-beta-glucoside)), from the juice of fresh *B. rubra* fruits. Their structures were elucidated from spectral analyses.

Banerjee *et al.* (1992) observed that *B. rubra*, known as poi, is used in the treatment of constipation in children and pregnant women, and urticaria. Palmitic, oleic, linoleic, linolenic and arachidonic acids were present in the fatty oil (10.7%) from seeds (collected locally), while the proteins (3.3%) included lysine, theonine, valine, methionine and leucine.

Demidov *et al.* (1991) with *B. rubra* [*B. alba*] in greenhouse container trials was conducted by the vegetatively propagated plants were grown in 3 different substrates viz. (1) natural zeolite, (2) zeolite + 5% chernozem and (3) a 1:1 mixture of leaf compost and river sand. All substrates had a similar nutrient content and 4-kg containers were used. The plants were grown in 30/20^{0}C day/night temperatures at 65.5% RH and 50 or 70 W/m^2 PAR, under a daily 12-h illumination. The foliage was cut at 15 cm above the substrate level 3 times per week. *B. alba* was found a promising salad crop giving a high yield per unit area.The highest productivity viz. 250-413 g/m^2 in 24 h was obtained on substrate (2) at 70 W/m^2 PAR.

Abdel (1996) carried two experiments at the Experiment Station Farm of Agriculture and Veterinary Medicine College, King Saud University, Saudi Arabia, in the winter of 1991-92 and 1992-93. Seeds of the lettuce cv. White Paris were sown in a nursery in October 1991 and 1992. Seedlings were transplanted in December. N as ammonium sulphate (20.5%N) was applied at 0, 100, 200 and 300 kg/ha in 3 equal doses 3, 5 and 7 weeks after transplanting. Increasing N concentration resulted in increases in all measured parameters. Head fresh weight and total yield both increased with increasing applications of N. It concluded that to maximise lettuce yields the optimum N application was 200 kg/ha.

Anez and Pino (1997) evaluated the methods and timing for the application of nitrogen fertilizer to lettuce(leafy vegetable) Great Lakes. Ten nitrogen treatments (side dressing of 100 kg/N ha at transplantation or 15, 30, 45 and 60 days after transplanting (DAT), side dressing of 50 kg N/ha plus 50 kg N/ha applied or foliar fertilizer applied at transplantation or 15, 30, 45 and 60 DAT; control without nitrogen fertilizer) were tested on a sandy-loam soil in Merida, Venezuela. Significant differences were found between methods of application and the control when 100 kg N/ha were applied at 45 DAT. No significant differences were observed between the treatments and the control when 100 kg N/ha was applied after 45 DAT.

Bastelaere (1999) stated that fertilizer application (12.5 kg/ha) in Indian spinach the autumn on well-leached soils resulted in glassiness and rib blight. However, after soil disinfection, an application of 25 kg/ha was sometimes necessary. Greater application rates resulted in stagnated growth and lower crop weight.

Kowalska (1997) conducted green house trials in two winter-spring seasons, N fertilizer in the form of urea, ammonium or nitrate was applied once before planting to pot grown plants Indian spinach cv. Alka in peat or a soil-based mixture (peat: sand: mineral soil, 1:1:1). The average fresh weight and dry matter yield of plants grown in peat was considerably higher than that of plants grown in the soil mixture. Application of fertilizer with reduced nitrogen forms increased the ammonium content of plants, where as nitrate-N increased nitrate accumulation. It was concluded that application of reduced forms of N significantly improved the quality of the vegetable by reducing the accumulation of nitrates especially in plants grown in peat which has a slower rate of nitrification.

El-Shinawy *et al.* (1999) reported that the highest in the control treatment, followed by poultry manure, pigeon manure and finally buffalo manure. Mineral composition of Indian spinach plants was influenced by treatment. The results suggested that poultry manure, with some modifications, could be used as an organic source under the nutrient film technique system.

Rodrigues and Casali (1999) observed that the highest estimated yields of Indian spinach 119.5, 119.4 and 153.9 g/plant were obtained with 37.7 t organic compost/ha with no mineral fertilizer application, 18.9 t organic compost/ha with half the recommended mineral fertilizer rate and 13 t organic compost/ha with the recommended mineral fertilizer rate. Organic compost application resulted in lower foliar N and Ca concentrations and higher foliar P, K and Na concentrations compared with mineral fertilizer application.

Tisselli (1999) reported that maximum rates of organic manure (usually poultry manure) and NPK recommended in 1998 for use in lettuce crops in Emilia-Romagna and Italy. Trials showed that a combination of organic and mineral fertilizers gave higher yields of marketable heads, fewer rejects and a better average weight/head than mineral fertilizer alone.

Rubeiz *et al.* (1992) mentioned that the lack of significant response in Indian spinach yield was due to sufficient levels of soil NO_3-N and available P in the untreated soil. Manure or fertilizer application had no effect on soil EC, pH or available P. Soil NO_3-N at harvest was significantly increased only by NH_4NO_3. Leaf PO_4-P concentration was not affected by treatments, but leaf NO_3-N at heading was significantly increased by all treatments.

Vidigal *et al*. (1997) mentioned that dried pig manure gave the highest yields in Indian spinach at 65 days after sowing (54.4 t/ha), an increase of 33.3% above those supplied with NPK, with similar results in a succeeding crop planted on the same ground in late September (a 39.4% increase over NPK). Napier grass + coffee straw + pig slurry was the best mixture, increasing yields 10.8% and 17.6% above those produced by NPK in 1st and 2nd crops, respectively.

Zarate *et al*. (1997) observed that the interaction between rate and method of application was significant in *B.alba.* In the absence of incorporated manure, surface application of 14 t manure/ha gave significantly higher yields (17.8 t fresh matter/ha) than other rates. When 7 t/ha was incorporated, the rate of surface application had no significant effect on yields (13.3-17.1 t/ha), whereas when 14 t/ha was incorporated, surface application of 7 t manure/ha gave the significantly highest yield (20.0 t fresh matter/ha).

Chapter 3

Materials and Methods

MATERIALS AND METHODS

Indian spinach (*Basella alba)* is being grown in a very large scale in Bangladesh, a good deal of interest has been generated for raising this crop due to its demand. It is necessary to explore the possibilities of growing Indian spinach in order to raise its yield level. fertilizer management and time of sowing affects on growth, development and yield. So, this experiment was undertaken to find out optimum time of sowing and doses of organic and inorganic fertilizer effective for yield of this crops.

3.1 Experimental Site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from February to May 2007. The experimental site was previously used as vegetable garden and recently developed for research work. The location of the site is 23° 74′N latitude and 90° 35′E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

3.2 Climate

The climate of the experimental site is sub-tropical, characterized by rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The total rainfall of the experimental site was 389mm during the study period. The average monthly maximum and minimum temperatures were 34.7°C and 12.4°C repectively during the experimental period. Kharif season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate and Weather Division) and have been presented (Appendix I).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP,1988). The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in appendix II. The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below –

AEZ No. : 28
Soil series : Tejgaon
General soil : Non-calcarious dark grey

3.4 Sowing Materials

Seed Rate : 2kg/ha
Seed required : 86 g
Veriety : *Basella alba* -Green
Source : BADC, Foundation Seed (lot no.-06/a/2006-07).

3.5 Treatments of the experiment

Factor A : Sowing time (three levels):

i. Sowing on 19 February 2007 (T_1)
ii. Sowing on 06 March 2007 (T_2)
iii. Sowing on 21 March 2007 (T_3)

Factor B : Fertilizer (four levels) :

i. Control (F_0)
ii. Cowdung (F_1) - (25 t/ha)
iii. Poultry litter (F_2) - (15 t/ha)
iv. Inorganic fertilizers (F_3) - Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha).

Treatment combination : $4 \times 3 = 12$ (T_1F_0, T_1F_1, T_1F_2, T_1F_3, T_2F_0, T_2F_1, T_2F_2, T_2F_3, T_3F_0, T_3F_1, T_3F_2 and T_3F_3).

3.6 Experimental design and layout

The experiment was in two factors laidout out Randomized Complete Block Design (RCBD) with three replications. Each block consisted of 12 plots, where 12 treatments were alloted at random. Thus the total number of plots was 36. The size of unit plot was 2.4 m × 1.8 m.= 4.32 m^2. The distance between the plots and the blocks were 50 cm and 75 cm, respectively. Each plot had 18 plants. The distance betwen row to row and plant to plant were 60 cm and 40 cm, respectively. Thus the total area of experiment was 35.8 m × 8.4 m = 300.72 m^2. The layout of the experiment was given in Figure 1.

3.7 Land preparation

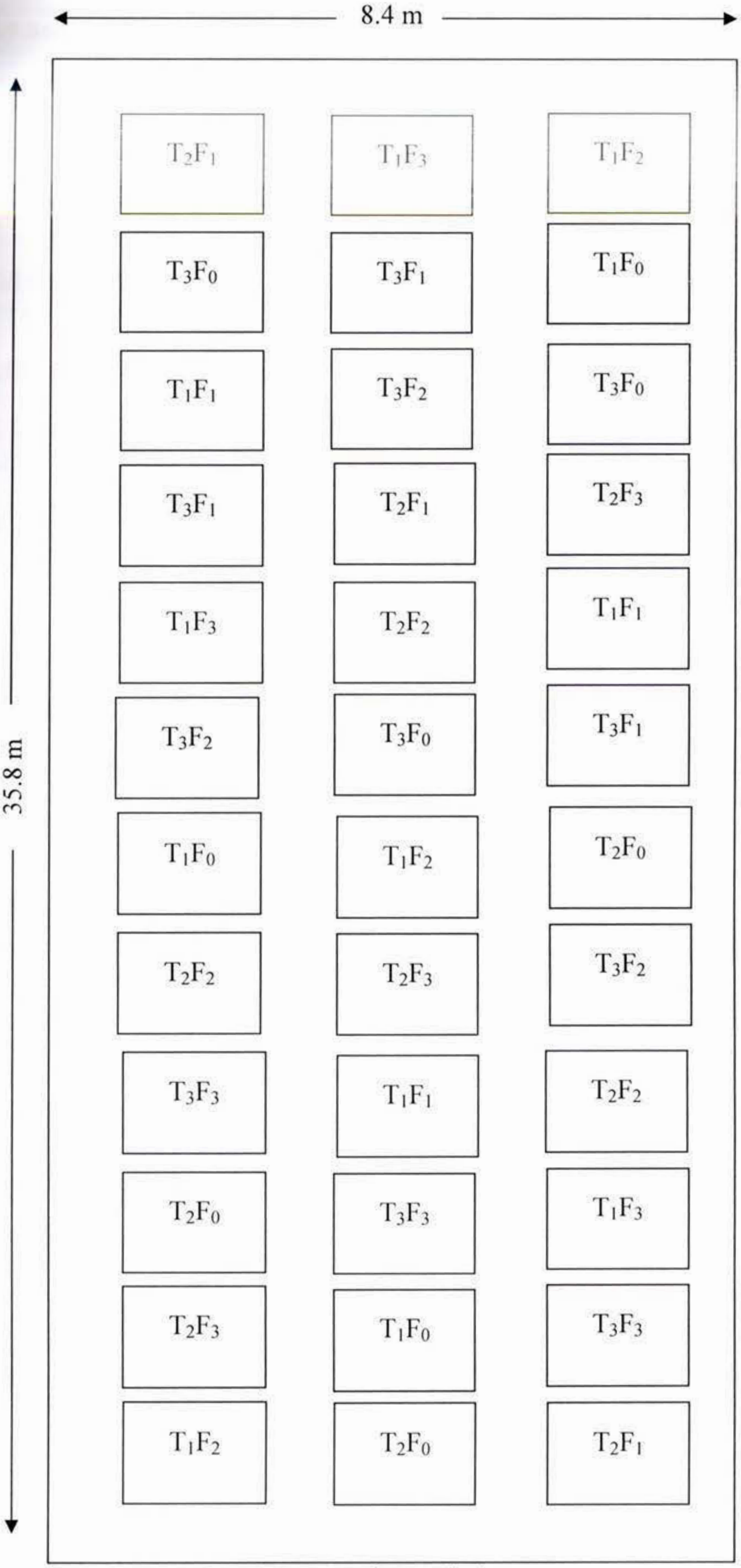
The land which was selected to conduct the experiment was opened on 4 February 2007 with the help of a power tiller and then it was kept open for 5 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have good tilth which was necessary for getting better yield of the crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was pulverized for good tilth.

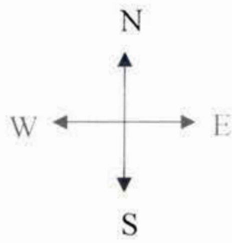
3.8 Application of manures and fertilizers

Manures and fertilizers were applied according to the treatments considering the recommended dose for Indian spinach according to Rashid (1994).

Table 1. Dose and method of application of fertilizers in Indian spinach field

Fertilizers	Dose/ha	Application (%)			
		Basal	15 DAT	30 DAT	45 DAT
Cowdung	25 tonnes	100	--	--	--
Poultry litter	15 tonnes	100	--	--	--
N (as urea)	400 kg	--	33.33	33.33	33.33
P_2O_5 (as TSP)	120 kg	100	--	--	--
K_2O (as MP)	180 kg	100	--	--	--





Plot size = 2.4 m × 1.8 m
Plot spacing = 50 cm
Between replication = 0.75 m

Factors A:

T_1=Sowing on 19 February, 07
T_2=Sowing on 06 March, 07
T_3=Sowing on 21 March, 07

Factors B:

F_0=Control
F_1=Cowdung 25 t/ha
F_2=Poultry litter 15t/ha
F_3=Urea 400 kg/ha + TSP (120 kg/ha and MP 180 kg/ha

Figure 1. Layout of the experimental plot

3.9 Seed sowing

First, second and third sowing were done on 19 February, 2007 (T_1), 6 March, 2007 (T_2) and 21 March 2007 (T_3), respectively as per design of the experiment. Light irrigation was provided in the evening after sowing of seeds. There were three rows in a plot, each rows had six plants, in total there were eighteen plants in each plot.

3.10 Intercultural operation

3.10.1 Gap filling

Dead, injured and weak seedlings were replaced by healthy seedlings from boarder line.

3.10.2 Weeding

Some weeds were found in the experimental plot. Weeding was done time to time in the plots to keep the plot clean.

3.10.3 Irrigation

Light irrigation was given just after the seedings. The plots were irrigated more frequently for better establishment of the plants.

3.10.4 Insects and Diseases

In early stage some insect was attacked. The was controlled by using systemic insecticides. There was no incidence of diseases.

3.11 Harvesting

Randomly selected 4 plants were harvested from each plot for data collection. First, second, third and final harvests were done at 30, 40, 50 and 60 DAS.

3.12 Data collection

Data were recorded on the following parameters from the sample plants. During the course of experiment 4 plants were sampled randomly from each unit plot for data collection.

3.12.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 30, 40, 50 and 60 days after seed sowing (DAS) from the point of attachment of the leaves to the ground level up to the tip of the plant.

3.12.2 Number of leaves per plant

Number of leaves of 4 randomly selected plants were counted at 30, 40, 50 and 60 days after seed sowing (DAS). All the leaves of each plant were counted seperately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of 4 plants gave the number of leaves per plant.

3.12.3 Leaf area per plant (cm^2)

The selected leaves of 4 randomly selected plants were measured at 30, 40, 50 and 60 days after seed sowing (DAS). Only the largest young leaves of the plant were measured. The average leaf area of the 4 plants gave leaf area per plant (cm^2).

3.12.4 Number of branches per plant

Number of branches of 4 randomly selected plants were counted at 30, 40, 50 and 60 days after seed sowing (DAS). Only the smallest young branches at the growing point of the plant were excluded from counting. The average number of branches of 4 plants gave number of branches per plant.

3.12.5 Fresh weight of leaves and twigs per plant in grams(g).

Leaves and twigs of 4 randomly selected plants at 30, 40, 50 and 60 days after seed sowing were detached by a sharp knife and average fresh weight of leaves and twigs was recorded in gram (g).

3.12.6 Dry matter estimation

One hundred grams of leaf and twigs sample previously cut into thin pieces were sundried. after that samples were placed in envelop, weighed and placed in oven maintained at 70^0C for 72 hours until these reached constant weight. The sample then was transferred into a desiccator and allowed to cool down to room temperature. The dry weight of the sample was taken at 30, 40, 50 and 60 days after seed sowing (DAS). The dry matter contents were computed by simple calculation from the weight by the following formula.

$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.12.7 Gross yield (kg/plot)

The yield of Indian spinach per hectare was calculated form every harvest of leaves and twigs per plot at 30, 40, 50 and 60 days after sowing (DAS).

3.12.8 Gross yield (t/ha)

It consisted of leaf and twigs of Indian spinach weighed and than coverted into ton per hectare.

3.13 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the sowing time and fertilizer management practices on yield and yield contributing characters of Indian spinach. The analysis of variance was performed by using MSTAT Program. The significance of the difference among the treatment combination means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability (Gomez and Gomez, 1984).

3.14 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of sowing time and fertilizer management practices. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% for eight months. The market price of Indian spinach was considered for estimating the cost and return. Analyses were done according to the procedure of Alma *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

Chapter 4

Results

Discussion

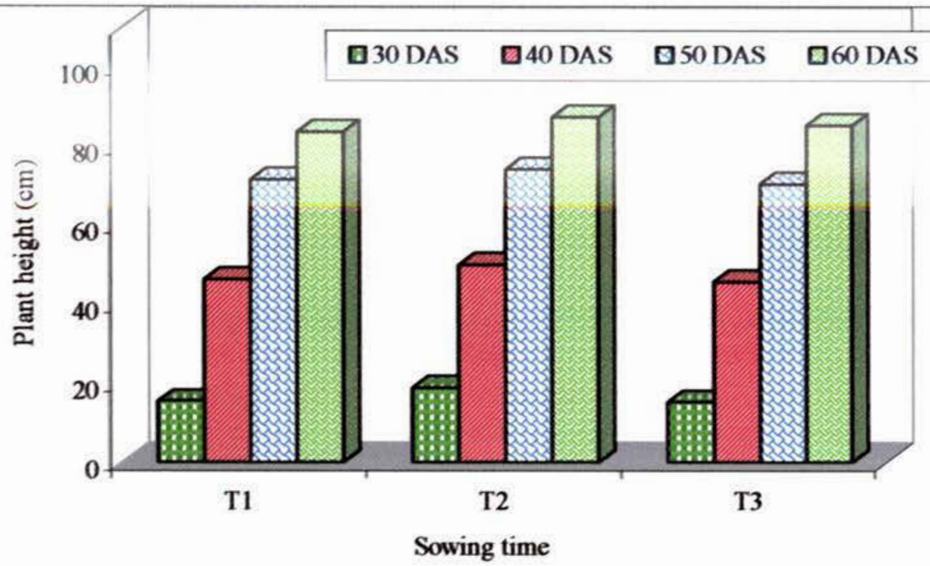
RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of sowing time and fertilizers on growth and yield of Indian spinach. Data on different yield contributing characters and yield at different days after sowing (DAS) were recorded. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield of Indian spinach are given in Appendix III-VII. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Plant height

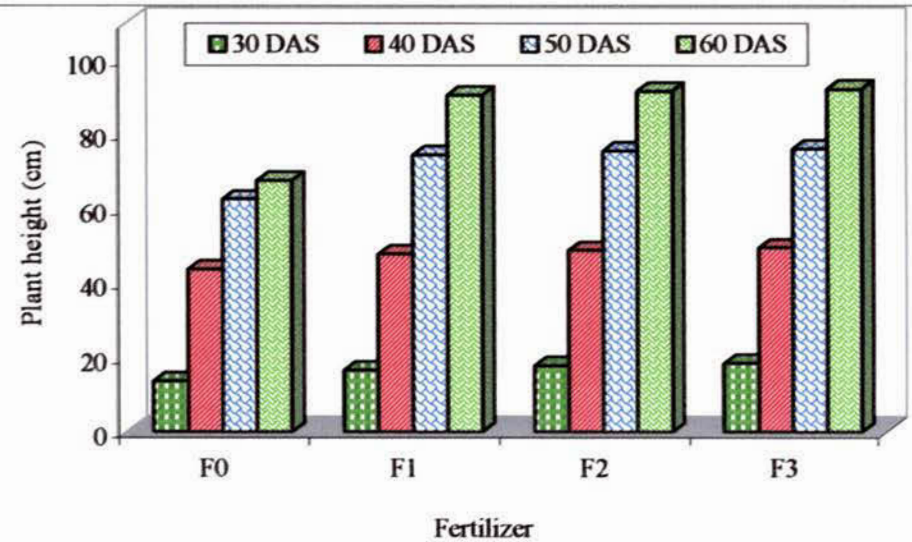
Sowing time varied significantly on plant height of Indian spinach at 30, 40, 50 and 60 DAS (Figure 2). At 30 DAS the longest plant height (18.89 cm) was recorded from T_2 (sowing on 06 March), while the shortest plant height (15.25 cm) was recorded from T_3 (sowing on 21 March) which was statistically identical (15.44 cm) with T_1 (sowing on 19 February). The longest plant height (50.00 cm) was recorded from T_2 and the shortest (45.67 cm) was recorded from T_3 which was statistically similar (46.31 cm) with T_1 at 40 DAS. At 50 DAS the longest plant height (74.21 cm) was recorded from T_2 and the shortest (70.39 cm) was found from T_3 which was statistically identical (71.60 cm) with T_1. At 60 DAS the longest plant height (87.32 cm) was recorded from T_2, while the shortest plant height (83.66 cm) was recorded from T_1 which was closely (85.24 cm) followed by T_3. Chowdhury *et al.* (1974), Bosch *et al* (1991) and Baca *et al.* (1993) also reported similar findings earlier.

Fertilizers showed significant variation on plant height at 30, 40, 50 and 60 DAS (Figure 3). The longest plant height (18.37 cm) was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (17.67 cm) with F_2 (Poultry litter: 15 t/ha) and the shortest (13.60 cm) was recorded from F_0 (control condition) which was closely (16.47 cm) followed by F_1 (Cowdung: 25 t/ha) at 30 DAS. At 40 DAS the



T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

Figure 2. Effect of sowing time on plant height of Indian spinach



F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 3. Effect of fertilizers on plant height of Indian spinach

Longest plant height (49.34 cm) was recorded from F_3 which was statistically identical (48.65 cm) with F_2 and the shortest (43.57 cm) was recorded from F_0 which was closely (47.75 cm) followed by F_1. The longest plant height (75.97 cm) was recorded from F_3 which was statistically similar (75.46 cm) with F_2 and the shortest (62.54 cm) was recorded from F_0 at 50 DAS. At 60 DAS the longest plant height (92.11 cm) was recorded from F_3 which was statistically identical (91.55 cm) with F_2 and the shortest (67.56 cm) was recorded from F_0. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant. Busuioc *et al.* (2000), Work (1997), Siddique and Rabbani (1987), Singh and Randhawa (1988) reported that chemical fertilzer gave maximum growth as well as plant height.

Interaction between sowing time and fertilizers for plant height at different days after sowing showed significant differences (Appendix III). At 30 DAS the longest plant height (22.11 cm) was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was followed by T_2F_2 and T_2F_1, while T_1F_0 (sowing on 19 February and control condition) gave the shortest plant height (13.53 cm) (Table 2). At 40 DAS the longest plant height (53.34 cm) was recorded from T_2F_3 whereas the shortest (42.76 cm) was recorded from T_1F_0. At 50 DAS the longest plant height (79.91 cm) was recorded from T_2F_3 which was followed by T_2F_2 and T_2F_1 and the shortest (64.73 cm) was recorded from T_1F_0. The longest plant height (96.33 cm) was recorded from T_2F_3 which was followed by T_2F_2 and T_2F_1 and the shortest (66.73 cm) was from T_1F_0 at 60 DAS. From the results it was noted that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results was the longest plant height with chemical fertilizer and organic fertilizer than the control.

Table 2. Interaction effect of sowing time and fertilizers on plant height and number of leaves per plant of Indian Spinach

Treatment	Plant height (cm) at				Number of leaves per plant at			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1F_0	13.53 de	42.76 f	64.73 d	66.73 de	13.22 cd	22.78 e	39.89 d	53.33 c
T_1F_1	15.28 cde	46.73 cde	73.11 c	88.53 c	14.67 cd	27.00 bcd	46.56 c	76.33 b
T_1F_2	16.10 cd	47.52 bcd	73.87 c	89.30 c	15.00 cd	27.22 bc	46.89 c	77.00 b
T_1F_3	16.86 bc	48.22 bc	74.69 bc	90.07 bc	15.33 bc	27.56 bc	47.33 bc	77.55 b
T_2F_0	12.77 e	43.50 ef	60.58 e	63.75 e	13.00 d	21.56 e	36.44 e	50.45 c
T_2F_1	19.25 ab	50.82 ab	77.07 ab	93.50 abc	17.11 ab	28.78 ab	48.45 abc	79.55 ab
T_2F_2	21.44 a	52.34 a	79.30 a	95.71 ab	18.32 a	29.56 a	49.56 ab	81.78 a
T_2F_3	**22.11 a**	**53.34 a**	**79.91 a**	**96.33 a**	**18.78 a**	**29.78 a**	**49.89 a**	**82.00 a**
T_3F_0	14.50 cde	44.45 def	62.29 de	72.19 d	14.00 cd	25.00 d	37.67 de	52.78 c
T_3F_1	14.88 cde	45.70 cdef	72.76 c	89.19 c	14.22 cd	26.33 cd	46.22 c	76.67 b
T_3F_2	15.46 cde	46.09 cdef	73.21 c	89.63 c	14.56 cd	26.78 bcd	46.44 c	77.22 b
T_3F_3	16.15 cd	46.46 cde	73.31 c	89.93 bc	15.11 cd	26.89 bcd	46.67 c	77.11 b
CV(%)	9.90	7.08	6.39	11.80	7.29	9.02	6.94	8.59

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

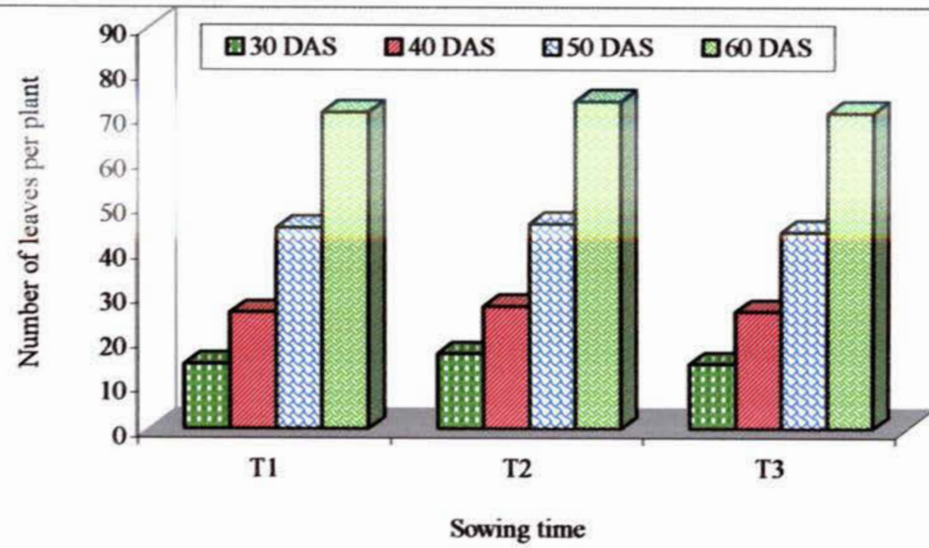
T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

4.2 Number of leaves per plant

Sowing time varied significantly for number of leaves per plant of Indian spinach at 30, 40, 50 and 60 DAS (Figure 4). At 30 DAS the maximum number of leaves per plant (16.80) was recorded from T_2 (sowing on 06 March), while the minimum number of leaves per plant (14.47) was recorded from T_3 (sowing on 21 March) which was statistically identical (14.56) with T_1 (sowing on 19 February). The maximum number of leaves per plant (27.42) was recorded from T_2 and the minimum (26.14) was recorded from T_1 which was statistically identical (26.25) with T_3 at 40 DAS. At 50 DAS the maximum number of leaves per plant (46.08) was recorded from T_2 and the minimum (44.25) was recorded from T_3 which was statistically identical (45.17) with T_1. At 60 DAS the maximum number of leaves per plant (73.45) was recorded from T_2, while the minimum number of leaves per plant (70.95) was recorded from T_1 which was closely (71.06) followed by T_3.

Fertilizers showed significant variation on number of leaves per plant at 30, 40, 50 and 60 DAS (Figure 5). The maximum number of leaves (16.41) per plant was recorded from F_3 which was statistically identical (15.96) with F_2 (Poultry litter: 15 t/ha) and the minimum (13.41) was recorded from F_0 (control condition) which was closely (15.33) followed by F_1 (Cowdung: 25 t/ha) at 30 DAS. At 40 DAS the maximum number of leaves per plant (28.07) was recorded from F_3 which was statistically identical (27.85) with F_2 and the minimum (23.11) was recorded from F_0. The maximum number of leaves per plant (47.96) was recorded from F_3 which was statistically similar (47.63) with F_2 and the minimum (38.00) was recorded from F_0 at 50 DAS. At 60 DAS the maximum number of leaves per plant (78.89) was recorded from F_3 which was statistically identical (78.67) with F_2 and the minimum (52.19) was recorded from F_0. Chemical fertilizer ensured the availability of maximum plant nutrients which helped proper growth of plant and consequently the highest number of leaves per plant was obtained.

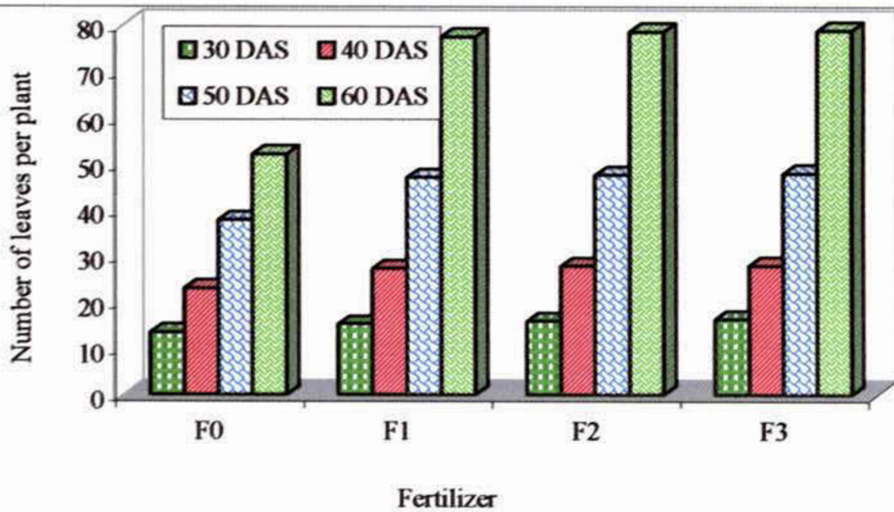


T_1: Sowing on 19 February

T_2: Sowing on 06 March

T_3: Sowing on 19 February

Figure 4. Effect of sowing time on number of leaves per plant of Indian spinach



F_0: Control

F_1: Cowdung (25 t/ha)

F_2: Poultry litter (15 t/ha)

F_3: Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 5. Effect of fertilizers on number of leaves of Indian spinach

Interaction between sowing time and fertilizers for number of leaves per plant at different days after sowing showed significant differences (Appendix III). At 30 DAS the maximum number of leaves (18.78) per plant was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing on 19 February and control condition) gave the minimum number of leaves (13.22) per plant (Table 2). At 40 DAS the maximum number of leaves (29.78) per plant was recorded from T_2F_3 whereas the minimum (22.78) was recorded from T_1F_0. At 50 DAS the maximum number of leaves (49.89) per plant was recorded from T_2F_3 and the minimum (39.89) was recorded from T_1F_0. The maximum number of leaves (82.00) per plant was recorded from T_2F_3 and the minimum (53.33) from T_1F_0 at 60 DAS. From the results it was noted that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results were the maximum number of leaves per plant with chemical fertilizer and organic fertilizer than the control.

4.3 Leaf area

Sowing time varied significantly for leaf area of Indian spinach at 30, 40, 50 and 60 DAS (Table 3). At 30 DAS the maximum leaf area (54.03 cm^2) was recorded from T_2 (sowing on 06 March), while the minimum leaf area (43.37 cm^2) was recorded from T_3 (sowing on 21 March) which was statistically identical (43.84 cm^2) with T_1 (sowing on 19 February). The maximum leaf area (158.86 cm^2) was recorded from T_2 and the minimum (144.63 cm^2) was recorded from T_3 which was statistically similar (146.31 cm^2) with T_1 at 40 DAS. At 50 DAS the maximum leaf area (258.05 cm^2) was recorded from T_2 and the minimum (245.11 cm^2) was found from T_3 which was statistically identical (249.18 cm^2) with T_1. At 60 DAS the maximum leaf area (295.39 cm^2) was recorded from T_2, which was similar with T_3 and the minimum leaf area (282.93 cm^2) was recorded from T_1.Siddique and Rashid (1990), Rashid *et al.* (1981), Hossain (1996) reported similar results earlier.

Table 3. Effect of sowing time and fertilizers on leaf area and number of branches per plant of Indian Spinach

Treatment	Leaf area (cm^2) at				Number of branches per plant at			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Sowing time								
T_1	43.84 b	146.31 b	249.18 b	282.93 b	0.08	4.64 b	10.19 b	16.11 ab
T_2	**54.03 a**	**158.86 a**	**258.05 a**	**295.39 a**	**0.50**	**6.83 a**	**11.47 a**	**16.97 a**
T_3	43.37 b	144.63 b	245.11 b	288.23 ab	0.25	4.56 b	10.31 b	15.31 b
Fertilizers								
F_0	38.35 c	137.75 b	217.44 b	226.42 b	0.11	3.56 b	7.30 b	9.00 b
F_1	46.78 b	151.55 a	258.74 a	306.58 a	0.22	5.44 a	11.41 a	18.04 a
F_2	50.56 ab	154.39 a	262.61 a	310.55 a	0.33	6.03 a	11.96 a	18.59 a
F_3	**52.62 a**	**156.05 a**	**264.33 a**	**311.85 a**	**0.44**	**6.33 a**	**11.96 a**	**18.89 a**
CV(%)	7.07	9.87	12.26	5.85	17.67	20.18	9.55	8.52

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Fertilizers showed significant variation in respect of leaf area at 30, 40, 50 and 60 DAS (Table 3). The maximum leaf area (52.62 cm^2) was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (50.56 cm^2) with F_2 (Poultry litter: 15 t/ha). The minimum (38.35 cm^2) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum leaf area (156.05 cm^2) was recorded from F_3 which was statistically identical (154.39 cm^2) with F_2. The minimum (137.75 cm^2) was recorded from F_0. The maximum leaf area (264.33 cm^2) was recorded from F_3 which was statistically similar (262.61 cm^2) with F_2. The minimum (217.44 cm^2) was recorded from F_0 at 50 DAS. At 60 DAS the maximum leaf area (311.85 cm^2) was recorded from F_3 which was statistically identical (310.55 cm^2) with F_2 and F_1 (306.58 cm^2), while the minimum (226.42 cm^2) was recorded from F_0. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant with highest leaf area.

Interaction between sowing time and fertilizers for leaf area at different days after sowing showed significant differences (Appendix IV). At 30 DAS the maximum leaf area (63.00 cm^2) was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was identical (61.11 cm^2) with T_2F_2, while T_1F_0 (sowing on 19 February and control condition) gave the minimum leaf area (37.26 cm^2). At 40 DAS the maximum leaf area (168.73 cm^2) was recorded from T_2F_3 which was similar to T_2F_2 and T_2F_1 where as the minimum (134.07 cm^2) was recorded from T_1F_0. At 50 DAS the maximum leaf area (277.54 cm^2) was recorded from T_2F_3 which was similar to T_2F_2 and T_2F_1 and the minimum (224.84 cm^2) was recorded from T_1F_0. The maximum leaf area (326.06 cm^2) was recorded from T_2F_3 and the minimum (223.58 cm^2) from T_1F_0 at 60 DAS (Table 4).

Table 4. Interaction effect of sowing time and fertilizers on leaf area and number of branches per plant of Indian Spinach

Treatment	Leaf area (cm^2) at				Number of branches per plant at			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1F_0	37.26 e	134.07 f	224.84 d	223.58 d	0.00	3.44 bc	7.00 e	10.55 c
T_1F_1	42.90 de	148.14 cde	253.92 c	300.51 b	0.00	4.78 bc	11.11 bc	17.56 b
T_1F_2	46.54 d	150.36 cd	257.04 c	302.83 b	0.00	5.11 bc	11.34 bc	18.11 ab
T_1F_3	48.64 cd	152.69 bc	260.91 bc	304.78 b	0.33	5.22 b	11.33 bc	18.22 ab
T_2F_0	36.76 e	138.32 ef	210.92 e	212.78 d	0.33	3.11 c	5.78 e	7.56 d
T_2F_1	55.25 bc	161.74 ab	267.84 ab	318.16 ab	0.33	7.22 a	12.67 ab	19.22 ab
T_2F_2	61.11 ab	166.66 a	275.88 a	324.57 a	0.67	8.43 a	13.67 a	20.45 a
T_2F_3	**63.00 a**	**168.73 a**	**277.54 a**	**326.06 a**	**0.67**	**8.56 a**	**13.78 a**	**20.67 a**
T_3F_0	41.02 de	140.86 def	216.56 de	242.90 c	0.00	4.11 bc	9.11 d	8.89 cd
T_3F_1	42.19 de	144.76 cde	254.45 c	301.06 b	0.33	4.33 bc	10.44 cd	17.34 b
T_3F_2	44.03 de	146.15 cde	254.90 c	304.25 b	0.33	4.56 bc	10.89 bcd	17.22 b
T_3F_3	46.23 d	146.73 cde	254.53 c	304.72 b	0.33	5.22 b	10.78 bcd	17.78 b
CV(%)	7.07	9.87	12.26	5.85	17.67	20.18	9.55	8.52

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

4.4 Number of branches per plant

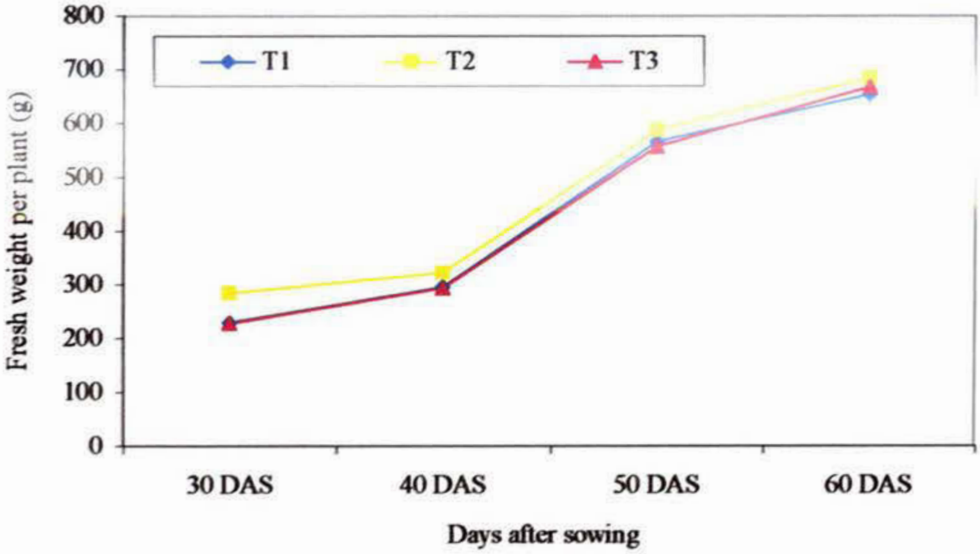
Number of branches per plant of Indian spinach varied significantly in respect of sowing time at 30, 40, 50 and 60 DAS (Table 3). At 30 DAS the maximum number of branches (0.50) per plant was recorded from T_2 (sowing on 06 March), while the minimum number of branches (0.08) per plant was recorded from T_1 (sowing on 19 February). The maximum number of branches (6.83) per plant was recorded from T_2 and the minimum (4.56) was recorded from T_3 which was statistically similar (4.64) with T_1 at 40 DAS. At 50 DAS the maximum number of branches (11.47) per plant was recorded from T_2 and the minimum (10.19) was recorded from T_1 which was statistically identical (10.31) with T_3. At 60 DAS the maximum number of branches (16.97) per plant was recorded from T_2, while the minimum number of branches (15.31) per plant was recorded from T_3 which was closely (16.11) followed by T_1. Devux and Haverkort (1987), Akand (2003) reported the simliar results.

There were no significant variation due to the application of different fertilizers on number of branches per plant at 30, 40, 50 and 60 DAS (Table 3). The maximum number of branches (0.44) per plant was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) and the minimum (0.11) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum number of branches (6.33) per plant was recorded from F_3 which was statistically identical (6.03) with F_2 and F_1 (5.44) the minimum (3.56) was recorded from F_0. The maximum number of branches (11.96) per plant was recorded from F_3 and F_2 and the minimum (7.30) was recorded from F_0 at 50 DAS. At 60 DAS the maximum number of branches (18.89) per plant was recorded from F_3 which was statistically identical (18.59) with F_2 and F_1 where as the minimum (9.00) was recorded from F_0 which was closely (18.04) followed by F_1. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant along with highest number of branches per plant.

Interaction between sowing time and fertilizers in case of number of branches per plant at different days after sowing showed significant differences (Appendix IV). At 30 DAS the maximum number of branches (0.67) per plant was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing 19 February and control condition) gave no number of branches per plant. At 40 DAS the maximum number of branches (8.56) per plant was recorded from T_2F_3 whereas the minimum (3.44) was recorded from T_1F_0. At 50 DAS the maximum number of branches (13.78) per plant was recorded from T_2F_3 and the minimum (7.00) was recorded from T_1F_0. The maximum number of branches (20.67) per plant was recorded from T_2F_3 and the minimum (10.55) from T_1F_0 at 60 DAS (Table 4). From the results it was revealed that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results were the maximum number of branches per plant.

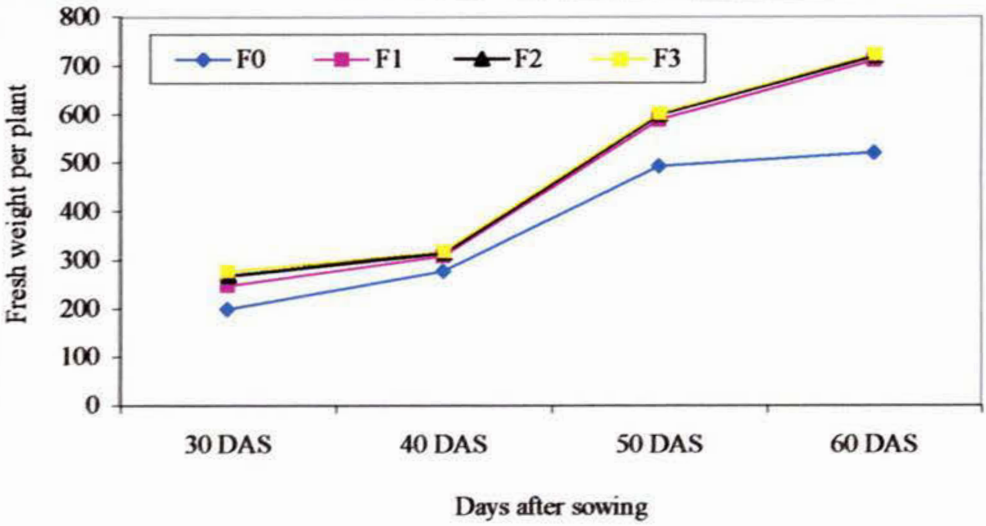
4.5 Fresh weight per plant

Sowing time varied significantly for fresh weight per plant of Indian spinach at 30, 40, 50 and 60 DAS (Figure 6). At 30 DAS the maximum fresh weight (285.45 g) per plant was recorded from T_2 (sowing on 06 March), while the minimum fresh weight (228.44 g) per plant was recorded from T_3 (sowing on 21 March). The maximum fresh weight (323.15 g) per plant was recorded from T_2 and the minimum (294.37 g) was recorded from T_3 which was statistically similar (295.84 g) with T_1 at 40 DAS. At 50 DAS the maximum fresh weight (587.91 g) per plant was recorded from T_2 and the minimum (556.89 g) was found from T_3 which was statistically identical (566.56 g) with T_1. At 60 DAS the maximum fresh weight (684.22 g) per plant was recorded from T_2, while the minimum fresh weight (654.28 g) per plant was recorded from T_1 which was closely (668.01 g) followed by T_3. El-Shinawy *et al.* (1999), Gopaqlan *et al.* (1977) and Islam *et al.* (1990) reported similar results earlier.



T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

Figure 6. Effect of sowing time on fresh weight per plant of Indian spinach



F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3: Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 7. Effect of fertilizers on fresh weight per plant of Indian spinach

Fertilizers showed significant variation in case of fresh weight per plant at 30, 40, 50 and 60 DAS (Figure 7). The maximum fresh weight (277.00 g) per plant was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (266.93 g) with F_2 (Poultry litter: 15 t/ha) and the minimum (199.86 g) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum fresh weight (317.64 g) per plant was recorded from F_3 which was statistically identical (314.45 g) with F_2 and the minimum (277.19 g) was recorded from F_0. The maximum fresh weight (601.54 g) per plant was recorded from F_3 which was statistically similar (598.71 g) with F_2 and the minimum (493.25 g) was recorded from F_0 at 50 DAS. At 60 DAS the maxim. fresh weight (722.70 g) per plant was recorded from F_3 which was statistically identical (719.72 g) with F_2 and the minimum (521.57 g) was recorded from F_0 which was closely (711.37 g) followed by F_1. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant and the results were the highest fresh weight per plant.

Interaction between sowing time and fertilizers in respect of fresh weight per plant at different days after sowing showed significant differences (Appendix V). At 30 DAS the maximum fresh weight (332.33 g) per plant was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing 19 February and control condition) gave the mini. Fresh weight (190.22 g) per plant (Table 5). At 40 DAS the maximum fresh weight (343.48 g) per plant was recorded from T_2F_3 whereas the minimum (264.62 g) was recorded from T_1F_0. At 50 DAS the maximum fresh weight (632.19 g) per plant was recorded from T_2F_3 and the minimum (508.30 g) was recorded from T_1F_0. The maximum fresh weight (754.68 g) per plant was recorded from T_2F_3 and the minimum (510.35 g) from T_1F_0 at 60 DAS. Sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate result was the maximum fresh weight per plant.

Table 5. Interaction effect of sowing time and fertilizers on fresh weight per plant and dry matter content of Indian Spinach

Treatment	Fresh weight (g) per plant at				Dry matter content (%)			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1F_0	190.22 e	264.62 f	508.30 d	510.35 d	7.01 de	7.51 ef	8.75 de	10.92 ef
T_1F_1	226.59 de	301.23 cde	578.16 c	696.32 b	7.90 cde	8.66 def	9.56 cde	11.85 de
T_1F_2	244.80 d	306.74 cd	586.06 c	703.36 b	8.29 bcd	9.23 cd	10.11 cd	12.23 de
T_1F_3	256.36 cd	310.76 bc	593.72 bc	707.10 b	8.74 bc	9.54 cd	10.46 bc	12.63 cd
T_2F_0	193.36 e	281.10 ef	479.35 e	491.98 d	6.66 e	7.42 f	8.49 e	10.24 f
T_2F_1	291.22 bc	328.62 ab	609.99 ab	739.53 ab	9.81 ab	10.51 bc	11.63 b	13.85 bc
T_2F_2	323.57 ab	339.42 a	630.09 a	750.67 a	10.39 a	11.54 ab	12.95 a	15.21 ab
T_2F_3	**332.33 a**	**343.48 a**	**632.19 a**	**754.68 a**	**10.84 a**	**12.23 a**	**12.91 a**	**15.48 a**
T_3F_0	215.99 de	285.83 def	492.09 de	562.38 c	7.37 cde	8.36 def	9.53 cde	11.41 def
T_3F_1	223.03 de	295.76 cde	576.78 c	698.26 b	7.91 cde	8.40 def	9.71 cde	11.61 def
T_3F_2	232.42 de	297.20 cde	579.99 c	705.11 b	8.06 cde	8.49 def	9.77 cde	11.81 de
T_3F_3	242.31 d	298.70 cde	578.70 c	706.31 b	8.36 bcd	9.11 cde	9.93 cd	12.77 cd
CV(%)	8.98	7.97	10.20	5.37	6.95	9.34	10.95	6.50

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

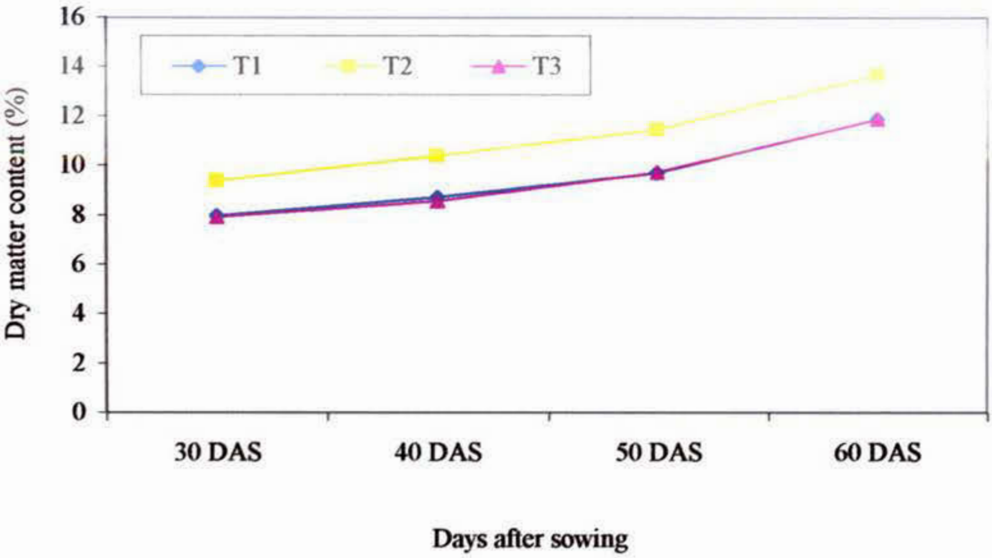
T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

4.6 Dry matter content

Sowing time varied significantly in respect of dry matter content of Indian spinach at 30, 40, 50 and 60 DAS (Figure 8). At 30 DAS the maximum dry matter content (9.42%) was recorded from T_2 (sowing on 06 March), while the minimum dry matter content (7.93%) was recorded from T_3 (sowing on 21 March) which was statistically identical (7.98%) with T_1 (sowing on 19 February). The maximum dry matter content (10.43%) was recorded from T_2 and the minimum (8.59%) was recorded from T_3 which was statistically similar (8.73%) with T_1 at 40 DAS. At 50 DAS the maximum dry matter content (11.50%) was recorded from T_2 and the minimum (9.72%) was found from T_1 which was statistically identical (9.74%) with T_3. At 60 DAS the maximum dry matter content (13.69%) was recorded from T_2, while the minimum dry matter content (11.90%) was recorded from T_1 which was statistically identical (11.91%) with T_3. Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results from their experiment.

Fertilizers showed significant variation incase of dry matter content at 30, 40, 50 and 60 DAS (Figure 9). The maximum dry matter content (9.31%) was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (8.91%) with F_2 (Poultry litter: 15 t/ha) and the minimum (7.02%) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum dry matter content (10.29%) was recorded from F_3 which was statistically identical (9.75%) with F_2 and the minimum (7.76%) was recorded from F_0. The maximum dry matter content (11.10%) was recorded from F_3 which was statistically similar (10.94%) with F_2 and the minimum (8.93%) was recorded from F_0 at 50 DAS. At 60 DAS the maximum dry matter content (13.63%) was recorded from F_3 which was statistically identical (13.08%) with F_2 and the minimum (10.86%) was recorded from F_0. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant and the results were the highest dry matter content in the plant.

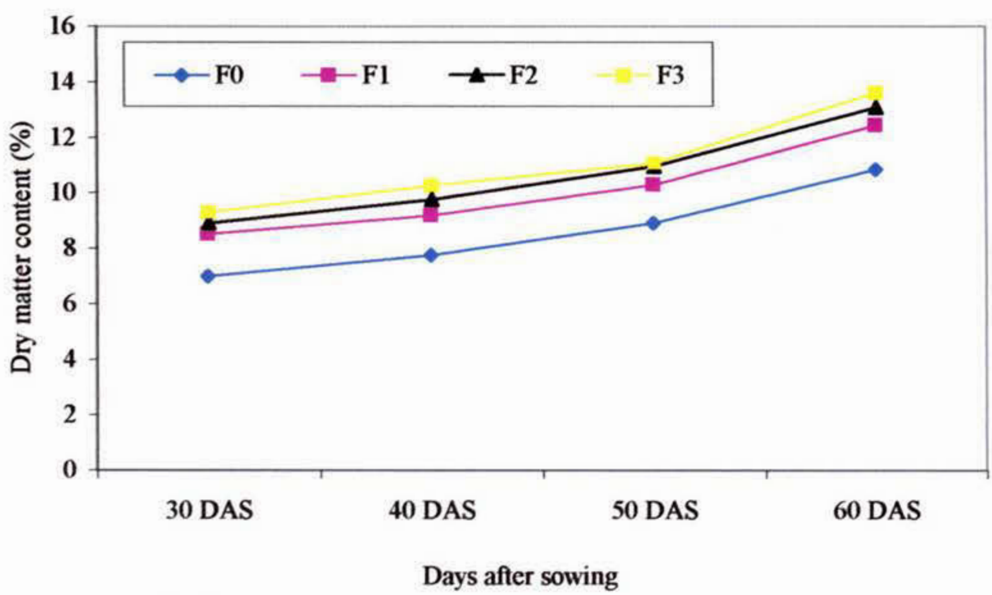


T_1: Sowing on 19 February

T_2: Sowing on 06 March

T_3: Sowing on 19 February

Figure 8. Effect of sowing time on dry matter content of Indian spinach



F_0: Control

F_1: Cowdung (25 t/ha)

F_2: Poultry litter (15 t/ha)

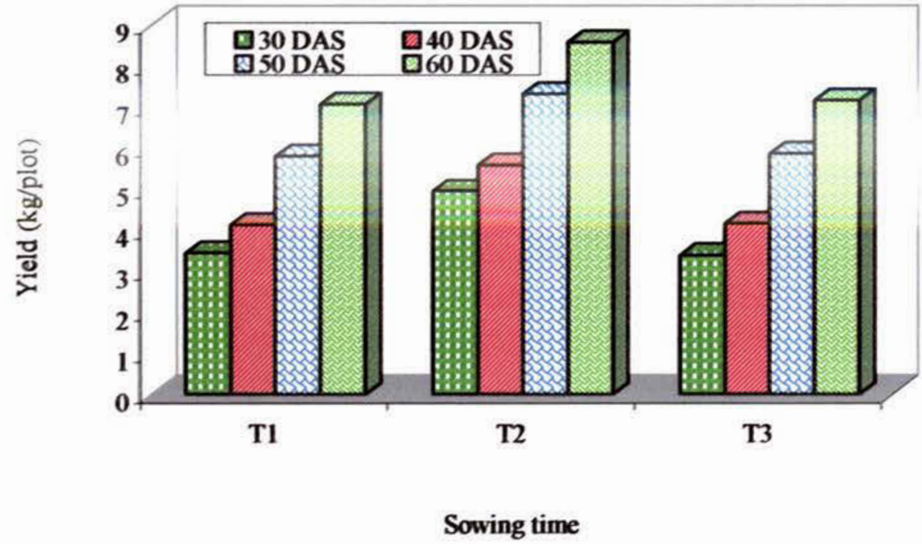
F_3: Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 9. Effect of fertilizers on dry matter content of Indian spinach

Interaction between sowing time and fertilizers on dry matter content at different days after sowing showed significant differences (Appendix V). At 30 DAS the maximum dry matter content (10.84%) was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing on 19 February and control condition) gave the minimum dry matter content (7.01%). At 40 DAS the maximum dry matter content (12.23%) was recorded from T_2F_3 whereas the minimum (7.51%) was recorded from T_1F_0. At 50 DAS the maximum dry matter content (12.91%) was recorded from T_2F_3 and the minimum (8.75%) was recorded from T_1F_0. The maximum dry matter content (15.48%) was recorded from T_2F_3 and the minimum (10.92%) from T_1F_0 at 60 DAS (Table 5). From the results it was revealed that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results is the maximum dry matter content with chemical fertilizer and organic fertilizer than the control.

4.7 Yield per plot

Sowing time varied significantly for yield per plot of Indian spinach at 30, 40, 50 and 60 DAS (Figure 10). At 30 DAS the maximum yield (4.96 kg) per plot was recorded from T_2 (sowing on 06 March), while the minimum yield (3.40 kg) per plot was recorded from T_3 (sowing on 21 March) which was statistically identical (3.45 kg) with T_1 (sowing on 19 February). The maximum yield (5.59 kg) per plot was recorded from T_2 and the minimum (4.15 kg) was recorded from T_1 which was statistically similar (4.18 kg) with T_3 at 40 DAS. At 50 DAS the maximum yield (7.32 kg) per plot was recorded from T_2 and the minimum (5.81 kg) was found from T_3 which was statistically identical (5.87 kg) with T_1. At 60 DAS the maximum yield (8.58 kg) per plot was recorded from T_2, while the mini. yield (7.07 kg) per plot was recorded from T_1 which was closely (7.17 kg) followed by T_3. These findings were similar with Islam (1992), Khan (1993) and Larion *et al.* (1984) and Malek *et al.* (1966), Khandaker (2003), Rahman *et al.* (1989) and Rashid (1975).

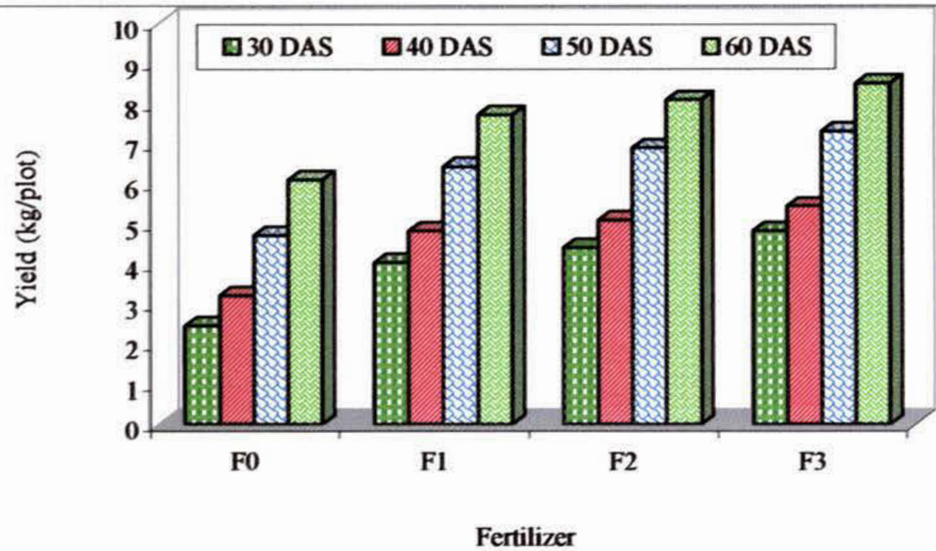


T_1: Sowing on 19 February

T_2: Sowing on 06 March

T_3: Sowing on 19 February

Figure 10. Effect of sowing time on yield per plot of Indian spinach



F_0: Control

F_1: Cowdung (25 t/ha)

F_2: Poultry litter (15 t/ha)

F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 11. Effect of fertilizers on yield per plot of Indian spinach

Fertilizers showed significant variation due to yield per plot at 30, 40, 50 and 60 DAS (Figure 11). The maximum yield (4.83 kg) per plot was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (4.42 kg) with F_2 (Poultry litter: 15 t/ha) and the minimum (2.45 kg) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum yield (5.44 kg) per plot was recorded from F_3 which was statistically identical (5.09 kg) with F_2 and the minimum (3.22 kg) was recorded from F_0. The maximum yield (7.31 kg) per plot was recorded from F_3 and the minimum (4.71 kg) was recorded from F_0 at 50 DAS. At 60 DAS the maximum yield (8.51 kg) per plot was recorded from F_3 and the minimum (6.10 kg) was recorded from F_0. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant and the results were the highest yield per plot. Rahim and Siddique (1982), Mannan and Rashid (1983), Prince *et al.* (1990); Sajjan *et al.* (1991), Welch *et al.* (1983), Nadasy (1999) and Islam (1982), Rashid *et al.* (1984) reported similar results earlier.

Interaction between sowing time and fertilizers for yield per plot at different days after sowing showed significant differences (Appendix VI). At 30 DAS the maxi. Yield (6.46 kg) per plot was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing 19 February and control condition) gave the minimum yield (2.39 kg) per plot. At 40 DAS the maximum yield (7.04 kg) per plot was recorded from T_2F_3 whereas the minimum (3.13 kg) was recorded from T_1F_0. At 50 DAS the maximum yield (8.86 kg) per plot was recorded from T_2F_3 and the minimum (4.62 kg) was recorded from T_1F_0. The maximum yield (10.01 kg) per plot was recorded from T_2F_3 and the minimum (5.87 kg) from T_1F_0 at 60 DAS (Table 6). From the results it was revealed that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results were the maximum yield per plot with chemical fertilizer and organic fertilizer than the control.

Table 6. Interaction effect of sowing time and fertilizers on yield per plot and hectare of Indian Spinach

Treatment	Yield (kg/plot) at				Yield (t/ha) at			
	30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1F_0	2.39 e	3.13 d	4.62 fg	5.87 e	5.53 e	7.23 d	10.70 fg	13.60 e
T_1F_1	3.41 cd	4.14 bc	5.75 de	7.11 cd	7.89 cd	9.59 bc	13.31 de	16.45 cd
T_1F_2	3.83 c	4.54 bc	6.15 cde	7.41 cd	8.87 c	10.52 bc	14.24 cde	17.15 cd
T_1F_3	4.15 c	4.79 b	6.73 c	7.90 bc	9.61 c	11.08 b	15.58 c	18.29 bc
T_2F_0	2.13 e	2.88 d	4.21 g	5.83 e	4.93 e	6.66 d	9.75 g	13.50 e
T_2F_1	5.32 b	6.15 a	7.73 b	8.94 ab	12.32 b	14.23 a	17.90 b	20.71 ab
T_2F_2	5.91 ab	6.30 a	8.48 ab	9.54 a	13.68 ab	14.59 a	19.64 ab	22.08 a
T_2F_3	**6.46 a**	**7.04 a**	**8.86 a**	**10.01 a**	**14.95 a**	**16.30 a**	**20.50 a**	**23.17 a**
T_3F_0	2.82 de	3.65 cd	5.29 ef	6.59 de	6.53 de	8.45 cd	12.25 ef	15.26 de
T_3F_1	3.39 cd	4.18 bc	5.80 cde	7.11 cd	7.84 cd	9.67 bc	13.42 cde	16.46 cd
T_3F_2	3.51 cd	4.43 bc	6.02 cde	7.33 cd	8.12 cd	10.25 bc	13.93 cde	16.97 cd
T_3F_3	3.89 c	4.48 bc	6.35 cd	7.63 cd	9.00 c	10.38 bc	14.69 cd	17.66 cd
CV(%)	13.09	11.39	8.03	8.49	13.09	11.39	8.03	8.49

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

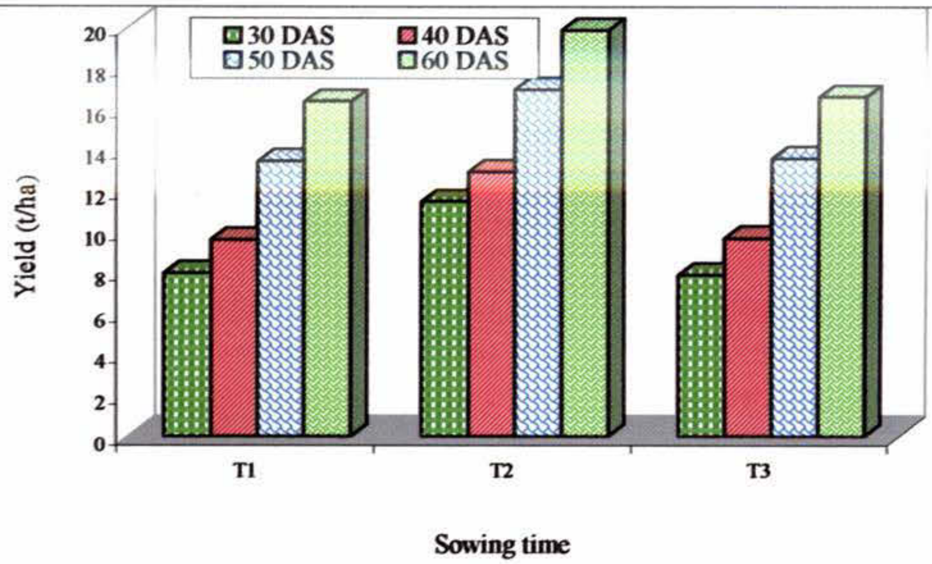
T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

4.8 Yield per hectare

Sowing time varied significantly in respect of yield per hectare of Indian spinach at 30, 40, 50 and 60 DAS (Figure 12). At 30 DAS the maximum yield (11.47 t/ha) was recorded from T_2 (sowing on 06 March), while the minimum yield (7.87 t/ha) was recorded from T_3 (sowing on 21 March) which was statistically identical (7.98 t/ha) with T_1 (sowing on 19 February). The maximum yield (12.94 t/ha) was recorded from T_2 and the mini. (9.69 t/ha) was recorded from T_1 which was statistically similar (9.60 t/ha) with T_3 at 40 DAS. At 50 DAS the maximum yield (16.95 t/ha) was recorded from T_2 and the minimum (13.46 t/ha) was found from T_1 which was statistically identical (13.58 t/ha) with T_1. At 60 DAS the maximum yield (19.86 t/ha) was recorded from T_2, while the minimum yield (16.37 t/ha) was recorded from T_1. Bosch *et al* (1991), Rashid (1983), Ryder (1979) Winter (1968) also reported that 1^{st} week of March sowing time was optimum for highest yield.

Fertilizers showed significant variation on yield per hectare at 30, 40, 50 and 60 DAS (Figure 13). The maximum yield (11.19 t/ha) was recorded from F_3 (Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha) which was statistically identical (10.23 t/ha) to F_2 (Poultry litter: 15 t/ha) and the minimum (5.67 t/ha) was recorded from F_0 (control condition) at 30 DAS. At 40 DAS the maximum yield (12.59 t/ha) was recorded from F_3 which was statistically identical (11.79 t/ha) to F_2 and the minimum (7.45 t/ha) was recorded from F_0. The maximum yield (16.92 t/ha) was recorded from F_3 which was statistically similar (15.94 t/ha) with F_2 and the minimum (10.90 t/ha) was recorded from F_0 at 50 DAS. At 60 DAS the maximum yield (19.71 t/ha) was recorded from F_3 which was statistically identical (18.73 t/ha) with F_2 and the minimum (14.12 t/ha) was recorded from F_0. Chemical fertilizer ensured maximum plant nutrients which helped proper growth of plant and the results were the highest yield per hectare. Busuioc *et al*. (2000) reported that chemical fertilzer gave highest yield in case of leafy vegetable.

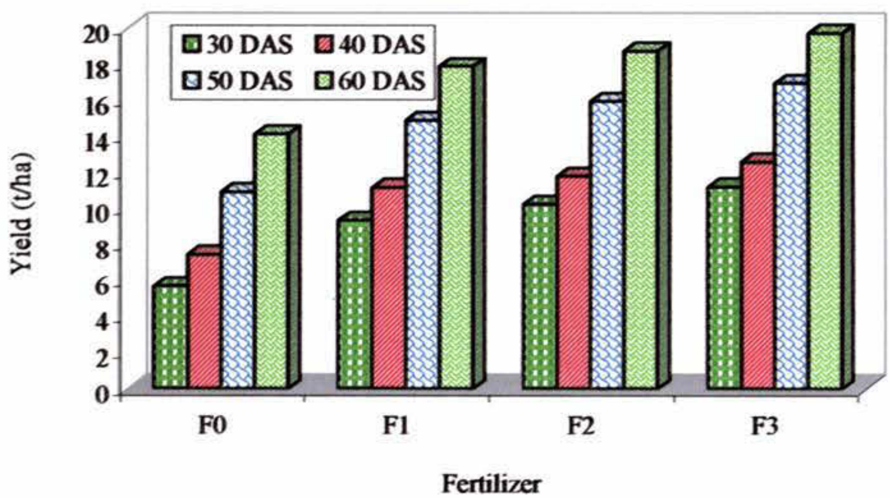


T_1: Sowing on 19 February

T_2: Sowing on 06 March

T_3: Sowing on 19 February

Figure 12. Effect of sowing time on yield per hectare of Indian spinach



F_0: Control

F_1: Cowdung (25 t/ha)

F_2: Poultry litter (15 t/ha)

F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Figure 13. Effect of fertilizers on yield per hectare of Indian spinach

Interaction between sowing time and fertilizers for yield per hectare at different days after sowing showed significant differences (Appendix VI). At 30 DAS the maximum yield (14.95 t/ha) was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing on 19 February and control condition) gave the minimum yield (5.53 t/ha). At 40 DAS the maximum yield (16.30 t/ha) was recorded from T_2F_3 whereas the minimum (7.23 t/ha) was recorded from T_1F_0. At 50 DAS the maximum yield (20.50 t/ha) was recorded from T_2F_3 and the minimum (10.70 t/ha) was recorded from T_1F_0. The maximum yield (23.17 t/ha) was recorded from T_2F_3 and the minimum (13.60 t/ha) from T_1F_0 at 60 DAS (Table 6). From the results it was revealed that sowing time and both organic and inorganic manure favored growth of Indian spinach and the ultimate results were the maximum yield per hectare.

4.9 Economic analysis

Input costs for land preparation, seed cost, fertilizer, thinning, irrigation and man power required for all the operations from sowing to harvesting of Indian Spinach were recorded for unit plot and converted into cost per hectare. Prices of Indian Spinach were considered as per market rate. The economic analysis was done to find out the gross and net return and benefit cost ratio in the present experiment and presented under the following headings-

4.9.1 Gross return

The combination of sowing time and fertilizers showed significant variation on gross return under the trial. The maximum gross return (Tk. 449,559/ha) was obtained from the treatment combination T_2F_2 and the second maximum gross return (Tk. 419,977/ha) was obtained from T_2F_2. The minimum gross return (Tk. 222,360/ha) was obtained from T_1F_0.

Table 7. Cost and return of Indian Spinach as influenced by sowing time and fertilizers

Treatment Combination	Cost of production (Tk./ha)	Yield at harvest				Price (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
		30 DAS	40 DAS	50 DAS	60 DAS				
T_1F_0	80021	5.53	7.23	10.70	13.60	222360	222381	142360	2.78
T_1F_1	103374	7.89	9.59	13.31	16.45	283440	283466	180092	2.74
T_1F_2	108965	8.87	10.52	14.24	17.15	304680	304708	195742	2.80
T_1F_3	83134	9.61	11.08	15.58	18.29	327360	327389	244255	3.94
T_2F_0	75418	4.93	6.66	9.75	13.50	209040	209060	133642	2.77
T_2F_1	103374	12.32	14.23	17.90	20.71	390960	390995	287621	2.78
T_2F_2	108965	13.68	14.59	19.64	22.08	419940	419977	311011	3.85
T_2F_3	83134	14.95	16.30	20.50	23.17	449520	449559	366426	5.41
T_3F_0	75418	6.53	8.45	12.25	15.26	254940	254964	179546	3.38
T_3F_1	103374	7.84	9.67	13.42	16.46	284340	284366	180992	2.75
T_3F_2	108965	8.12	10.25	13.93	16.97	295620	295647	186682	2.81
T_3F_3	83134	9.00	10.38	14.69	17.66	310380	310408	227274	3.73

T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

4.9.2 Net return

In case of net return different treatment combination showed different amounts of net return. The maximum net return (Tk. 366,426/ha) was obtained from the treatment combination of T_2F_3 and the second maximum net return (Tk. 311,011/ha) was obtained from the combination of T_2F_2. The minimum net return (Tk. 142.360/ha) was obtained in T_1F_0.

4.9.3 Benefit cost ratio

The combination of different sowing time and fertilizers the maximum (5.41) benefit cost ratio was attained from the combination T_2F_3 and the second maximum (3.94) benefit cost ratio was estimated from the combination T_1F_3. The minimum (2.78) benefit cost ratio was obtained from T_1F_0 (Table 7). From economic point of view, it was apparent from the above results that the combination T_2F_3 was more profitable than rest of the combinations.

Chapter 5
Summary & conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to May 2007 to study the effect of different levels of sowing time and fertilizers on growth and yield of Indian spinach. The experiment considered two factors. Factor A: Sowing time (3 levels) i.e. Sowing on 19 February 2007 (T_1); Sowing on 06 March 2007 (T_2) and Sowing on 21 March 2007 (T_3) and Factor B: Fertilizers (4 levels) i.e. Control (F_0); Cowdung (F_1)- (25 t/ha); Poultry litter (F_2) – (15 t/ha) and Inorganic fertilizers (F_3)–Urea (400 kg/ha), TSP (120 kg/ha), and MP (180 kg/ha). There were on the whole 12 treatment combinations. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of the Indian spinach. Data were collected in respect of the plant growth characters and yield at different days after sowing. The data recorded from different characters were statistically analyzed to find out the significance of difference for different sowing time and fertilizers on yield and yield contributing characters of Indian spinach.

At 60 DAS the longest plant height (87.32 cm) was recorded from T_2 (sowing on 06 March, 2007), while the shortest plant height (83.66 cm) was recorded from T_1 (Sowing on 19 February 2007). The maximum number of leaves (73.45) per plant was recorded from T_2, while the minimum number of leaves (70.95) per plant was recorded from T_1. The maximum leaf area (295.39 cm^2) was recorded from T_2, and the minimum leaf area (282.93 cm^2) was recorded from T_1. The maximum number of branches (16.97) per plant was recorded from T_2, while the minimum number of branches (15.31) per plant was recorded from T_1. The maximum fresh weight (684.22 g) per plant was recorded from T_2, while the minimum fresh weight (654.28 g) per plant was recorded from T_1.

The maximum dry matter content (13.69%) was recorded from T_2, while the minimum dry matter content (11.90%) was recorded from T_1. The maximum yield (8.58 kg) per plot was recorded from T_2, while the minimum yield (7.07 kg) per plot was recorded from T_1. The maximum yield (19.86 t/ha) was recorded from T_2, while the minimum yield (16.37 t/ha) was recorded from T_1.

At 60 DAS the longest plant height (92.11 cm) was recorded from F_3 as Urea (400kg/ha), TSP (120 kg/ha), and MP (180 kg/ha) and the shortest plant height (67.56 cm) was recorded from F_0 (Control). The maximum number of leaves (78.89) per plant was recorded from F_3 and the minimum (52.19) was recorded from F_0. The maximum leaf area (311.85 cm^2) was recorded from F_3, while the minimum (226.42 cm^2) was recorded from F_0. The maximum number of branches (18.89) per plant was recorded from F_3 where as the minimum (9.00) was recorded from F_0. The maximum fresh weight (722.70 g) per plant was recorded from F_3 and the minimum (521.57 g) was recorded from F_0. The maximum dry matter content (13.63%) was recorded from F_3 and the minimum (10.86%) was recorded from F_0. The maximum yield (8.51 kg) per plot was recorded from F_3 and the minimum (6.10 kg) was recorded from F_0. The maximum yield (19.71 t/ha) was recorded from F_3 and the minimum (14.12 t/ha) was recorded from F_0.

Interaction between sowing time and fertilizers for all the recorded characters showed significant differences for different days after sowing. The maximum value was recorded from T_2F_3 (sowing on 06 March and Urea: 400 kg/ha + TSP: 120 kg/ha and MP: 180 kg/ha), while T_1F_0 (sowing on 19 February and control condition) gave the minimum value. The maximum gross return (Tk. 449,559/ha) was obtained from the treatment combination of T_2F_2 and the minimum gross return (Tk. 222,360/ha) was found from T_1F_0.

The maximum net return (Tk. 366,426/ha) was obtained from the treatment combination of T_2F_3 and the minimum net return (Tk. 142.360/ha) was obtained in T_1F_0. The maximum benefit cost ratio (5.41) was attained from the combination of T_2F_3 and the minimum benefit cost ratio (2.78) was obtained in T_1F_0.

CONCLUSION :

It is concluded that sowing on 06 March, 2007 (T_2) showed the highest value (results) where as the minimum value was recorded from Sowing on 19 February 2007 (T_1). Inorganic fertilizers (F_3) showed highest value (results), organic fertilizers also showed similar results where as the minimum value was recorded from control plot (F_0). T_2F_3 showed highest value (results), T_2F_2 also showed similar results where as the minimum value was recorded from T1F0. So it may be concluded that combination of T_2F_3 and T_2F_2 was profitable than rest of the combinations.

Considering the finding of the experiment, further studies may be suggested in the following areas;

1. Similar study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances;
2. Another sowing time may be included in the future program;
3. Other fertilizers with different levels for both organic and inorganic may be included in the future program.

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Appendices

APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from January to June/07

Year	Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	Soil temperature			*Sunshine (hr)
		Maximum	Minimum			5 cm depth	10 cm depth	20 cm depth	
2007	January	24.5	12.4	68	00	17.8	19.2	20.0	5.7
	February	27.1	16.7	67	30	21.1	22.5	22.9	6.7
	March	31.4	19.6	54	11	24.8	26.9	26.9	8.2
	April	33.6	23.6	69	163	28.9	30.1	30.1	6.4
	May	34.7	25.9	70	185	30.5	31.4	31.5	7.8
	June	32.4	25.5	81	628	30.0	30.8	30.7	5.7

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate and weather division) Agargoan, Dhaka - 1212

Appendix II. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm , SAU, Dhaka
AEZ – 28	Madhupur Tract
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Winter Vegetable – Summer Vegetable

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

* **Source**: SRDI

Appendix III. Analysis of variance of the data on plant height and number of leaves per plant of Indian Spinach as influenced by sowing time and fertilizers

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm) at				Number of leaves per plant at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	1.889	0.514	0.624	5.100	0.675	0.410	0.455	4.294
Sowing time (A)	2	50.417**	65.497**	45.773**	40.593*	21.001**	6.021**	10.091**	23.938**
Fertilizers (B)	3	39.855**	60.329**	367.883**	1278.941**	15.727**	49.489**	206.711**	1544.445**
Interaction (A×B)	6	11.144**	9.729*	18.082**	38.477**	4.170*	7.162**	6.851**	12.086**
Error	22	2.676	3.721	2.957	10.535	1.240	1.145	1.758	3.472

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on leaf area and number of branches per plant of Indian Spinach as influenced by sowing time and fertilizers

Source of variation	Degrees of freedom	Mean square							
		Leaf area (cm^2) at				Number of branches per plant at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	9.949	4.048	13.335	57.466	0.194	0.434	0.097	0.309
Sowing time (A)	2	435.642**	725.934**	525.156**	469.508*	0.528	20.005**	6.014**	8.329*
Fertilizers (B)	3	357.652**	625.036**	4495.462**	15636.59**	0.185	13.988**	45.766**	204.481**
Interaction (A×B)	6	81.363**	97.313*	210.685**	476.207**	0.046	4.118**	6.916**	5.734*
Error	22	18.246	33.695	32.249	106.759	0.225	1.162	1.036	1.887

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on fresh weight per plant and dry matter content of Indian Spinach as influenced by sowing time and fertilizers

Source of variation	Degrees of freedom	Mean square							
		Fresh weight (g) per plant at				Dry matter content (%)			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	165.025	40.958	101.349	376.997	0.384	0.254	0.212	1.457
Sowing time (A)	2	12618.17**	3153.534**	3022.431**	2694.403**	8.637**	12.541**	12.503**	12.817**
Fertilizers (B)	3	10553.74**	3102.345**	24133.45**	86959.14**	9.080**	10.664**	8.821**	12.937**
Interaction (A×B)	6	2254.824**	409.829*	1064.625**	2517.929**	1.889*	2.818**	3.036**	3.595**
Error	22	495.066	146.073	158.074	508.364	0.706	0.746	0.514	0.659

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield per plot and hectare of Indian Spinach as influenced by sowing time and fertilizers

Source of variation	Degrees of freedom	Mean square							
		Yield (kg/plot) at				Yield (t/ha) at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.219	0.097	0.098	0.023	1.175	0.520	0.523	0.122
Sowing time (A)	2	9.391**	8.127**	8.788**	8.568**	50.318**	43.549**	47.088**	45.913**
Fertilizers (B)	3	9.785**	8.699**	11.727**	10.035**	52.429**	46.614**	62.836**	53.771**
Interaction (A×B)	6	1.924**	1.821**	2.394**	1.716**	10.308**	9.757**	12.830**	9.197**
Error	22	0.265	0.280	0.259	0.417	1.422	1.499	1.386	2.232

**: Significant at 0.01 level of probability

Appendix VII. Cost of production of Indian Spinach

A. Material Cost

Treatment Combination	Labour cost	Ploughing cost	Seed cost (Tk)	Irrigation Cost	Thinning Cost	Pesticides	Fertilizers				Miscellaneous cost	Sub Total (A)
							Organic	Urea	TSP	MP		
T_1F_0	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	0.00	0.00	0.00	10000.00	30300.00
T_1F_1	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	25000.00	0.00	0.00	0.00	10000.00	55300.00
T_1F_2	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	30000.00	0.00	0.00	0.00	10000.00	60300.00
T_1F_3	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	2400.00	1800.00	2700.00	10000.00	37200.00
T_2F_0	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	0.00	0.00	0.00	10000.00	30300.00
T_2F_1	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	25000.00	0.00	0.00	0.00	10000.00	55300.00
T_2F_2	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	30000.00	0.00	0.00	0.00	10000.00	60300.00
T_2F_3	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	2400.00	1800.00	2700.00	10000.00	37200.00
T_3F_0	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	0.00	0.00	0.00	10000.00	30300.00
T_3F_1	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	25000.00	0.00	0.00	0.00	10000.00	55300.00
T_3F_2	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	30000.00	0.00	0.00	0.00	10000.00	60300.00
T_3F_3	10000.00	4000.00	800.00	3500.00	1000.00	1000.00	0.00	2400.00	1800.00	2700.00	10000.00	37200.00

T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)

Appendix VII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 6,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 12 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_1F_0	39000	1515	9206	49721	80021
T_1F_1	39000	2765	6309	48074	103374
T_1F_2	39000	3015	6650	48665	108965
T_1F_3	39000	1860	5074	45934	83134
T_2F_0	39000	1515	4603	45118	75418
T_2F_1	39000	2765	6309	48074	103374
T_2F_2	39000	3015	6650	48665	108965
T_2F_3	39000	1860	5074	45934	83134
T_3F_0	39000	1515	4603	45118	75418
T_3F_1	39000	2765	6309	48074	103374
T_3F_2	39000	3015	6650	48665	108965
T_3F_3	39000	1860	5074	45934	83134

T_1: Sowing on 19 February
T_2: Sowing on 06 March
T_3: Sowing on 19 February

F_0: Control
F_1: Cowdung (25 t/ha)
F_2: Poultry litter (15 t/ha)
F_3:Urea (400kg/ha), TSP (120kg/ha), and MP (180 kg/ha)