EFFECT OF PLANTING TIME AND SPACING ON THE GROWTH AND YIELD OF INDIAN SPINACH

BY

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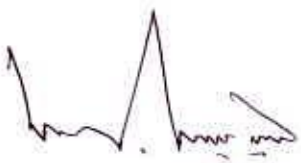

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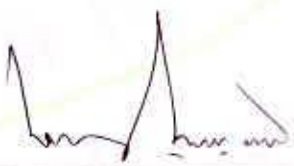
This is to certify that the thesis entitled "Effect of Planting Time and Spacing on the Growth and Yield of Indian Spinach" submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bona fide research work carried out by ***Md. Rifat Sikder****, Registration No.* ***07-02635*** *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.



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DEDICATED
TO
MY BELOVED PARENTS
&
YOUNGER SISTER

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BY

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ABSTRACT

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July 2008. The experiment consisted with two factors. Factor A : Three Planting times; P_1 :10 March; P_2 : 25 March and P_3 : 9 April and Factor B: Four levels spacing; S_1: 60 cm × 30 cm; S_2: 60 cm × 40 cm; S_3: 60 cm × 50 cm and S_4: 60 cm × 60 cm. The experiment was laid out with Randomized Complete Block Design with three replications. In case of planting time the highest yield (27.90 t/ha) was observed from P_2 and the lowest (24.62 t/ha) was found in P_1. In case of spacing the highest yield (29.40 t/ha) was found in S_3 and the lowest (21.64 t/ha) was recorded from S_1. For combined effect the highest yield (31.85 t/ha) was observed from P_2S_3 and the lowest (20.47 t/ha) was recorded from P_1S_1. So, it may be concluded that 25 March planting time with 60 cm × 50 cm spacing are suitable for growth and yield of Indian Spinach.

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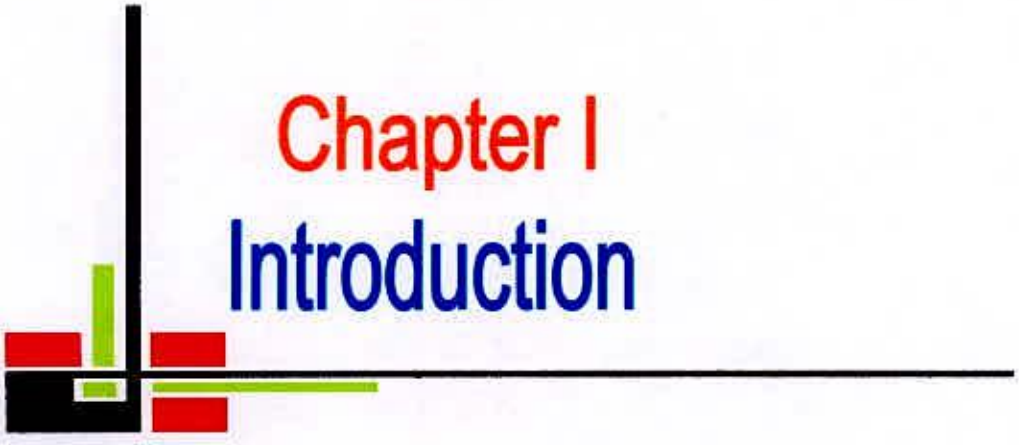
LIST OF ABBREVIATED TERMS

ABBREVIATION		FULL NAME
AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
BBS	=	Bangladesh Bureau of Statistics
CV	=	Coefficient of Variance
cv.	=	Cultivar
DAS	=	Days after sowing
DMRT	=	Duncan's Multiple Range Test
FAO	=	Food and Agricultural Organization
Hort.	=	Horticulture
LAI	=	Leaf Area Index
MOP	=	Muriate of Potash
N	=	Nitrogen
PHT	=	Postharvest Technology
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
TSP	=	Triple Super Phosphate
UNDP	=	United Nations Development Program



Chapter I
Introduction

CHAPTER I

INTRODUCTION

Indian spinach (*Basella alba* L.) commonly known as 'pui' and belongs to the family Basellaceae. It is a popular summer leafy vegetable which is widely cultivated in Bangladesh, India, 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 veins, petioles and stems. Both the green and red leaved cultivers are consumed as vegetables but green-leaved cultivers are commercially cultivated. All the cultivars are trained on poles, pandals or trellis or grown on ground (Bose and Som, 1990). 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 sweetter 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 for the human diet plus substantial amount of fibre and that of water (Ghosh and Guha, 1933), the plant is reported to contain the following salts and vitamins. Water-93%, Protein (1.2%), Iron (1.4%), Calcium (0.15)%, Vitamin A (3250 IU/100 g). In addition, *Basella alba* contains 16 g fluoride/100 g and nitrate content is 764 ppm on dry weight basis (Sanni, 1983). There was no loss of nitrate even after 48 hrs 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 as 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 well 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.

A number of agronomic practices have been found to affect the yield to 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.

Plant spacing is another important aspect of crop production for maximizing the yield. Optimum plant spacing ensures judicious use of natural resources and makes the intercultural operations easier. It helps to increase the number of leaves, branches and healthy foliage. Densely planted crop obstruct the proper growth and development. On the other hand, wider spacing ensures the basic requirements but decrease the total number of plants as well as total yield. Yield may be increased upto 25% by using optimum spacing (Bansal, *et al.*, 1995). In Bangladesh like other management practices information about spacing to be used in Indian Spinach cultivation is scanty. The farmers of Bangladesh cultivate this crop according to their own choice due to the absence or unavailability of standard production technique. As a result, they do not get satisfactory yield and return from investment.

Like many other vegetables such as root and tuber crops as well as spices, the growth and yield of Indian spinach is also influenced by growing time and spacing. A number of factors like temperature, soil moisture are involved with

planting time and spacing which ultimately influence the growth and yield of the crop. But still to day there is few research works focusing on the effects of planting time and spacing on the growth and yield of Indian spinach production in Bangladesh.

Considering the above circumstances, the present study was undertaken with the following objectives:

- To find out the optimum planting time for Indian Spinach production
- To find out the optimum spacing on the growth and yield of Indian Spinach
- To find out the interaction effect for different planting time with spacing

Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Indian spinach (*Basella alba* L.) is one of the important leafy vegetable in Bangladesh as well as in many other countries of the world. The crop has received much attention to the researcher of different countries including 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 planting time and spacing. There is a little or no combined research work to the effect of planting time and spacing on growth and yield of Indian spinach in Bangladesh. The literature related to the present study with other leafy vegetable are reviewed in this chapter.

2.1 Effect of planting time

Mengistu *et al.* (2003) conducted a research in the Lai Gaint area of South Gonder, Amhara Region, Ethiopia, to test the possibility of producing seeds head cabbage and to determine the appropriate sowing or planting time. Direct sown the head cabbage cv. Drum Head was transplanted at monthly intervals during 2000-01. Results revealed that seeds of this vegetable could be successfully produced in Lai Gaint. Cabbage seeds were not harvested because of bird damage; however, the ideal planting date for head cabbage was also in October, when temperatures were lowest.

Rajesh *et al.* (2003) conducted an experiment to find out the effects of sowing date (1, 11, 21 or 31 December; 10, 20 or 30 January; and 10 February) on seed production of kharif onion. Plant height was evaluated from 29 January to 23 April, whereas foliage weight, and bulb diameter and bulb weight were evaluated from 18 March to 23 April. Under all sowing dates, plant height increased up to 30 March then decreased thereafter. Sowing on 1 and 11 December resulted in the greatest plant height, foliage weight, bulb weight and diameter, number of large (>5-10 g) sets and total bulb yield; these parameters decreased with the delay in sowing. The highest yield of large sets (1496.0

g/m^2) was obtained with sowing on 1 December. The proportion of large sets was highest (approximately 50%) with sowing on December.

Sharma (2002) conducted an field experiment in Nauni, Solan, Himachal Pradesh, India, during the winter seasons of 1995/96, 1996/97, 1997/98, and 1998/99 to study the effect of sowing date (15 October, 30 October, 15 November, and 30 November) and row spacing (20, 30, and 40 cm) on pea (cv. Arkel) seed yield. Sowing on 30 October gave the tallest plants (88.2 cm) and the greatest pod number per plant (14.0), pod length (7.4 cm), seed number per pod (6.8), seed yield (9.1 q/ha), and 100-seed weight (20.1 g). The tallest plants (82.5 cm) and longest pods (7.4 cm), as well as the highest seed number per pod (5.5) and seed yield (8.7 q/ha), were obtained with a spacing of 20 cm. The highest pod number per plant (14.1) and 100-seed weight (20.3 g) were recorded for 40 cm spacing. Based on interaction effects, sowing on 30 October and a row spacing of 20 cm gave the highest seed yield (10.6 q/ha), net return (Rs. 17400/ha).

Busuioc, *et al* (2000) were studied chlorophyll and carotene contents of *B. alba* and *B. rubra*, plants grown in greenhouse conditions at Iasi, Romania, from April to July, and at Targovise from June to September.They reported that chlorophyll a content was the highest during the summer. Chlorophyll b content was the highest during the last phenological phase. Carotene content was the highest during the spring.

Incalcaterra *et al.* (2000) conducted an experiment with cultivar "Cavolfiore Verde di Palermo" is a green curded cauliflower widely grown in Western Sicily, Italy. Depending on the harvesting time, various types of "Cavolfiore Verde di Palermo" are cultivated all year round. Seeds of Agostino, a summer-maturing type of Cavolfiore Verde di Palermo, were sown monthly from January to December 1995 and seedlings were transplanted at the 4- to 5-leaf stage of development. Sowing date significantly affected cauliflower seed production. The highest seed yields were obtained from plants raised from seeds sown either in April (1000 kg/ha) or in May (1120 kg/ha). The lowest

seed yields were recorded with the July (70 kg/ha) and August (20 kg/ha) sowings. Sowing date also affected total number of leaves at harvest, number of seeds/siliqua, number of siliquas/plant, siliqua length and thousand seed weight.

Caruso *et al.* (2000) conducted a field experiment in 1994 and 1995 in Sele Plain, Italy to investigate the effect of planting time and chemical weed control on weed flora evaluation and on yield and growth in cabbage cv. "Precoce di Copenhagen", a field experiment was carried out in 1994 and 1995 in Sele Plain, Italy, on a clay loam soil. Three planting times (15 March, 21 April and 29 May, in 1994; 6 April, 9 May and 5 June, in 1995). In comparison with the highest yield, which was obtained with the 1st planting time (62 t/ha as an average for the 2 years,, reductions of 20.4 and 45.1% were recorded for the second and the third planting times, respectively.

Kazim *et al.* (2000) conducted an experiment on the effects of sowing/planting dates on seed yield and quality of lettuce in Southeastern Anatolian project area. Lettuce cv. Lital seeds were sown in autumn (8 and 22 September, and 8 and 23 October) during the 1993/94 and 1994/95 growing seasons, and spring (13 and 18 March) during the 1993/94 season. Seedlings with 5-6 true leaves were transplanted in the field (Harran Plams, Turkey) on 29 October, 11 Novenber, 21 December and 8 January, respectively, for autumn-sown plants; and on 19 and 29 April, respectively, for spring-sown plants. For autumn-sown plants 50% bolting occurred from the middle of April to 10 May; seed maturation time was between 16 and 30 June; and seeds were harvested on 20-30 June and from 16 June to 1 July for the first and second seasons, respectively. For plants sown in spring, bolting occurred in the second part of June, plants matured during 18-29 August, and the seeds were harvested at maturity. Seed germination and emergence were evaluated immediately after harvest and 6 months later. Seed yields of spring-sown plants were approximately half the yields of autumn-sown plants. No significant differences in seed quality and percentage germination were observed, but

emergence ratio and emergence period assessed 6 months after harvesting showed some differences between sowing dates. The most suitable lettuce sowing and planting dates for the Southeastern Anatolian project area are from 20 September to 10 October and from 10 November to 20 December, respectively.

Nuruzzaman (1999) found significant effect of planting time on the growth and yield of cabbage. He got the highest gross and marketable yield (102.42 t/ha and 70.18 t/ha) from early planting.

Quader (2007) observed significant effect of planting time on the growth and yield of Indian Spinach. He got at 60 DAS the longest plant height (87.32 cm), maximum number of leaves per plant (73.45), maximum dry matter content (13.69%) and maximum yield (19.86 t/ha) was recorded from sowing on 06 March, 2007, while all above the parameter was lowest sowing on 19 February 2007.

Futane *et al.* (1995) reported that the number of head forming plants and yield of cabbage were influenced by the planting times. They transplanted cabbage seedlings on 27 October, 17 November, 7 December and 27 December and found that the percentage of head forming plants were lower in the December and that the percentage of head forming plants were lower in the 27 December planting than in the other planting dates. The yield was the highest with planting on 7 December, while the lowest was noted with the planting on 27 December (5.24 t/ha and 3.54 t/ha, respectively).

Ghanti and Malik (1995) conducted an experiment at Bidhan Chandra Krishi Viswavidyalaya of West Bengal in 2 consecutive years. They transplanted six early cabbage cultivars during different summer months. Stem were longest in August-transplanted crops and in early market. The most compact heads were recorded for crops transplanted in September.

Shashidhar *et al.* (1994) studied the yield of cabbage affected by the planting dates. They carried out an experiment with 2-year trials at Karnataka, India and recorded the highest leaf damage occurred in the plantings of first week of January and that was the lowest in the plantings of first October. They also found that the highest average yield was 87.14 t/ha when the seedlings were planted in the first week of October.

Sajjan *et al.* (1992) studied the response of lettuce cv. Great lakes to different dates of transplanting (20 july, 20 August and 20 September) and levels of fertilizer (50:25:25, 75:25:25, 100:50:50, 125:50:50, 150:75:75, 175:75:75, kg N, P_2O_5, K_2 O/ha) during 1988-89. The seed yield was highest when the crop was transplanted on 20 August The treatment receiving 175:75:75 kg N, P_2O_5, K_2O/ha gave the highest seed yield and interaction was significant. Number of capsules plant number of seed/capsule and 1000 seed weight contributed to seed yield.

Mancini and Sario (1992) observed that the yield of cabbage was influenced with the planting dates under Italian climatic condition. In 2-year trials they planted seedlings on 2, 10 or 20 October or 2 November on plots. Results of the experiment indicated that head yield declined when planting date was delayed i.e. the yield of 54 t/ha against planting date o 2 October was decreased to 39.3 t/ha with planting on 20 October.

Everaarts *et al.* (1990) found that the head formation and yield of cabbage were affected by the planting date in the Netherlands. They conducted an experiment with two-year trials, planted in mid-May, mid-June and mid-July and harvested at the end of October. They observed that the head formation was usually more rapid with June planting and the yield/ha declined with later planting.

Begum *et al.* (1990) reported that transplanting 30 days old cabbage seedlings at an interval of 15 days from 14 September to 13 December demonstrated a wide variation in vegetative growth and yield of seed. Planting during 14

October to 13 November resulted in increased vegetative growth and large heads than earlier or late plantings.

Gavrilov *et al.* (1987) conducted an experiment at Belgium with cabbage and reported that delay in sowing time beyond the optimum affected the growth, head development, quality and yield. The highest commercial yield and quality observed at the planting time of 20-30 April and the lowest yield was in 01-10 May.

Hans and park (1985) found that heading of cabbage was affected by sowing time. They added that the best result was obtained at the planting time in September compared to the planting time of October under the climatic condition of Cheju Lslan in South Korea.

Csizinszky and Schuster (1985) reported that planting time influenced the yield of cabbage. They found that marketable yield was higher in spring (February-April) than autumn-winter (October-December) under South American climate condition.

Hossain *et al.* (1983) observed that the yield of cabbage was influenced by different planting times and spacings. In a trial seeds were sown on 20 September, 15 October or 5 November and the seedlings were transplanted 30 days later. Sowing on 15 October gave the highest yield (50 kg/plot). The late planting date of sowing showed unsatisfactory results for all the cases.

Hossain and Haque (1980) worked with two heat tolerant varieties of cabbage namely K-Y cross and Fukamidori. The seedlings were transplanted on 18th February and 5th March 1976. K-Y cross was found to be better earliness at both planting dates. The higher yield was recorded on 5th March as compared with 18th February.

2.1 Effect of plant spacing

Moore *et al.* (2004) conducted an experiment to study the effects of spacing on harvesting and yield of stem amaranth with 6, 9, 12 and 18 plants/5 m or row. In these experiments the yield increased upto a certain level and then decreased. With highest spacing per plant yield increased upto a certain level but the total per hectare decreased.

Abbasdokht *et al.* (2003) conducted an experiment to determine the effect of crop densities (10, 20 and 40 plants m^{-1}) of amaranth in Iran. Yield and yield contributing characters were statistically significant in different density. The density with 40 plants m^{-1} gave the minimum yield, whereas 10 plants m^{-1} gave the highest single plant yield but lowest yield was found when yield in hectare was considered.

Santos *et al.* (2003) conducted field trials in South Florida, United States, to determine the extent of yield reduction due to population densities of stem amaranth and recorded that yield reductions reached 24% with densities higher than 8 plants/6 m row planting.

Missinga and Currie (2002) conducted an experiment to assess the impact of plant densities of amaranth on yield and yield contributing characters and reported that spacing didn't affect the individual plant yield but the yield per hectare was greatly influenced due to plant spacing.

Bali *et al.*, (2000) conducted a field experiment to study the effect of planting density and different N and P fertilizer rates on cabbage cultivar KS 101, in Jammu and Kashmir, India, during the rabi seasons of 1995-1996 and 1996-1997,. Plants were sown at 25, 33 and 50 plants per square m, and at 40 × 10, 30 × 10 and 20 × 10, respectively. N was applied at 30, 60 and 90 kg/ha, while P was applied @ 30, 45 and 60 kg/ha. Seed yield was highest at 33 plants per square m and at 30 × 10 cm spacing. Seed yield increased with increasing N rates up to 60 kg/ha, and also increased with increasing P rates. N at 60 kg/ha gave the highest returns and cost benefit ratio.

Das and Ghosh (1999) conducted an experiment from March to August 1999 in Salna, Gazipur, Bangladesh to evaluate the seed yield potential of 3 amaranthus cultivars (Drutaraj, Bashpata and Sureshsari) grown under 5 different spacing levels (30 × 10, 30 × 15, 30 × 20, 30 × 25 and 30 × 30 cm). Spacing had pronounced effect on the seed yield and yield contributing characters. Plants grown at the widest spacing of 30 × 30 cm produced the longest stem (95.25 cm), maximum seed yield per plant (24.24 g) and had germination percentage of 80.60%. However, plants grown at a spacing of 30 × 20 cm recorded the highest seed yield/ha (3.64 t/ha).

Jehangir *et al.* (1999) conducted an experiment to study the response of different varieties to row spacing was conducted on a silty clay-loam soil of Shalimar (Kashmir) during rabi, [winter] 1993-1994. cabbage Cv. KS-101 gave seed yield 8.4, 18.2 and 20.2% higher than KS-103, KS-102 and KOS-1, respectively. The row spacing of 30 × 10 cm recorded a significant increase of 11.9 and 19.2% in seed yield over 15 × 10 cm and 45 × 10 cm row spacing, respectively.

Gupta and Arvind (1995) carried out a field studies in 1990-1991 at Pantnagar, Naintal and noted that seed and oil yields of *B. campestris* were highest with spacing 30 × 15 cm and harvest index was highest with spacing at 40 × 10 cm. Gupta and Panda (1995) reported from field trial in winter 1989-1990 at Pantnagar, Uttar Pradesh that *B. campestris* (var. toria cv. PT 303) was line sown or broadcast at various spacings to give 160000-500000 plants/ha. Seed yield was higher with broadcasting than line sowing and was highest at a density of 220 000 plants/ha (30 x 15 cm spacing).

Islam (2008) found significant effect of spacing on the growth and yield of Indian Spinach. He got the longest plant (34.48 cm), maximum number of branches (6.25) and the highest yield (22.69 t/ha) was recorded from 50x50 cm, while all the above parameter was lowest at 50x30 cm.

Bansal *et al.* (1995) reported from an experiment that closer inter row (40 cm) and intra row spacing (10 cm) significantly reduced the dry matter accumulation, number of functional leaves and hence yield/plant.

Quasem and Hossain (1995) conducted an experiment to evaluate 16 germplasms of local stem amaranth in summer. Spacing was maintained at 30 × 15 cm. Plant height at last harvest was found to be the maximum in SAT 0034 (88.3 cm) and minimum in SAT 0062 (13.4 cm). The highest yield was recorded in SAT 0054 (54 t/ha) and lowest in SAT 0024 (15.5 t/ha).

Norman and Shongwe (1993) were conducted two field experiments by on a sandy clay loam soil during the summer seasons of 1990-1991 and 1991-1992. Seeds of amaranth were sown in for the 1st experiment with 4 spacings (60 × 45, 60 × 60, 90 × 45 and 90 × 60, cm) and in the second experiment with 5 spacings (45 × 45, 60 × 45, 60 × 60, 90 × 45, 90 × 60). These spacings recorded no significant improvement in shoot, leaf or stem quality.

Damrong and Krung (1994) conducted an experiment with Chinese cabbage 2 varieties, ASVEG no.1 and commercial cultivar Elephant brand which were planted under different spacing of 40×40, 40×30, 40×25, 30×30, 30×25 cm during July to September 1987 at Kasetsart University Kamphaengsaen Nakhon Pathom. They found that closer spacing had more number of plants per unit area. Increasing of plant population did not produce better yield because the percent of non-heading plant was increased and consequently their mean head weight. The most suitable spacing between plant for growing Chinese cabbage variety ASVEG no.1 was 40 cm the commercial cultivar Elephant brand gave very low yield only 4-11 t/ha while ASVEG no.1 produced 26-28 t/ha.

Park *et al.* (1993) conducted an experiment to study the effect of plant spacing on the growth and yield of Gimakalmi. From their findings it was clear that 30 cm × 30 cm was better than 15 cm × 15 cm or 45 cm × 45 cm in consideration of growth and yield of the crop.

Kler, *et al.* (1992) conducted a field trial at Ludhiana, Indian Punjab in 1988-1990, Chinese cabbage seedling were sown with 30 cm spacing between N-S rows, or with bidirectional sowing with 30 cm between N-S and E-W rows, or with 30 cm row spacing between N-S rows and 45 cm between E-W rows. Crops received 60, 90 or 120 kg N/ha. Seed yield was increased by cross-sowing and by increasing N rate from 60 to 90 kg/ha. Correlation coefficients between different yield components were calculated. Seed yield was positively correlated with plant height, days to maturity and harvest index. These parameters, and seed yield, were all positively correlated with light interception.

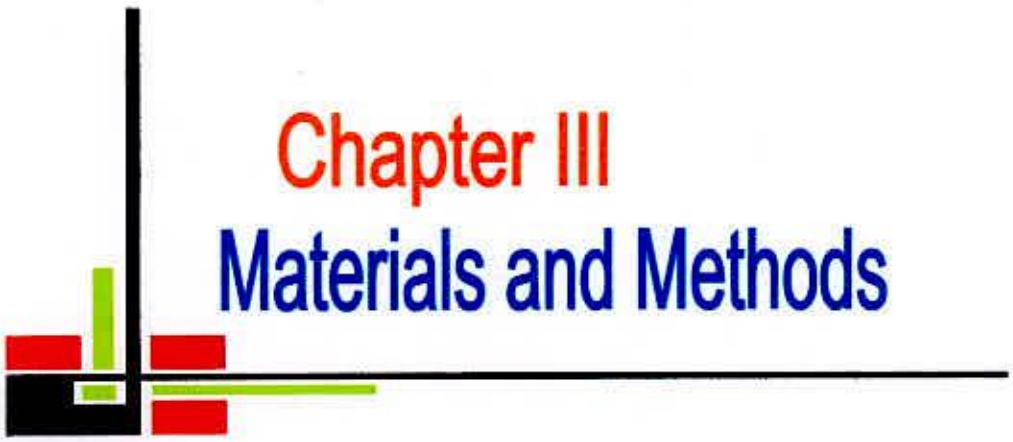
Hill (1990) conducted an experiment by at Manjimup Research Station, Australia on a sandy loam over clay at 60 cm, Chinese cabbage cv. Early Jade Pagoda was grown at spacing of 25 × 25, 30 × 30, 35 × 35 or 40 × 40 cm with 0, 50, 100, 200, 300 or 400 kg N/ha. The highest marketable yields, 126.6 and 123.6 t/ha, were produced at the closest spacing, marketable yield for this spacing increased as N rate increased from 0 to 200 kg/ha, and remained constant from 200 to 300 kg/ha but decreased when the N rate was increased to 400 kg/ha. The yield potential of Chinese cabbage was higher at closer spacing than at the wider.

Vogel and Paschold (1989) conducted an experiment in Germany on Pak-choi (*Brassica chinesis* L.) in relation to different spacing and dates of planting. A crop density of 160,000 plants per hectare with spacings of 25 cm × 25 cm gave the highest yields and high proportion of plant weighing 200-600 g.

Koay and Chua (1979) conducted an experiment to study the effect of appropriate planting method and density for economical production of Pak-choi (*Brassica chinensis* L.) in Singapore. The treatment compared were direct seeding, bare root transplanting or ball root transplanting in rows 30 cm apart with inter plant spacing of 10 cm, 20 cm, 30 cm. The highest yield (50 t/ha) was obtained from the transplanted plants at the closest spacing.

Lee (1983) studied the effects of plant densities on some leafy vegetables including Pak-choi. Four plant densities viz. 10 cm × 10 cm, 15 cm × 15 cm, 20 cm × 20 cm and 30 cm × 30 cm were included in the study. The highest yield was obtained in 15 cm × 15 cm spacing but had no significant difference with 10 cm × 10 cm spacing.

Davey (1965) observed maximum head size in cabbage with a spacing of 25-40 cm in row. However, closer spacing resulted in higher yields per hectare with greater variability in head size. Somos (1954) reported that wider spacing resulted in better growth and rapid development than closer spacing.



Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to July 2008 to find out the effect of planting time and spacing on the growth and yield of Indian Spinach.

3.1 Experimental Site

Location of the experimental site is $23^0 74^/N$ latitude and $90^0 35^/E$ longitude an elevation of 8.2 m from the sea level (Anon., 1989).

3.2 Climate

Experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data related to the temperature, relative humidity and rainfall during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in 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 : 2 kg/ha

Seed required: 86 g

Veriety : *Basella alba* -Green

Source : Foundation Seed, BADC.

3.5 Treatments of the experiment

Factor A : Three Planting times

i. P_1 : 10 March
ii. P_2 : 25 March
iii. P_3 : 9 April

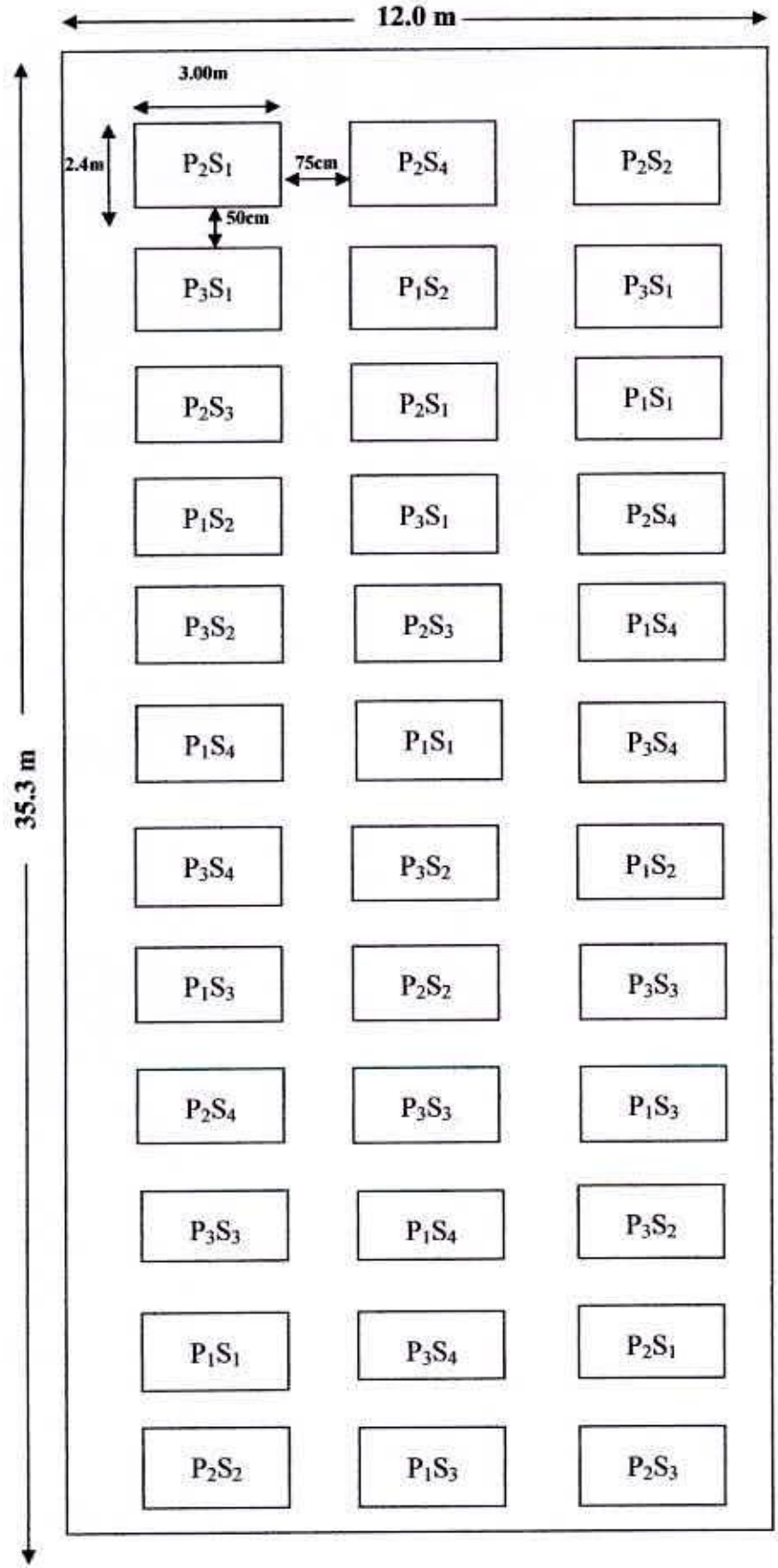
Factor A: Four levels of spacing

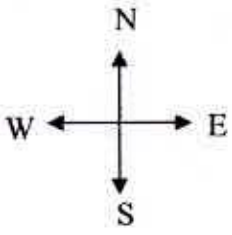
i. S_1: 60 cm × 30 cm
ii. S_2: 60 cm × 40 cm
iii. S_3: 60 cm × 50 cm
iv. S_4: 60 cm × 60 cm

Treatment combination : 3 × 4 = 12 (P_1S_1, P_1S_2, P_1S_3, P_1S_4, P_2S_1, P_2S_2, P_2S_3, P_2S_4, P_3S_1, P_3S_2, P_3S_3, and P_3S_4).

3.6 Experimental design and layout

The experiment consisted of two factors laidout at 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 × 2.00 m. The distance between the plots and the blocks were kept 50 cm and 75 cm, respectively. The layout of the experiment was given in Figure 1.





Plot size = 3.00 m × 2.4 m
Plot spacing = 50 cm
Between replication = 75 cm

Factors A:

P_1= 10 March
P_2= 25 March
P_3= 9 April

Factors B:

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

Figure 1. Layout of the experimental plot

3.7 Land preparation

The land which was selected to conduct the experiment was opened 25 February 2008 with the help of a power tiller and then it was kept open to sun 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 made until good tilth.

3.8 Application of manures and fertilizers

Recommended doses of well-decomposed cowdung and chemical fertilizers were mixed with the soil of each unit plot. Fertilizers of N, P_2O_5 and K_2O as urea, TSP and MP were applied, respectively. The amount of manure and fertilizers were used as shown in Table 1 Rashid (1999).

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

Fertilizers	Dose/ha	Application (%)			
		Basal	15 DAS	30 DAS	45 DAS
Cowdung	15 tons	100	--	--	--
Nitrogen(as urea)	250 kg	--	33.33	33.33	33.33
P_2O_5 (as TSP)	150 kg	100	--	--	--
K_2O (as MP)	150 kg	100	--	--	--

3.9 Seed sowing

First, second and third sowing were done on 10th March 25th March and 9th April 2008, respectively as per design of the experiment. Light irrigation was provided in the evening after sowing of seeds.

3.10 Intercultural operation

3.10.1 Gap filling

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

3.10.2 Weeding

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

3.10.3 Irrigation and drainage

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

3.10.4 Insects and Diseases

For controlling leaf caterpillars, Malathion 57 EC @ 1.5-2ml/L water were applied 2 times at an interval of 10 days starting soon after the appearance of infestation. There was no incidence of disease.

3.11 Harvesting

Randomly selected 5 plants were harvested from each plot for data collection. First, second, third and 4^{th} harvest was done at 30, 45, 60 and 75 DAS.

3.12 Data collection

Data were recorded on the following parameters from the sample plants During the course of experiment 5 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, 45, 60 and 75 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 branches per plant

Number of branches of 5 randomly selected plants were counted at 30, 45, 60 and 75 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 5 plants gave number of branches per plant.

3.12.3 Number of leaves per plant

Number of leaves of 5 randomly selected plants were counted at 30, 45, 60 and 75 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 number of leaves was calculated from the average number of leaves of 5 randomly selected plants.

3.12.4 Leaf area index (cm^2)

The selected leaves of 5 randomly selected plants were measured length and width at 30, 45, 60 and 75 days after seed sowing (DAS). Leaf areawas calculated from the average number of leaves of 5 randomly selected plants.

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

Leaves and twigs of 5 randomly selected plants at 30, 45, 60 and 75 days after seed sowing were detached by a sharp knife and average fresh weight of leaves and twigs was recorded and expressed 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, were weighed and placed in oven and maintained temperature at 70^0C for 72 hours to reach at constant weight. The sample then was transferred into a desiccator and allowed to cool down to the room temperature. The dry weight of the sample was taken at 30, 45, 60 and 75 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 per plot

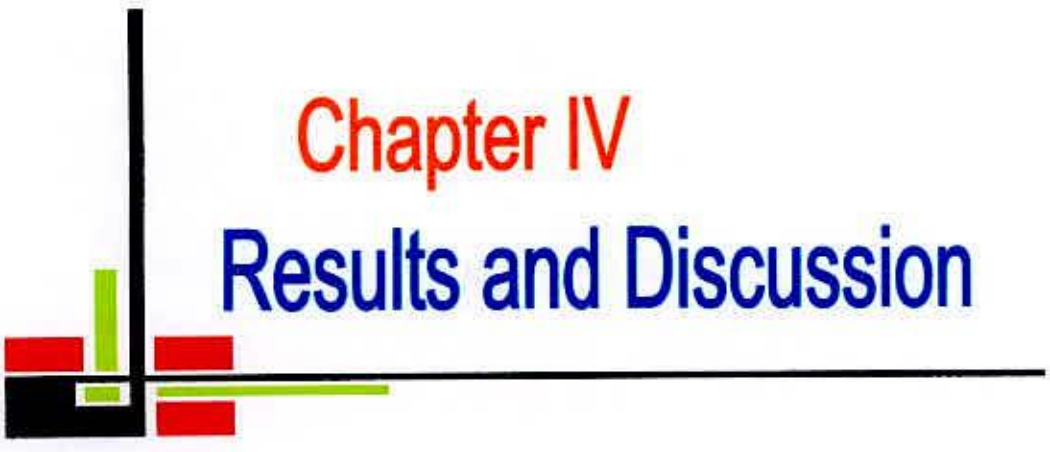
The yield of Indian spinach per plot was calculated in kg per plot for every harvest of leaves and twigs per plot at 20, 40, 60 and 80 days after sowing (DAS).

3.12.8 Gross yield per hectare

The yield of Indian spinach per hectare which was also calculated in ton per hectare by converting the total yield of leaves and twigs per plot at 20, 40, 60 and 80 days after sowing (DAS).

3.13 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the planting time and spacing 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 combinations means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability according to Gomez and Gomez, (1984).



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of planting time and spacing 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 components and yield are given in Appendix III-X. The results have been presented and discussed, and possible interpretations are given under the following headings-

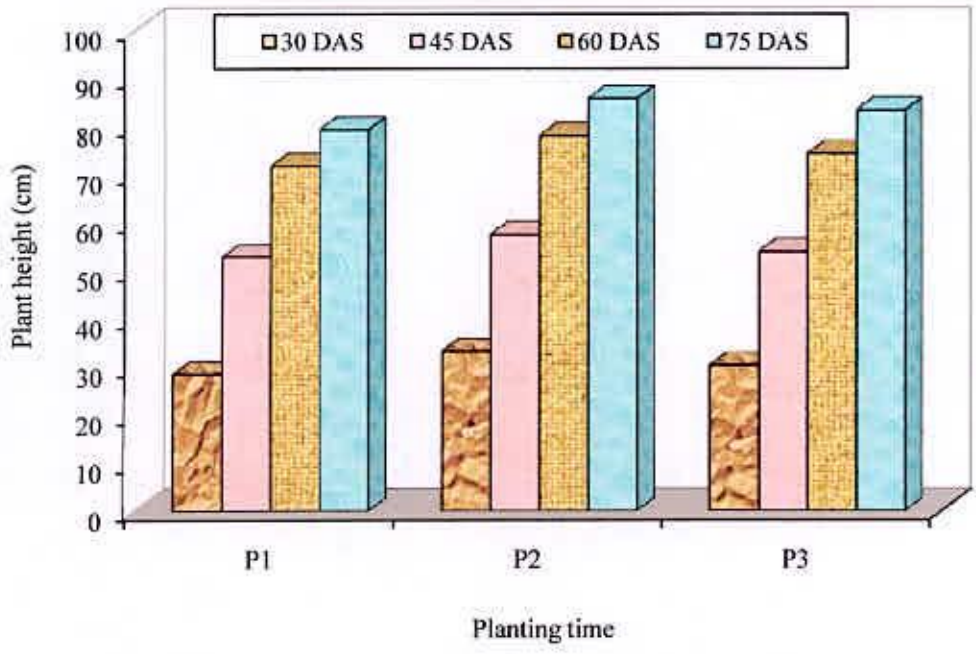
4.1 Plant height

Plant height of Indian Spinach differs significantly due to different planting time at 30, 45, 60 and 75 DAS (Appendix III). At 30 DAS, the longest plant (33.26 cm) was found in P_2 (25 March) and the shortest plant (28.55 cm) was recorded form P_1 (10 March). The longest plant (57.54 cm) was found in P_2 and the shortest plant (52.84 cm) was recorded from P_1 which was statistically similar (53.94 cm) to P_3 at 45 DAS. At 60 DAS, the longest plant (78.03 cm) was observed from P_2 which was statistically similar (74.34 cm) by P_3 and the shortest plant (71.75 cm) was recorded from P_1. The longest plant (85.81 cm) was found from P_2 which was statistically similar (83.40 cm) with P_3, while the shortest plant (79.35 cm) was obtained from P_1 at 75 DAS (Figure 2). These results indicate that there was a very little effect of planting time on plant height of Indian spinach in all growing period. But the sowing time of 25 March was the best for the growth of plant comparing the others sowing date and that sowing date Indian spinach produced tallest plant. Boztok, S. 1985. also reported the similar findings earlier.

Different spacing showed significant differences on plant height of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix III). The longest plant (33.21cm) was recorded from S_3 (60 cm × 50 cm) which was statistically identical (31.73

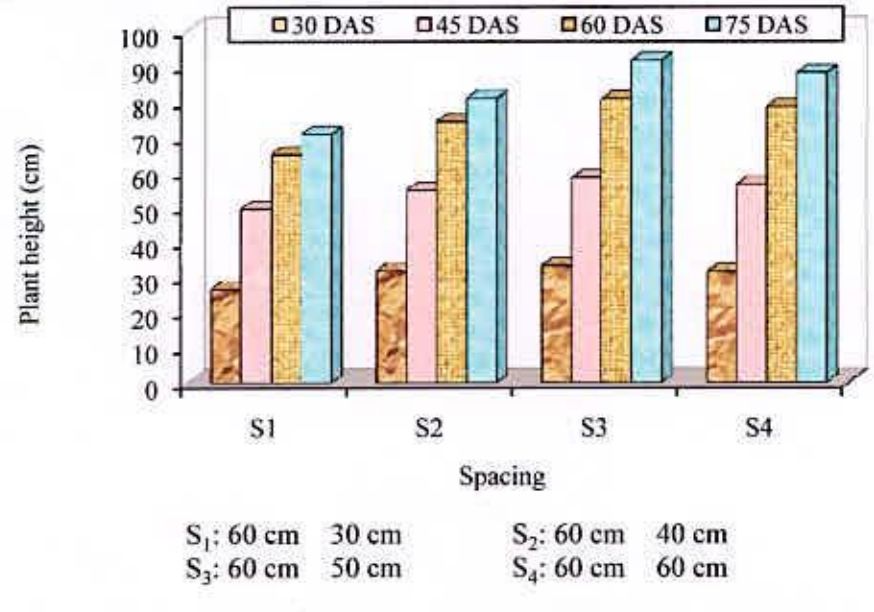
cm and 31.38 cm) with S_2 (60 cm × 40 cm) and S_4 (60 cm × 60 cm) while the shortest plant (26.62 cm) was recorded from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the longest plant (58.31 cm) was recorded from S_3, which was statistically similar (56.41 cm) with S_4, while the shortest plant (49.54 cm) was recorded from S_1. The longest plant (80.73 cm) was recorded from S_3, which was statistically similar (78.58 cm) with S_4, while the shortest plant (65.15 cm) was recorded from S_1 at 60 DAS. At 75 DAS, the longest plant (91.59 cm) was recorded from S_3, which was statistically similar (88.01 cm) with S_4, and closely followed (80.98 cm) by S_2, while the shortest plant (70.82 cm) was recorded from S_1 (Figure 3). These results indicated that both wider and closer spacings reduced plant height of Indian spinach. Variations in plant height among different spacing were prominent. Plants grown with widest spacing received higher amount of light, nutrient, water and the reverse happened to plants grown with closest spacing. This finding coincided with that of Rashid *et al.* (1984) and Islam *et al.* (1984).

Interaction effect of planting time and spacing showed a significant difference on plant height of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix III). The longest plant (36.69 cm) was recorded from P_2S_2 (25 March and 60 cm × 40 cm) and the shortest plant (24.56 cm) was recorded from P_2S_1 (25 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the longest plant (61.87 cm) was recorded from P_2S_3 and the shortest plant (47.57 cm) was recorded from P_1S_1. The longest plant (86.48 cm) was recorded from the treatment combination of P_2S_3 and the shortest plant (64.39 cm) was recorded from P_1S_1 at 60 DAS. At 75 DAS, the longest plant (97.96 cm) was recorded from P_2S_3 and the shortest plant (67.47 cm) was found in P_2S_1 (Table 2). From the results, it was revealed that both planting time and spacing favored growth of Indian spinach and the ultimate results is the highest plant.



P_1: 10 March 2008
P_2: 25 March 2008
P_3: 9 April 2008

Figure 2. Effect of planting time on plant height of Indian Spinach



S_1: 60 cm 30 cm S_2: 60 cm 40 cm
S_3: 60 cm 50 cm S_4: 60 cm 60 cm

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

Table 2. Interaction effect of planting time and spacing on plant height of Indian Spinach

Treatment	Plant height (cm) at			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	26.13de	47.57 g	64.39 f	72.46 d
P_1S_2	27.67 cde	52.79 def	70.69 de	74.60 d
P_1S_3	31.93 bc	56.47 bcd	76.94 c	86.24 bc
P_1S_4	28.46 cde	54.52 cde	74.98 cd	84.11 bc
P_2S_1	24.56 e	48.05 fg	64.44 f	67.47 d
P_2S_2	**36.69 a**	60.64 ab	77.98 c	86.38 bc
P_2S_3	36.34 a	**61.87 a**	**86.48 a**	**97.96 a**
P_2S_4	35.45 ab	59.60 abc	83.21 ab	91.41 ab
P_3S_1	29.16 cd	53.00 def	66.62 ef	72.53 d
P_3S_2	30.82 c	51.02efg	74.40 cd	81.97 c
P_3S_3	31.36 bc	56.60 bcd	78.77 bc	90.58 ab
P_3S_4	30.23 cd	55.12 cde	77.56 c	88.52 bc
$LSD_{(0.05)}$	3.941	4.735	4.904	7.119
Level of Significance	0.01	0.01	0.05	0.05
CV(%)	7.57	5.11	8.88	5.07

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

P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.2 Number of branches per plant

Significant difference was recorded for number of branches per plant of Indian Spinach due to different planting time at 30, 45, 60 and 75 DAS (Appendix IV). At 30 DAS, the highest number of branches per plant (1.63) was obtained form P_2 (25 March) whereas the lowest number of branches per plant (1.11) was found in P_1 (10 March). The highest number of branches per plant (4.04) was found in P_2, while the lowest number of branches per plant (3.62) was observed from P_3 which was statistically similar (3.54) to P_1 at 45 DAS. At 60 DAS, the highest number of branches per plant (9.28) was found in P_2 and the lowest number of branches per plant (8.17) was recorded from P_1. The highest number of branches per plant (12.01) was found in P_2 which was statistically similar (11.81) with P_3, whereas the lowest number of branches per plant (11.55) was found in P_1 at 75 DAS (Table 3). Futane *et al.* (1995) reported the simliar results.

Number of branches per plant of Indian Spinach showed significant differences for different spacing at 30, 45, 60 and 75 DAS (Appendix IV). The highest number of branches per plant (1.62) was obtained from S_3 (60 cm × 50 cm), on the other hand the lowest number of branches per plant (1.04) was found in S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest number of branches per plant (3.99) was found in S_3, which was statistically similar (3.84) with S_4, whereas the lowest number of branches per plant (3.32) was recorded from S_1. The highest number of branches per plant (9.06) was observed from S_3, which was statistically similar (8.94) with S_4. On the contrary the lowest number of branches per plant (7.90) was found in S_1 at 60 DAS. At 75 DAS, the highest number of branches per plant (12.33) was recorded from S_3, which was statistically similar (11.96 and 11.93) with S_4 and S_2 and the lowest number of branches per plant (10.94) was recorded from S_1 (Table 3). Plants grown with widest spacing received higher amount of light, nutrient and water enhancing more number of branches per plant and the reverse happened to plants grown with closest. This finding coincided with that of Islam *et al.* (1984).

Table 3. Effect of planting time and spacing on number of branches per plant of Indian Spinach

Treatment	Number of branches per plant at			
	30 DAS	45 DAS	60 DAS	75 DAS
Planting time				
P_1	1.11 c	3.54 b	8.17 b	11.55 b
P_2	**1.63 a**	**4.04 a**	**9.28 a**	**12.01 a**
P_3	1.32 b	3.62 b	8.41 b	11.81 ab
$LSD_{(0.05)}$	0.126	0.144	0.389	0.341
Level of Significance	0.01	0.01	0.01	0.01
Spacing				
S_1	1.04 c	3.32 c	7.90 c	10.94 b
S_2	1.43 b	3.79 b	8.57 b	11.93 a
S_3	**1.62 a**	**3.99 a**	**9.06 a**	**12.33 a**
S_4	1.33 b	3.84 ab	8.94 ab	11.96 a
$LSD_{(0.05)}$	0.145	0.167	0.449	0.394
Level of Significance	0.01	0.01	0.01	0.01
CV(%)	10.97	6.59	5.33	7.42

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

P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

In combined effect of planting time and spacing showed a significant difference on number of branches per plant of Indian Spinach for at 30, 45, 60 and 75 DAS (Appendix IV). The highest number of branches per plant (2.03) was obtained from P_2S_3 (25 March and 60 cm × 50 cm) and the lowest (0.89) was recorded from P_1S_1 (10 March and 60 cm × 30 cm spacing) at 30 DAS. At 45 DAS, the highest number of branches per plant (4.42) was recorded from the treatment combination of P_2S_3 and the lowest (3.16) was recorded from P_1S_1. The highest number of branches per plant (9.82) was found in P_2S_3 and the lowest (7.79) was recorded from P_1S_1 at 60 DAS. At 75 DAS, the highest number of branches per plant (12.89) was observed from P_2S_3 and the lowest (10.89) was recorded from P_2S_1 (Table 4).

Table 4. Interaction effect of planting time and spacing on number of branches per plant of Indian Spinach

Treatment	Number of branches per plant at			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	0.89 g	3.16 g	7.79 f	11.04 cd
P_1S_2	1.01 fg	3.60 def	7.98 ef	11.72 bc
P_1S_3	1.44 cd	3.71 de	8.42 def	11.72 bc
P_1S_4	1.11 efg	3.70 de	8.48 def	11.72 bc
P_2S_1	0.92 g	3.29 fg	8.28 def	10.89 d
P_2S_2	1.91 ab	4.34 ab	9.40 abc	12.03 b
P_2S_3	**2.03 a**	**4.42 a**	**9.82 a**	**12.89 a**
P_2S_4	1.67 bc	4.10 bc	9.60 ab	12.23 ab
P_3S_1	1.31 de	3.51 ef	7.63 f	10.89 d
P_3S_2	1.35 de	3.43 efg	8.34 def	12.03 b
P_3S_3	1.40 d	3.83 cd	8.93 bcd	12.39 ab
P_3S_4	1.21 def	3.70 de	8.74 cde	11.92 a
$LSD_{(0.05)}$	0.251	0.288	0.778	0.682
Level of Significance	0.01	0.01	0.01	0.05
CV(%)	10.97	6.59	5.33	7.42

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

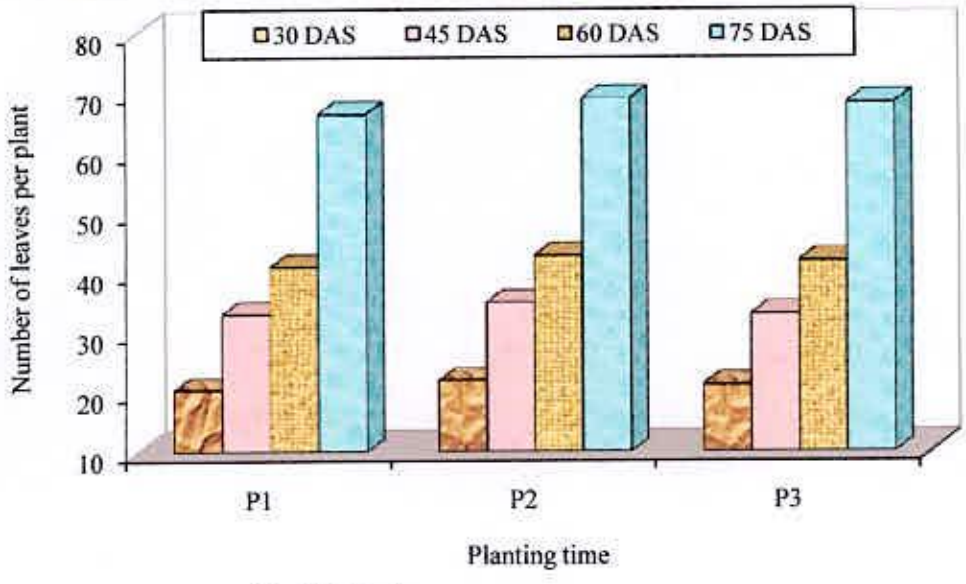
P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.3 Number of leaves per plant

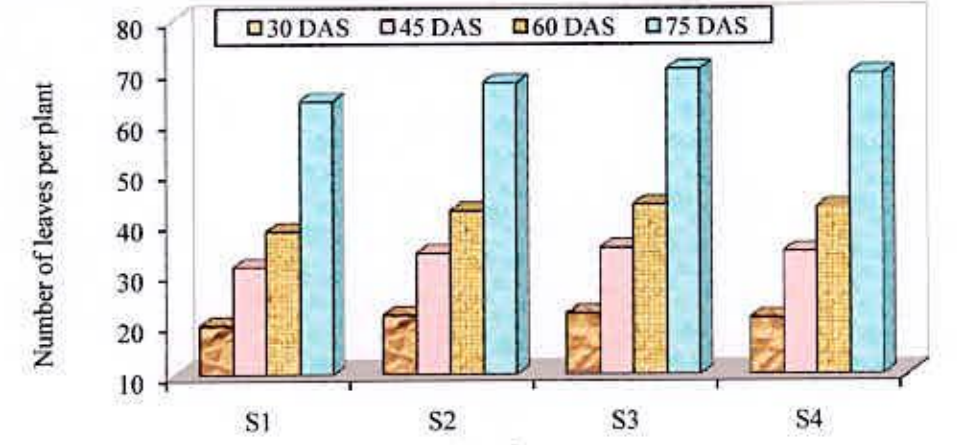
Different planting time showed statistically significant differences for number of leaves per plant of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix V). In case of 30 DAS, the highest number of leaves per plant (21.90) was found form P_2 (25 March) while the lowest number of leaves per plant (20.35) was recorded form P_1 (10 March). The highest number of leaves per plant (34.99) was obtained from P_2 and the lowest number of leaves per plant (32.99) was recorded from P_3 which was statistically similar (33.02) to P_1 at 45 DAS. At 60 DAS, the highest number of leaves per plant (42.84) was found in P_2 which was closely followed (41.94) by P_3, whereas the lowest number of leaves per plant (40.94) was recorded from P_1. The highest number of leaves per plant (68.99) was recorded from P_2 which was statistically similar (68.22) with P_3 again, the lowest number of leaves per plant (66.41) was found in P_1 at 75 DAS (Figure 4). Ghanti and Malik (1995) reported the simliar results.

A statistically significant difference was recorded for different spacing on number of leaves per plant of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix V). The highest number of leaves per plant (21.98) was observed from S_3 (60 cm × 50 cm) which was statistically identical (21.67 and 21.24) with S_2 (60 cm × 40 cm) and S_4 (60 cm × 60 cm) whereas the lowest number of leaves per plant (19.67) was recorded from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest number of leaves per plant (35.08) was found in S_3, which was statistically similar (34.37) with S_4, again the lowest number of leaves per plant (31.23) was recorded from S_1. The highest number of leaves per plant (43.73) was recorded from S_3, which was statistically similar (43.14) with S_4. On the other hand, the lowest number of leaves per plant (38.36) was recorded from S_1 at 60 DAS. At 75 DAS, the highest number of leaves per plant (70.29) was obtained from S_3, which was statistically similar (69.44) with S_4 and the lowest number of leaves per plant (64.13) was found in S_1 (Figure 5). Similar trends of result were also obtained by Damrong and Krung (1994). Plants grown with wider spacing received higher amount of light, nutrient, water thus attaining more height along with more number of leaves per plant and the reverse happened to plants grown with closer spacing.



P_1: 10 March
P_2: 25 March
P_3: 9 April

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



S_1: 60 cm 30 cm
S_2: 60 cm 40 cm
S_3: 60 cm 50 cm
S_4: 60 cm 60 cm

Figure 5. Effect of spacing on number of leaves per plant of Indian spinach

Interaction effect of planting time and spacing varied significantly in terms of number of leaves per plant of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix V). The highest number of leaves per plant (24.02) was found in the treatment combination of P_2S_3 (25 March and 60 cm × 50 cm) and the lowest (18.85) was observed from P_2S_1 (25 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest number of leaves per plant (36.64) was recorded from P_2S_3 and the lowest (30.93) was found in P_1S_1. The highest number of leaves per plant (45.23) was recorded from P_2S_3 and the lowest (37.78) was recorded from P_2S_1 at 60 DAS. At 75 DAS, the highest number of leaves per plant (71.79) was recorded from P_2S_3 and the lowest (64.01) was recorded from P_1S_1 (Table 5).

Table 5. Interaction effect of planting time and spacing on number of leaves per plant of Indian Spinach

Treatment	Number of leaves per plant at			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	19.48 ef	30.93 e	38.23 f	64.01 d
P_1S_2	20.90cde	33.16 cd	40.65 de	65.40 d
P_1S_3	20.46 de	34.04 c	42.67 bc	67.95 bc
P_1S_4	20.57 cde	33.93 c	42.23 cd	68.29 bc
P_2S_1	18.85 f	31.04 e	37.78 f	64.11 d
P_2S_2	22.61 ab	36.60 a	44.00 abc	69.72 abc
P_2S_3	**24.02 a**	**36.64 a**	**45.23 a**	**71.79 a**
P_2S_4	22.12 bc	35.71 ab	44.34 ab	70.34 ab
P_3S_1	20.69 cde	31.71 e	39.08 ef	64.28 d
P_3S_2	21.51 bcd	32.19 de	42.49 bc	67.77 c
P_3S_3	21.47 bcd	34.60 bc	43.31 bc	71.14 a
P_3S_4	21.03 bcde	33.48 cd	42.86 bc	69.70 abc
$LSD_{(0.05)}$	1.435	1.376	1.703	2.255
Level of Significance	0.01	0.01	0.05	0.05
CV(%)	6.01	9.41	7.40	5.96

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

P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.4 Leaf Area Index (LAI)

Leaf area index of Indian Spinach varied significantly due to different planting time at 30, 45, 60 and 75 DAS (Appendix VI). At 30 DAS, the maximum leaf area (36.08 cm^2) was obtained form P_2 (25 March) and the minimum leaf area index (32.95 cm^2) was recorded form P_1 (10 March). The maximum leaf area index (121.17 cm^2) was recorded from P_2, while the minimum leaf area (111.18 cm^2) was found in P_1 which was statistically similar (111.16 cm^2) to P_3 at 45 DAS. At 60 DAS, the maximum leaf area index (245.90 cm^2) was observed from P_2 which was statistically identical (236.91 cm^2) with P_3 and the minimum leaf area (231.22 cm^2) was obtained from P_1. The maximum leaf area index (333.28 cm^2) was found in P_2 which was statistically similar (328.13 cm^2) with P_3 and the minimum leaf area (296.85 cm^2) was recorded from P_1 at 75 DAS (Table 6). Rashid *et al.* (1984), Hossain (1996) reported similar results earlier.

Leaf area index of Indian Spinach showed significant differences for different spacing at 30, 45, 60 and 75 DAS (Appendix VI). The maximum leaf area index (36.09 cm^2) was found in S_3 (60 cm × 50 cm) which was statistically identical (35.20 cm^2 and 34.81 cm^2) with S_2 (60 cm × 40 cm) and S_4 (60 cm × 60 cm) and the minimum leaf area index (31.65 cm^2) was obtained from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the maximum leaf area index (121.71 cm^2) was found in S_3, which was statistically similar (118.07 cm^2) with S_4, again the minimum leaf area index (102.22 cm^2) was obtained from S_1. The maximum leaf area index (255.67 cm^2) was recorded from S_3, which was statistically similar (249.78 cm^2) with S_4, while the minimum leaf area index (207.20 cm^2) was recorded from S_1 at 60 DAS. At 75 DAS, the maximum leaf area index (343.38 cm^2) was found in S_3, which was statistically similar (335.33 cm^2) with S_4, while the minimum leaf area (278.51 cm^2) was observed from S_1 (Table 6). Islam and Hossain (1984) reported similar results earlier.

Table 6. Effect of planting time and spacing on leaf area index of Indian Spinach

Treatment	Leaf area index (cm^2) at			
	30 DAS	45 DAS	60 DAS	75 DAS
Planting time				
P_1	32.95 c	111.18 b	231.22 b	296.85 b
P_2	**36.08 a**	**121.17 a**	**245.90 a**	**333.28 a**
P_3	34.28 b	111.16 b	236.91 ab	328.13 a
$LSD_{(0.05)}$	1.186	3.505	9.547	10.04
Level of Significance	0.01	0.01	0.01	0.01
Spacing				
S_1	31.65 b	102.22 c	207.20 c	278.51 c
S_2	35.20 a	116.03 b	239.38 b	320.47 b
S_3	**36.09 a**	**121.71 a**	**255.67 a**	**343.38 a**
S_4	34.81 a	118.07 ab	249.78 ab	335.33 a
$LSD_{(0.05)}$	1.369	4.048	11.02	11.60
Level of Significance	0.01	0.01	0.01	0.01
CV(%)	8.07	9.62	6.74	7.71

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

P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

In combined effect of planting time and spacing showed varied significantly in terms of leaf area index of Indian Spinach at 30, 45, 60 and 75 (Appendix VI). The maximum leaf area index (38.68 cm^2) was found in P_2S_3 (25 March and 60 cm × 50 cm), whereas the minimum leaf area index (30.20 cm^2) was observed from P_2S_1 (25 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the maximum leaf area index (129.34 cm^2) was recorded from P_2S_2 and the minimum leaf area index (100.38 cm^2) was recorded from P_1S_1. The maximum leaf area index (269.39 cm^2) was recorded from P_2S_3 and the minimum leaf area index (195.80 cm^2) was obtained from P_2S_1 at 60 DAS. At 75 DAS, the maximum leaf area index (362.41 cm^2) was found in P_2S_3 and the minimum leaf area index (273.68 cm^2) was recorded from P_1S_1 (Table 7).

Table 7. Interaction effect of planting time and spacing on leaf area index of Indian Spinach

Treatment	Leaf area index (cm^2) at			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	31.31 cd	100.38 f	212.07 ef	273.68d
P_1S_2	32.79 bc	111.98 cde	224.22 de	289.67 d
P_1S_3	34.69 b	116.55 c	246.24 bc	310.49 c
P_1S_4	33.02 bc	115.82 c	242.34 bcd	313.57 c
P_2S_1	30.20 d	101.40 f	195.80 f	280.24 d
P_2S_2	38.15 a	129.34 a	257.94 ab	341.44 ab
P_2S_3	**38.68 a**	**129.28 a**	**269.39 a**	**362.41 a**
P_2S_4	37.29 a	124.67 ab	260.46 ab	349.03 ab
P_3S_1	33.42 bc	104.87 ef	213.72 ef	281.60d
P_3S_2	34.67b	106.76 def	235.99 cd	330.29 bc
P_3S_3	34.91 b	119.28 bc	251.37 abc	357.24 a
P_3S_4	34.13 b	113.72 cd	246.54 bc	343.38 ab
$LSD_{(0.05)}$	2.372	7.011	19.09	20.09
Level of Significance	0.01	0.01	0.05	0.05
CV(%)	8.07	9.62	6.74	7.71

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

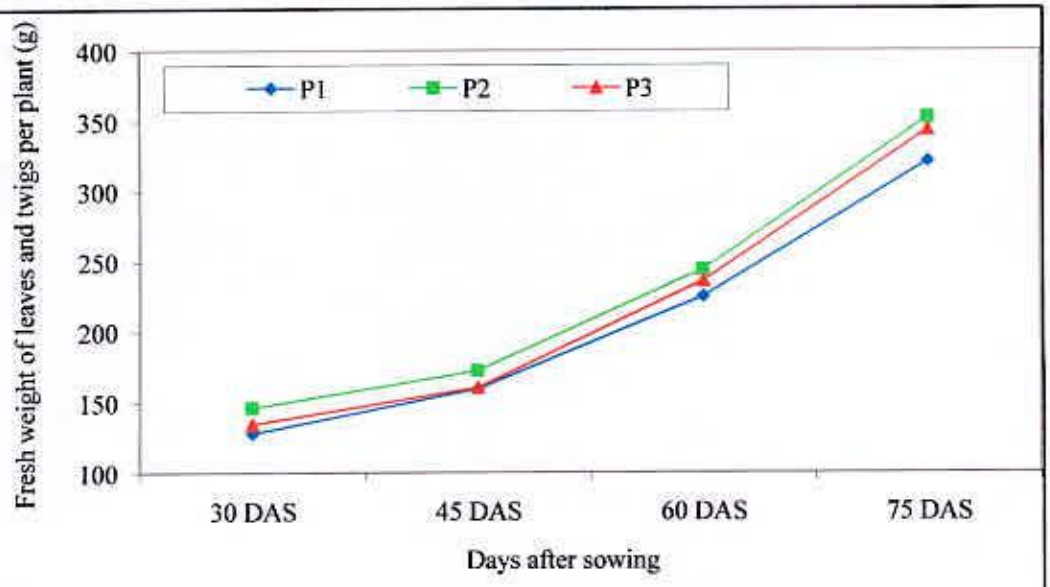
P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

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

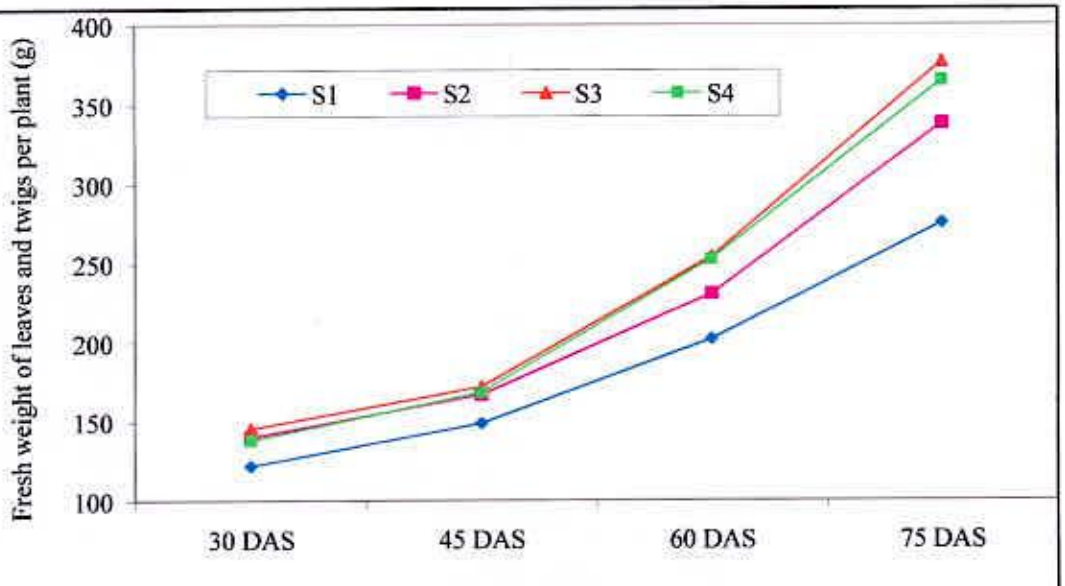
Fresh weight leaves and twigs per plant of Indian Spinach showed a significant difference due to different planting time at 30, 45, 60 and 75 DAS (Appendix VII). At 30 DAS, the maximum fresh weight leaves and twigs per plant (146.11 g) was found in P_2 (25 March) whereas the minimum fresh weight leaves and twigs per plant (128.08 g) was found in P_1 (10 March). The maximum fresh weight leaves and twigs per plant (172.32 g) was found in P_2 and the minimum fresh weight leaves and twigs per plant (160.33 g) was obtained from P_1 which was statistically similar (160.33 g) to P_3 at 45 DAS. At 60 DAS, the maximum fresh weight leaves and twigs per plant (243.99 g) was observed from P_2, while the minimum fresh weight leaves and twigs per plant (224.87 g) was recorded from P_1. The maximum fresh weight leaves and twigs per plant (352.10 g) was observed from P_2 which was statistically similar (343.49 g) with P_3 and the minimum fresh weight leaves and twigs per plant (320.96 g) was obtained from P_1 at 75 DAS (Figure 6). Nuruzzaman (1999) and Quader (2007) reported similar results earlier.

A significant difference was recorded for different spacing in terms of fresh weight leaves and twigs per plant of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix VII). The maximum fresh weight leaves and twigs per plant (145.38 g) was obtained from S_3 (60 cm × 50 cm) which was statistically identical (140.00 g) with S_2 (60 cm × 40 cm) while the minimum fresh weight leave and twigs per plant (121.79 g) was found from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the maximum fresh weight leaves and twigs per plant (172.00 g) was obtained from S_3, which was statistically similar (168.32 g and 167.01 g) with S_4 and S_2, respectively. On the other hand the minimum fresh weight leaves and twigs per plant (148.82 g) were observed from S_1. The maximum fresh weight leaves and twigs per plant (254.17 g) was found in S_3, which was statistically similar (252.68 g) with S_4, and closely followed (230.93 g) by S_2, while the minimum fresh weight leaves and twigs per plant (202.01 g) was obtained from S_1 at 60 DAS. At 75 DAS, the maximum fresh weight leaves and



P_1: 10 March 2008
P_2: 25 March 2008

Figure 6. Effect of planting time on fresh weight of leaves and twigs per plant of Indian spinach



S_1: 60 cm 30 cm
S_2: 60 cm 40 cm
S_3: 60 cm 50 cm
S_4: 60 cm 60 cm

Figure 7. Effect of spacing on fresh weight of leaves and twigs per plant of Indian spinach

twigs per plant (376.86 g) was recorded from S_3, which was statistically similar (364.89 g) with S_4, while the minimum fresh weight leaves and twigs per plant (275.58 g) was found in S_1 (Figure 7). Plants grown with widest spacing received higher amount of light, nutrient and water and the reverse happened to plants grown with closest spacing. This finding coincided with that of Islam *et al.* (1984).

Interaction effect of planting time and spacing showed a significant difference in terms of fresh weight leaves and twigs per plant of Indian Spinach at 30, 45, 60 and 75 (Appendix VII). The maximum fresh weight leaves and twigs per plant (166.10 g) was obtained P_2S_3 (25 March and 60 cm × 50 cm) and the minimum fresh weight leaves and twigs per plant (117.60 g) was recorded from P_2S_1 (25 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the maximum fresh weight leaves and twigs per plant (182.51 g) was recorded from P_2S_3 and the minimum fresh weight leaves and twigs per plant (147.08 g) was found in P_1S_1. The maximum fresh weight leaves and twigs per plant (265.60 g) was recorded from P_2S_3 and the minimum fresh weight leaves and twigs per plant (196.37 g) was observed from P_1S_1 at 60 DAS. At 75 DAS, the maximum fresh weight leaves and twigs per plant (399.76 g) was found in the treatment combination of P_2S_3 and the minimum fresh weight leaves and twigs per plant (266.01 g) was recorded from P_2S_1 (Table 8).

Table 8. Interaction effect of planting time and spacing on fresh weight of leaves and twigs per plant of Indian Spinach

Treatment	Fresh weight of leaves and twigs (g) per plant at			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	117.75 d	147.08 e	196.37 d	279.61 fg
P_1S_2	130.85 c	158.70 cde	212.93 c	309.80 ef
P_1S_3	132.35 c	166.98 bc	247.84 b	344.72 cd
P_1S_4	131.37 c	165.09 bc	242.35 b	349.70 cd
P_2S_1	117.60 d	147.65 e	203.63 cd	266.01 g
P_2S_2	151.66 b	182.20 a	241.23 b	366.20 bcd
P_2S_3	**166.10 a**	**182.51 a**	**265.48 a**	**399.76 a**
P_2S_4	149.07 b	176.95 ab	265.60 a	376.42 abc
P_3S_1	130.04 c	151.74 de	206.04 cd	281.12 fg
P_3S_2	137.50 c	160.14 cde	238.64 b	338.19 de
P_3S_3	137.68 c	166.51 bc	249.20 b	386.10 ab
P_3S_4	133.21 c	162.93 cd	250.09 b	368.57 abcd
$LSD_{(0.05)}$	10.02	11.90	14.04	28.98
Level of Significance	0.01	0.05	0.01	0.05
CV(%)	9.34	5.28	7.53	5.05

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

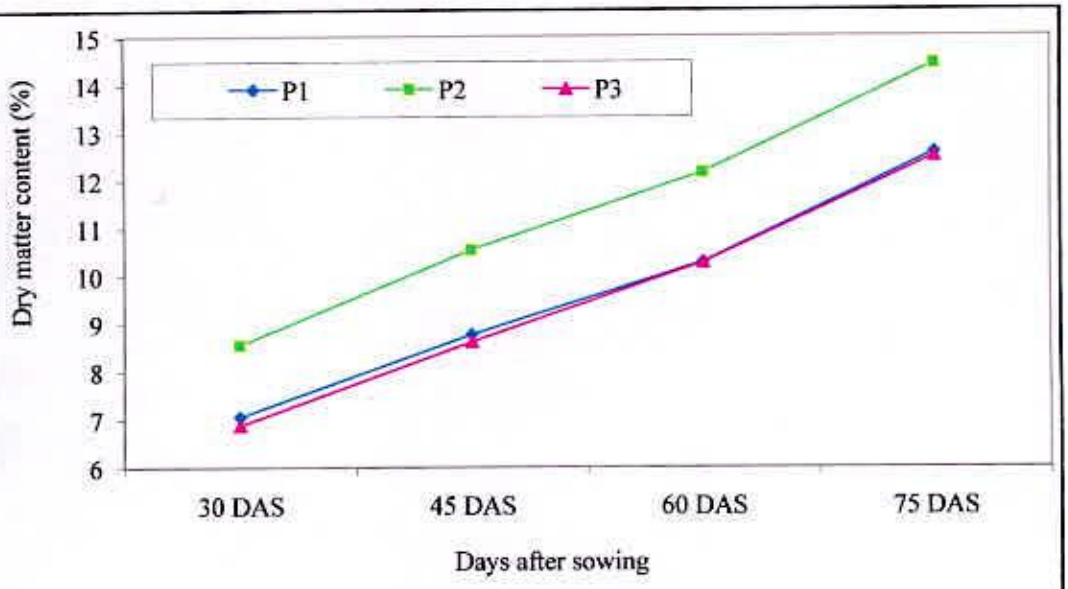
P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.6 Dry matter content (%)

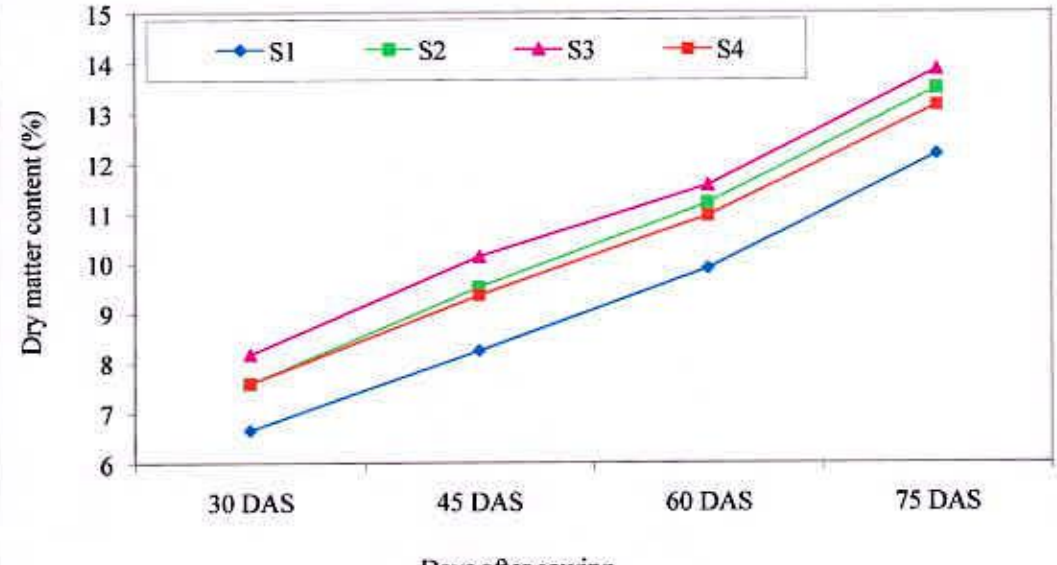
Different planting time showed a statistical significant difference for dry matter content of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix VIII). At 30 DAS, the highest dry matter content (8.55%) was recorded form P_2 (25 March, 2008) again, the lowest dry matter content (6.88%) was found in P_3 (9 April, 2008) which was statistically identical (7.06%) by P_1 (sowing on 10 March, 2008). The highest dry matter content (10.54%) was obtained from P_2, while the lowest dry matter content (8.62%) was recorded from P_3 which was statistically similar (8.77%) to P_1 at 45 DAS. At 60 DAS, the highest dry matter content (12.15%) was found in P_2 and the lowest dry matter content (10.27%) was recorded from P_3 which was statistically identical (10.28%) by P_1. The highest dry matter content (14.42%) was obtained from P_2, while the lowest dry matter content (12.50%) was obtained from P_3 which was statistically similar (12.58%) with P_1 at 75 DAS (Figure 8). Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results.

Different spacing showed significant differences on dry matter content of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix VIII). The highest dry matter content (8.17%) was observed from S_3 (60 cm × 50 cm) whereas the lowest dry matter content (6.65%) was recorded from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest dry matter content (10.13%) was recorded from S_3, which was closely followed (9.51% and 9.35%) with S_4 and S_2, respectively. On the other hand the lowest dry matter content (8.24%) was recorded from S_1. The highest dry matter content (11.56%) was recorded from S_3, which was statistically similar (11.20% and 10.95%) with S_2 and S_4, while the lowest dry matter content (9.89%) was obtained from S_1 at 60 DAS. At 75 DAS, the highest dry matter content (13.86%) was recorded from S_3, which was statistically similar (13.48% and 13.15%) with S_2 and S_4 again, the lowest dry matter content (12.18%) was found in S_1 (Figure 9). Plants grown with widest spacing received higher amount of light, nutrient and water and the reverse happened to plants grown with closest spacing. This finding coincided with that of Islam *et al.* (1984).



P_1: 10 March
P_2: 25 March
P_3: 9 April

Figure 8. Effect of planting time on dry matter content (%) of Indian spinach



S_1: 60 cm 30 cm
S_2: 60 cm 40 cm
S_3: 60 cm 50 cm
S_4: 60 cm 60 cm

Figure 9. Effect of spacing on dry matter content (%) of Indian spinach

In combined effect of planting time and spacing showed a significant difference in terms of dry matter content of Indian Spinach at 30, 45, 60 and 75 (Appendix VIII). The highest dry matter content (9.76%) was observed from P_2S_3 (25 March and 60 cm × 50 cm) and the lowest dry matter content (6.66%) was found from P_1S_1 (10 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest dry matter content (11.99%) was recorded from P_2S_3 and the lowest dry matter content (8.01%) was recorded from P_1S_1. The highest dry matter content (13.39%) was obtained from the treatment combination of P_2S_3 and the lowest dry matter content (9.44%) was recorded from P_1S_1 at 60 DAS. At 75 DAS, the highest dry matter content (15.85%) was recorded from P_2S_3 and the lowest dry matter content (12.16%) was recorded from P_1S_1 (Table 9).

Table 9. Interaction effect of planting time and spacing on dry matter content (%) of Indian Spinach

Treatment	Dry matter content (%)			
	30 DAS	45 DAS	60 DAS	75 DAS
P_1S_1	6.66 cd	8.01 d	9.44 b	12.16 b
P_1S_2	7.08 cd	9.04 cd	10.60 b	12.49 b
P_1S_3	7.55 c	9.39 c	10.79 b	12.91 b
P_1S_4	6.97 cd	8.64 cd	10.30 b	12.76 b
P_2S_1	6.83 cd	8.37 cd	10.11 b	12.20 b
P_2S_2	8.61 b	11.00 b	12.72 a	14.98 a
P_2S_3	**9.76 a**	**11.99 a**	**13.39 a**	**15.85 a**
P_2S_4	8.99 ab	10.79 b	12.40 a	14.64 a
P_3S_1	6.45 d	8.36 cd	10.12 b	12.17 b
P_3S_2	7.06 cd	8.50 cd	10.29 b	12.98 b
P_3S_3	7.20 cd	9.00 cd	10.50 b	12.82 b
P_3S_4	6.79 cd	8.64 cd	10.16 b	12.05 b
$LSD_{(0.05)}$	0.780	0.977	1.199	1.277
Level of Significance	0.01	0.01	0.05	0.05
CV(%)	6.14	7.20	6.49	5.73

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

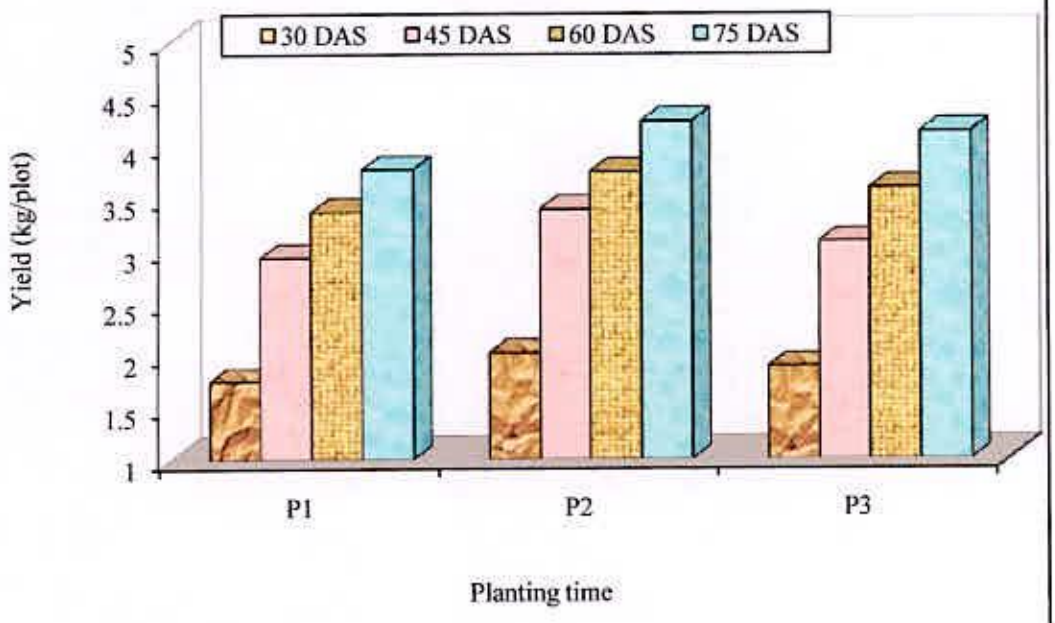
P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.7 Yield per plot

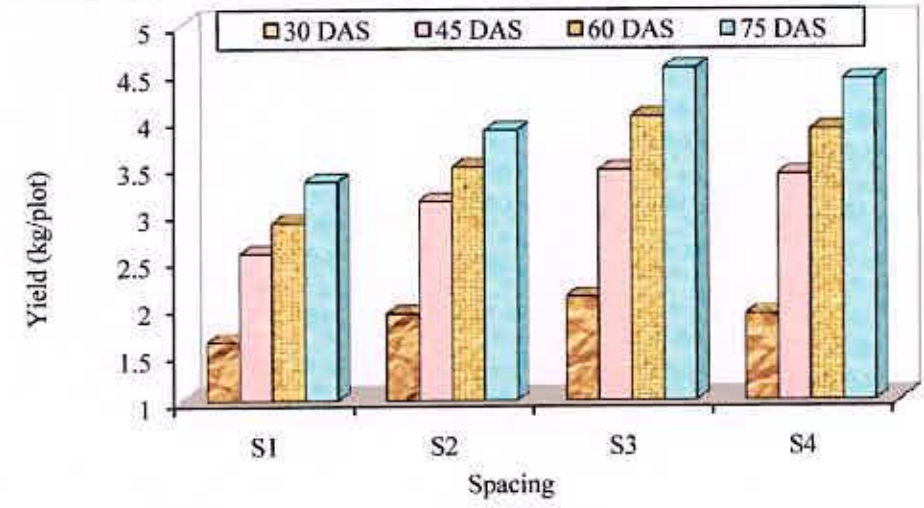
Different planting time showed a statistically significant difference for yield per plot of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix IX). At 30 DAS, the highest yield per plot (2.02 kg) was recorded from P_2 (25 March) while the lowest yield per plot (1.75 kg) was obtained from P_1 (10 March). The highest yield per plot (3.39 kg) was found from P_2, whereas the lowest yield per plot (2.93 kg) was obtained from P_1 at 45 DAS. At 60 DAS, the highest yield per plot (3.75 kg) was observed from P_2 and the lowest yield per plot (3.37 kg) was found from P_1. The highest yield per plot (4.23 kg) was recorded from P_2, which was statistically similar (4.13 kg) with P_1 while the lowest yield per plot (3.77 kg) was obtained from P_1 at 75 DAS (Figure 10). Totally, the highest yield per plot (13.39 kg) was recorded from P_2, which was closely followed (12.68 kg) by P_3 while the lowest yield per plot (11.82 kg) was obtained from P_1(Figure 12). These findings were similar with Hossain *et al.* (1983) and Quader (2007).

A statistically significant difference was recorded for different spacing in terms of yield per plot of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix IX). The highest yield per plot (2.10 kg) was observed from S_3 (60 cm × 50 cm), again the lowest yield per plot (1.62 kg) was recorded from S_1 (60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest yield per plot (3.45 kg) was recorded from S_3, which was statistically similar (3.41 kg) with S_4. On the other hand the lowest yield per plot (2.56 kg) was obtained from S_1. The highest yield per plot (4.03 kg) was recorded from S_3, which was statistically similar (3.89 kg) with S_4 whereas the lowest yield per plot (2.89 kg) was recorded from S_1 at 60 DAS. At 75 DAS, the highest yield per plot (4.54 kg) was found in S_3, which was statistically similar (4.42 kg) with S_4, while the lowest yield per plot (3.33 kg) was recorded from S_1(Figure 11). Totally the highest yield per plot (14.11 kg) was found in S_3, which closely followed (13.64 kg) by S_4, while the lowest yield per plot (10.39 kg) was recorded from S_1 (Figure 13). This finding was supported by Lee (1983) and Islam (2008).



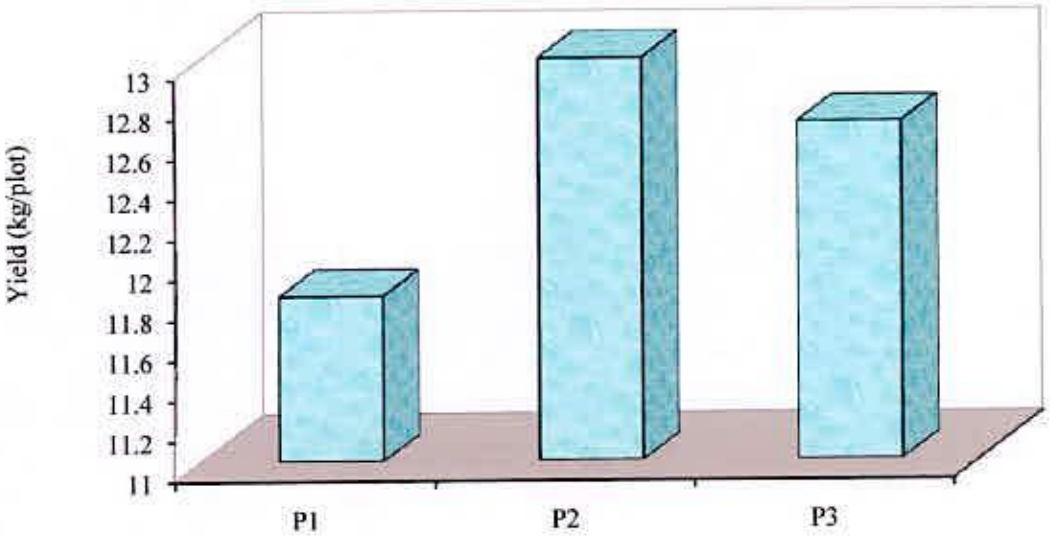
P_1: 10 March
P_2: 25 March
P_3: 9 April

Figure 10. Effect of planting time on yield per plot on different DAS of harvesting of Indian spinach



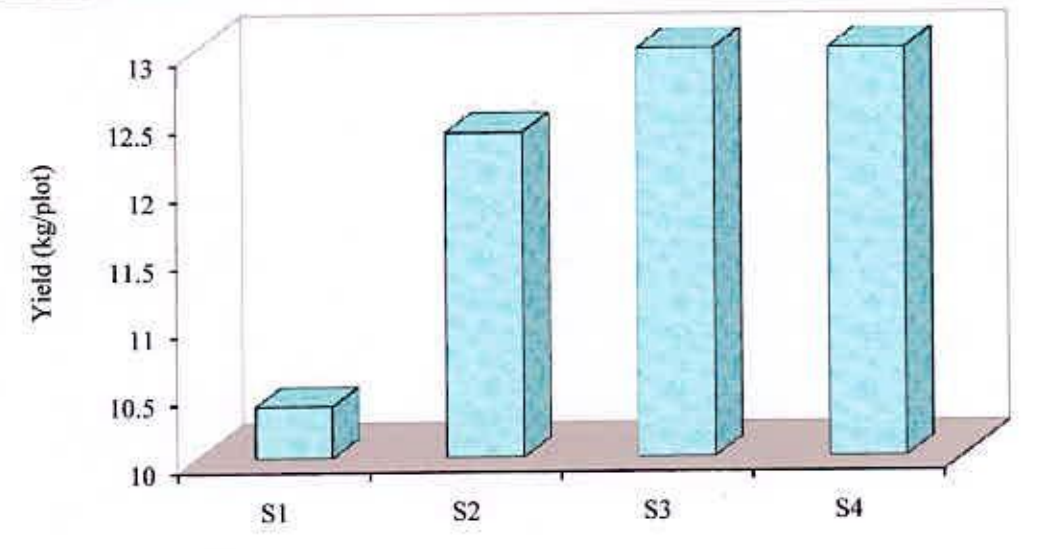
S_1: 60 cm 30 cm S_2: 60 cm 40 cm
S_3: 60 cm 50 cm S_4: 60 cm 60 cm

Figure 11. Effect of spacing on yield per plot on different DAS of harvesting of Indian spinach



P_1: 10 March 2008
P_2: 25 March 2008
P_3: 9 April 2008

Figure 12. Effect of planting time on yield per plot of Indian spinach



S_1: 60 cm 30 cm
S_2: 60 cm 40 cm
S_3: 60 cm 50 cm
S_4: 60 cm 60 cm

Figure 13. Effect of spcing on yield per plot of Indian spinach

Interaction effect of planting time and spacing varied significantly in terms of yield per plot of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix IX). The highest yield per plot (2.32 kg) was recorded from the treatment combination of P_2S_3 (25 March and 60 cm × 50 cm) while the lowest (1.48 kg) was obtained from P_1S_1 (10 March and 60 cm × 30 cm) at 30 DAS. At 45 DAS, the highest yield per plot (3.90 kg) was found in P_2S_3 and the lowest (2.29 kg) was recorded from P_1S_1. The highest yield per plot (4.30 kg) was recorded from P_2S_3 and the lowest (2.77 kg) was recorded from P_1S_1 at 60 DAS. At 75 DAS, the highest yield per plot (4.77 kg) was observed from P_2S_3, whereas the lowest (3.29 kg) was found from P_1S_1 (Table 10). Totally, the highest yield per plot (15.29 kg) was observed from P_2S_3, whereas the lowest (9.83 kg) was found from P_1S_1 (Table 10).

Table 10. Interaction effect of planting time and spacing on yield per plot of Indian Spinach

Treatment	Yield (kg/plot) at				
	30 DAS	45 DAS	60 DAS	75 DAS	Total
P_1S_1	1.48 e	2.29 f	2.77 f	3.29 e	9.83 i
P_1S_2	1.86 cd	3.02 d	3.23 e	3.68 cd	11.80 g
P_1S_3	2.01 bc	3.18 cd	3.78 cd	4.05 bc	13.02 de
P_1S_4	1.66 de	3.23 c	3.70 cd	4.04 bc	12.63 ef
P_2S_1	1.55 e	2.69 e	2.96 ef	3.32 e	10.52 hi
P_2S_2	2.01 bc	3.30 c	3.62 d	4.20 b	13.13 de
P_2S_3	**2.32 a**	**3.90 a**	**4.30 a**	**4.77 a**	**15.29 a**
P_2S_4	2.18 ab	3.68 b	4.12 ab	4.62 a	14.61 ab
P_3S_1	1.82 cd	2.69 e	2.93ef	3.38 de	10.82 h
P_3S_2	1.88 cd	3.02 d	3.59 d	3.75 c	12.23 fg
P_3S_3	1.97 bc	3.27 c	3.99 abc	4.80 a	14.02 bc
P_3S_4	1.89 cd	3.32 c	3.86 bcd	4.59 a	13.67 cd
$LSD_{(0.05)}$	0.214	0.169	0.303	0.343	0.704
Level of Significance	0.01	0.01	0.05	0.05	0.05
CV(%)	6.79	7.27	8.97	5.03	6.29

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

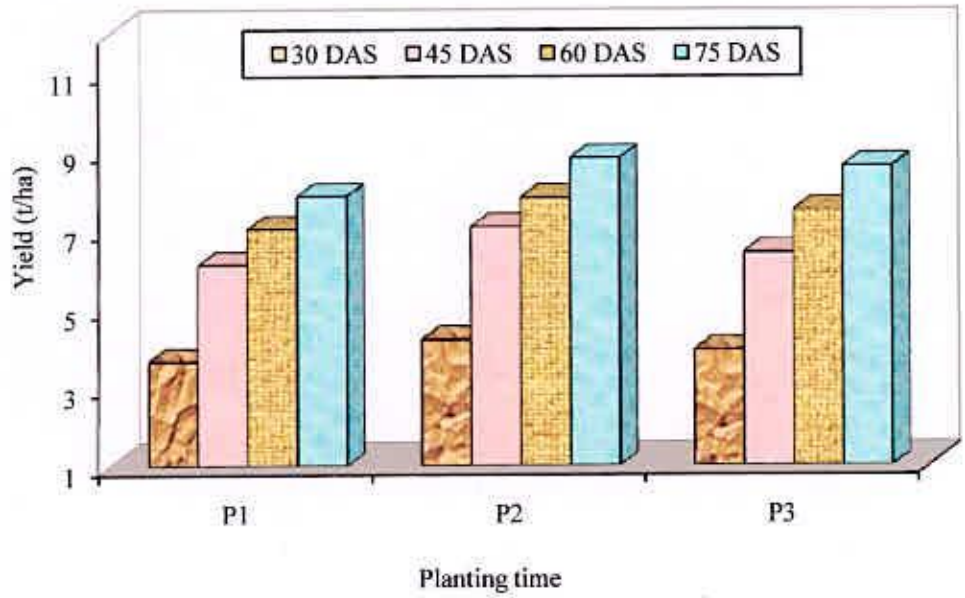
P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm

4.8 Yield per hectare

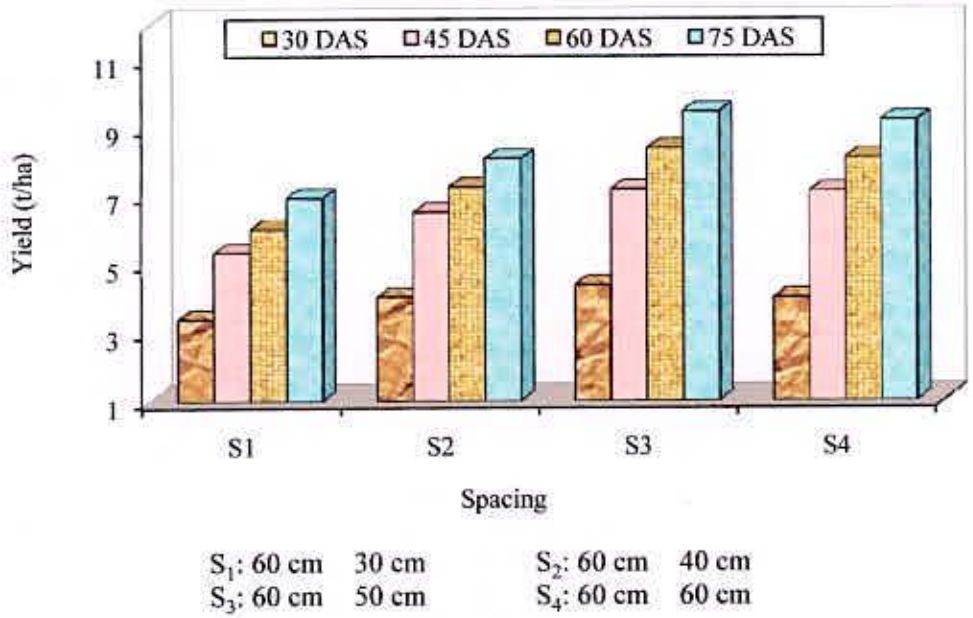
Yield per hectare of Indian Spinach showed a statistically significant difference due to different planting time at 30, 45, 60 and 75 DAS (Appendix X). At 30 DAS, the highest yield (4.20 t/ha) was found in P_2 (25 March) and the lowest yield (3.65 t/ha) was obtained form P_1 (10 March). The highest yield (7.07 t/ha) was recorded from P_2, while the lowest yield (6.11 t/ha) was recorded from P_1 at 45 DAS. At 60 DAS, the highest yield (7.81 t/ha) was obtained from P_2 and the lowest yield (7.02 t/ha) was recorded from P_1. The highest yield (8.81 t/ha) was observed from P_2, which was statistically similar (8.60 ton) with P_1 again the lowest yield (7.85 t/ha) was found in P_1 at 75 DAS (Figure 14). Totally the highest yield (27.90 t/ha) was observed from P_2, which was closely followed (26.43 ton) by P_2 again the lowest yield (24.62 t/ha) was found in P_1 (Figure 16). These findings were similar with Hossain *et al.* (1983), Kazim *et al.*(2000) and Quader (2007).

Different spacing showed significant differences on yield of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix X). The highest yield (4.37 t/ha) was obtained from S_3 (60 cm × 50 cm) while the lowest yield (3.37 t/ha) was recorded from S_1 (60 cm × 30 cm) at 20 DAS. In case of 45 DAS, the highest yield (7.18 t/ha) was found in S_3, which was statistically similar (7.11 t/ha) with S_4. On the other hand the lowest yield (5.32 t/ha) was recorded from S_1. The highest yield (8.39 t/ha) was recorded from S_3, which was statistically similar (8.11 t/ha) with S_4, whereas the lowest yield (6.01 t/ha) was obtained from S_1 at 60 DAS. At 75 DAS, the highest yield (9.46 t/ha) was found in S_3, which was statistically similar (9.21 t/ha) with S_4 and the lowest yield (6.93 t/ha) was obtained from S_1 (Figure 15). Totally, the highest yield (29.40 t/ha) was found in S_3 and the lowest yield (21.64 t/ha) was obtained from S_1 (Figure 17). These findings were similar with Islam *et al.* (1984), Moore *et al.* (1984) and 2004 Islam (2008).



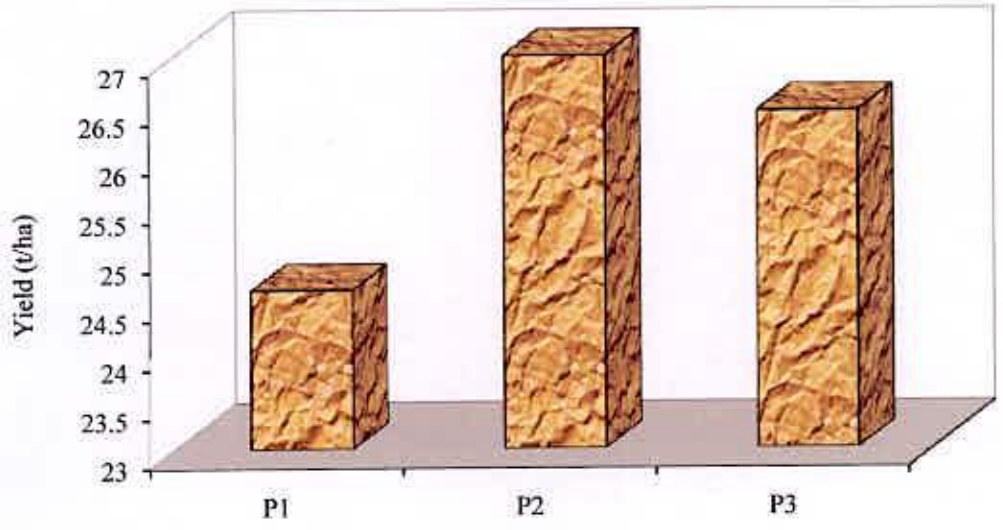
P_1: 10 March
P_2: 25 March
P_3: 9 April

Figure 14. Effect of planting time on yield per hectare on different DAS of harvesting of Indian spinach



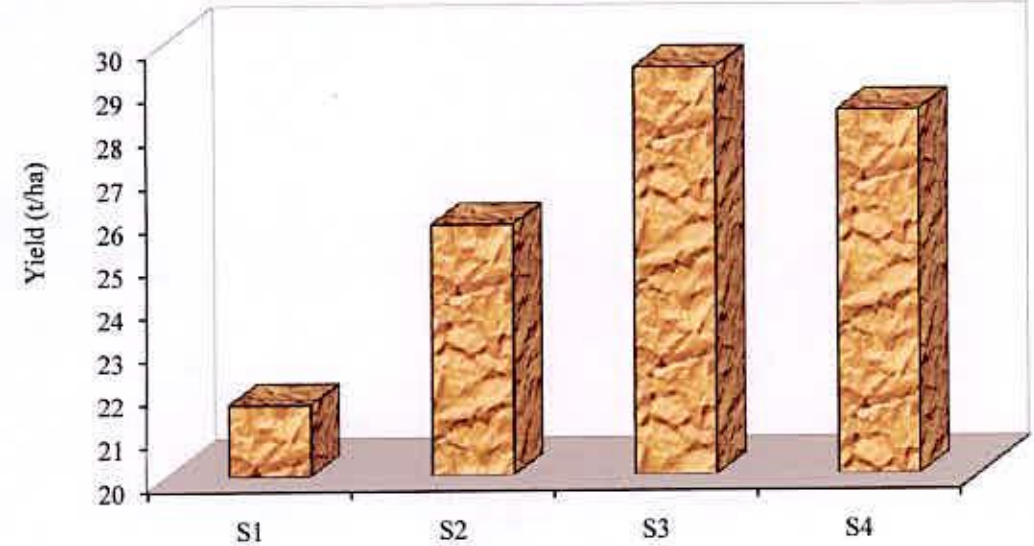
S_1: 60 cm 30 cm S_2: 60 cm 40 cm
S_3: 60 cm 50 cm S_4: 60 cm 60 cm

Figure 15. Effect of spacing on yield per hectare on different DAS of harvesting Indian spinach



P_1: 10 March
P_2: 25 March
P_3: 9 April

Figure 16. Effect of planting time on yield per hectare of Indian spinach



S_1: 60 cm 30 cm S_2: 60 cm 40 cm
S_3: 60 cm 50 cm S_4: 60 cm 60 cm

Figure 17. Effect of spcing on yield per hectare of Indian spinach

In combined effect of planting time and spacing showed a significant difference in terms of yield of Indian Spinach at 30, 45, 60 and 75 DAS (Appendix X). The highest yield (4.84 t/ha) was found in P_2S_3 (25 March and 60 cm × 50 cm) and the lowest (3.09 ton) was recorded from P_1S_1 (10 March and 60 cm × 30 cm spacing) at 30 DAS. At 45 DAS, the highest yield (8.12 t/ha) was recorded from P_2S_3 and the lowest (4.76 t/ha) was recorded from P_1S_1. The highest yield (8.96 t/ha) was obtained from P_2S_3, while the lowest (5.76 t/ha) was recorded from P_1S_1 at 60 DAS. At 75 DAS, the highest yield (9.63 t/ha) was found from P_2S_3 and the lowest (6.85 ton) was recorded from P_1S_1 (Table 11). Totally, the highest yield (31.85 t/ha) was found from P_2S_3 and the lowest (20.47 t/ha) was recorded from P_1S_1 (Table 11).

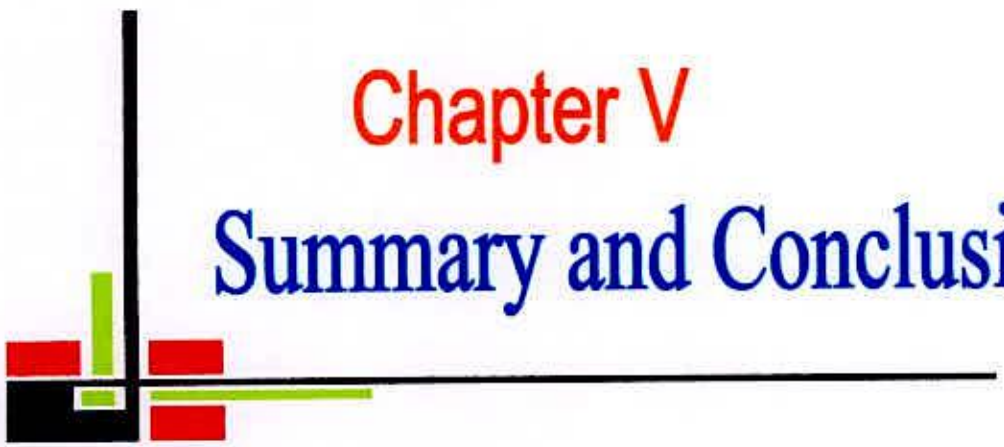
Table 11. Interaction effect of planting time and spacing on yield per hectare of Indian Spinach

Treatment	Yield (t/ha) at				
	30 DAS	45 DAS	60 DAS	75 DAS	Total
P_1S_1	3.09 e	4.76 f	5.76 f	6.85 e	20.47 i
P_1S_2	3.88 cd	6.30 d	6.72 e	7.68 cd	24.58 g
P_1S_3	4.18 bc	6.63 cd	7.87 cd	8.44 bc	27.12 de
P_1S_4	3.45 de	6.74 c	7.71 cd	8.42 bc	26.32 ef
P_2S_1	3.24 e	5.60 e	6.17 ef	6.92 e	21.92 hi
P_2S_2	4.20 bc	6.87 c	7.54 d	8.75 b	27.36 de
P_2S_3	**4.84 a**	**8.12 a**	**8.96 a**	**9.94 a**	**31.85 a**
P_2S_4	4.55 ab	7.68 b	8.59 ab	9.63 a	30.44 ab
P_3S_1	3.78 cd	5.61 e	6.11 ef	7.03 de	22.53 h
P_3S_2	3.91 cd	6.30 d	7.47 d	7.81 c	25.48 fg
P_3S_3	4.10 bc	6.81 c	8.32 abc	9.99 a	29.22 bc
P_3S_4	3.94 cd	6.92 c	8.04 bcd	9.57 a	28.47 cd
$LSD_{(0.05)}$	0.451	0.363	0.627	0.716	1.467
Level of Significance	0.01	0.01	0.05	0.05	0.05
CV(%)	6.79	7.27	8.97	5.03	6.29

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

P_1: 10 March
P_2: 25 March
P_3: 9 April

S_1: 60 cm × 30 cm
S_2: 60 cm × 40 cm
S_3: 60 cm × 50 cm
S_4: 60 cm × 60 cm



Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Present experiment was conducted to investigate the effect of planting time and spacing on the growth and yield of Indian Spinach at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to July 2008. There were three Planting times viz. P_1 : 10 March; P_2 : 25 March and P_3 : 9 April and four levels of spacing; S_1: 60 cm × 30 cm; S_2: 60 cm × 40 cm; S_3: 60 cm × 50 cm and S_4: 60 cm × 60 cm. The experiment was laidout out in Randomized Complete Block Design (RCBD) with three replications.

At 30, 45, 60 and 75 DAS, the longest plant (33.26 cm, 57.54 cm, 78.03 cm and 85.81 cm) was found in P_2 and the shortest plant (28.55 cm, 52.84 cm, 71.75 cm and 79.35 cm) was recorded form P_1. The highest number of branches per plant (1.63, 4.04, 9.28 and 12.01) was found in P_2 and the lowest (1.11, 3.62, 8.17 and 11.55) was recorded form P_1. The highest number of leaves per plant (21.90, 34.99, 42.84 and 68.99) was found form P_2 and the lowest (20.35, 32.99, 40.94 and 66.41) was recorded form P_1. The maximum leaf area index (36.08 cm^2, 121.17 cm^2, 245.90 cm^2, 333.28 cm^2,) was found in P_2 and the minimum (32.95 cm^2, 111.18 cm^2, 231.22 cm^2, 296.85 cm^2) was recorded form P_1. The maximum fresh weight of leaves and twigs per plant (146.11 g, 172.32 g, 243.99 g and 352.10 g) was found in P_2 and the minimum (128.08 g, 159.46 g, 224.87 g and 320.96 g) was recorded form P_1. The highest dry matter content (8.55%, 10.54%, 12.15% and 14.42 g) was obtained form P_2 and the lowest (6.88%, 8.62%, 10.27% and 12.50%) was recorded form P_1. The highest yield per plot (2.02 kg, 3.39 kg, 3.75 kg and 4.23 kg) was found in P_2 and the lowest (1.75 kg, 2.93 kg, 3.37 kg and 3.77) was observed form P_1. The highest yield per hectare (4.20 ton, 7.07 ton, 7.81 ton and 8.81 ton) was obtained form P_2 and the lowest (3.65 ton, 6.11 ton, 7.02 ton and 7.85 ton) was recorded form P_1. Totally the highest yield (27.90 t/ha) was observed from P_2 again the lowest (24.62 t/ha) was found in P_1.

In case of 30, 45, 60 and 75 DAS, the longest plant (33.21 cm, 58.31 cm, 80.73 cm and 91.59 cm) was found in S_3 and the shortest plant (26.62 cm, 49.54 cm, 65.15 cm and 70.82 cm) was recorded form S_1. The highest number of branches per plant (1.62, 3.99, 9.06 and 12.33) was obtained form S_3 and the lowest (1.04, 3.32, 7.90 and 10.94) was recorded form S_1. The highest number of leaves per plant (21.98, 35.08, 43.73 and 70.29) was found in S_3 and the lowest (19.67, 31.23, 38.36 and 64.13) was observed form S_1. The maximum leaf area index (36.09 cm^2, 121.71 cm^2 255.67 cm^2, 343.38 cm^2,) was obtained form S_3 and the minimum (31.65 cm^2, 102.22 cm^2, 207.20 cm^2 and 278.51 cm^2,) was recorded form S_1. The maximum fresh weight of leaves and twigs per plant (145.38 g, 172.00 g, 254.17 g and 376.86 g) was found in S_3 and the minimum (121.79 g, 148.82 g, 202.01 g and 275.58 g) was obtained form S_1. The highest dry matter content (8.17%, 10.13%, 11.56% and 13.86 %) was found in S_3 and the lowest (6.65%, 8.24%, 9.89% and 12.18%) was recorded form S_1. The highest yield per plot (2.10 kg, 3.45 kg, 4.03 kg and 4.54 kg) was found in S_3 and the lowest (1.62 kg, 2.56 kg, 2.89 kg and 3.33) was recorded form S_1. The highest yield per hectare (4.37 ton, 7.18 ton, 8.39 ton and 9.46 ton) was obtained form S_3 and the lowest (3.37 ton, 5.32 ton, 6.01 ton and 6.93 ton) was recorded form S_1. Totally, the highest yield (29.40 t/ha) was found in S_3, and the lowest (21.64 t/ha) was obtained from S_1.

At 30, 45, 60 and 75 DAS, the longest plant (36.69 cm, 61.87 cm, 86.48 cm and 97.96 cm) was obtained from the treatment combination of P_2S_2 and the shortest plant (24.56 cm, 47.57 cm, 64.39 cm, 67.47 cm) was observed from P_2S_1. The highest number of branches per plant (2.03, 4.42, 9.82 and 12.89) was found in the treatment combination of P_2S_3 and the lowest (0.89, 3.16, 7.79 and 10.89) was recorded from P_1S_1. The highest number of leaves per plant (24.02, 36.64, 45.23 and 71.79) was recorded from the treatment combination of P_2S_3 and the lowest (18.85, 30.93, 37.78 and 64.01) was obtained from P_2S_1. The maximum leaf area index (38.68 cm^2, 129.34 cm^2, 269.39 cm^2 and 362.41cm^2) was found in the treatment combination of P_2S_3 and the minimum

(30.20 cm^2, 100.38 cm^2, 195.80 cm^2 and 273.68 cm^2) was recorded from P_2S_1. The maximum fresh weight of leaves and twigs per plant (166.10 g, 182.51 g, 265.60 g, and 399.76 g) was obtained from the treatment combination of P_2S_3 and the minimum (117.60 g, 147.08 g, 196.37 g and 266.01 g) was recorded from P_2S_1. The highest dry matter content (9.76%, 11.99%, 13.39% and 15.85%) was observed from the treatment combination of P_2S_3 and the lowest (6.66%, 8.01%, 9.44%and 12.16%) was found in P_1S_1. The highest yield per plot (2.32 kg, 3.90 kg, 4.30 kg and 4.77 kg) was obtained from the treatment combination of P_2S_3 and the lowest (1.48 kg, 2.29 kg, 2.77 kg and 3.29 kg) was recorded from P_1S_1. The highest yield (4.84 t/ha, 8.12 t/ha, 8.96 t/ha and 9.63 t/ha) was found in the treatment combination of P_2S_3 and the lowest (3.09 ton, 4.76 ton, 5.76 ton and 6.85 ton) was observed from P_1S_1. Totally, the highest yield (31.85 t/ha) was found in P_2S_3 and the lowest (20.47 t/ha) was recorded from P_1S_1.

Conclusion:

Among the treatment combination planting time P_2 (25 March) and spacing S_3 (60 cm × 50 cm) was more effective for yield and yield contributing characters of Indian Spinach

Considering the findings of the present experiment, further studies in the following areas may be suggested:

1. Such study was needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Another planting time may be included for drawing conclusion.
3. Another spacing may be used for further study in order to get higher yield.

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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 March to July 08

Year	Month	Average air temperature (^{0}C)			Total rainfall (mm)	Average relative humidity (%)	Total sunshine hours
		Maximum	Minimum	Mean			
2008	March	34.6	16.5	26.6	45	67	5.9
	April	36.9	19.6	29.2	91	64	8.5
	May	36.7	20.3	29.3	205	70	7.7
	June	35.4	22.5	28.7	577	80	4.2
	July	36.0	24.6	28.5	563	83	3.1

* 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 Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
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 of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	6.048	21.789	6.279	4.877
Planting time (A)	2	67.718**	72.663**	119.421**	127.513**
Spacing (B)	3	73.403**	127.707**	428.510**	753.979**
Interaction (A×B)	6	24.520**	28.216**	18.449*	49.951*
Error	22	5.417	7.819	8.389	17.674

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

Appendix IV. Analysis of variance of the data on number of branches per plant of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Number of branches per plant at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	0.025	0.028	0.132	0.337
Planting time (A)	2	0.822**	0.855**	4.071**	0.642*
Spacing (B)	3	0.530**	0.746**	2.450**	3.192**
Interaction (A×B)	6	0.199**	0.176**	1.952**	0.438*
Error	22	0.022	0.029	0.211	0.162

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

Appendix V. Analysis of variance of the data on number of leaves per plant of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Number of leaves per plant at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	0.162	1.001	0.574	4.467
Planting time (A)	2	7.163**	15.723**	10.789**	20.995**
Spacing (B)	3	9.471**	25.634**	52.925**	67.120**
Interaction (A×B)	6	3.231**	3.500**	2.612*	3.017*
Error	22	0.718	0.660	1.012	1.773

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

Appendix VI. Analysis of variance of the data on leaf area index of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Mean square			
		Leaf area index (cm^2) at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	1.602	9.487	56.776	13.776
Planting time (A)	2	29.589**	400.17**	657.516**	4663.671**
Spacing (B)	3	33.793**	653.55**	4205.04**	7506.444**
Interaction (A×B)	6	10.153**	90.562**	409.650*	386.881*
Error	22	1.962	17.143	127.155	140.705

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

Appendix VII. Analysis of variance of the data on fresh weight of leaves and twigs per plant of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Mean square			
		Fresh weight of leaves and twigs in grams (g) per plant at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	19.977	65.463	79.171	8.867
Planting time (A)	2	999.596**	620.081**	1105.605**	3103.319**
Spacing (B)	3	927.055**	966.271**	5354.321**	18379.77**
Interaction (A×B)	6	254.521**	113.061*	137.992**	840.297*
Error	22	35.039	49.379	68.778	292.982

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

Appendix VIII. Analysis of variance of the data on dry matter content (%) of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom				
		Dry matter content (%)			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	0.760	0.348	0.013	0.030
Planting time (A)	2	10.033**	13.615**	14.108**	14.132**
Fertilizers (B)	3	3.556**	5.539**	4.655**	4.681**
Interaction (A×B)	6	0.891**	1.425**	1.296*	1.812*
Error	22	0.212	0.333	0.501	0.569

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

Appendix IX. Analysis of variance of the data on yield per plot of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Mean square			
		Yield (kg/plot) at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	0.009	0.022	0.035	0.003
Planting time (A)	2	0.212**	0.670**	0.442**	0.707**
Spacing (B)	3	0.356**	1.534**	2.363**	2.778**
Interaction (A×B)	6	0.074**	0.067**	0.125*	0.132*
Error	22	0.016	0.010	0.032	0.041

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

Appendix X. Analysis of variance of the data on hectare of Indian Spinach as influenced by planting time and spacing

Source of variation	Degrees of freedom	Yield (t/ha) at			
		20 DAS	40 DAS	60 DAS	80 DAS
Replication	2	0.038	0.094	0.153	0.013
Planting time (A)	2	0.920**	2.908**	1.920**	3.068**
Spacing (B)	3	1.547**	6.659**	10.256**	12.056**
Interaction (A×B)	6	0.323**	0.292**	0.907*	0.571*
Error	22	0.071	0.046	0.137	0.179

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