EFFECT OF SPACING AND HARVESTING INTERVAL ON THE GROWTH AND YIELD OF INDIAN SPINACH (*Basella alba* L.)

BY

REG. NO. : 00797

A Thesis
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 (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2008

APPROVED BY:

Prof. Md. Ruhul Amin
Dept. of Horticulture and Postharvest Technology
SAU, Dhaka
Supervisor

Dr. Abul Faiz Md. Jamal
Assistant Professor
Dept. of Horticulture and Postharvest Technology
SAU, Dhaka
Co-Supervisor

Prof. Md. Ruhul Amin
Chairman
Examination Committee

SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA-1207.

PABX: 9144270-9
Fax: 9112649
Website: www.sau.edu.bd

CERTIFICATE

This is to certify that the thesis entitled ***"Effect of Spacing and Harvesting Interval on the Growth and Yield of Indian Spinach"*** *submitted to the Dept. of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* ***A. B. M. Jamiul Islam****, Registration number 00797 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:30. 06. 2008
Place:Dhaka, Bangladesh

Prof. Md. Ruhul Amin
Dept. of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor


DEDICATED
TO
MY BELOVED PARENTS

ACKNOWLEDGEMENTS

The author first wants to express his enormous sense of gratefulness to the Almighty Allah for His countless blessing, love, support, protection, guidance, wisdom and assent to successfully complete MS degree.

The author like to express his deepest sense of sincere appreciation to his respected supervisor, Prof. Md. Ruhul Amin, Chairman, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.

The author also expresses his gratefulness and best regards to respected Co-Supervisor, Dr. Abul Faiz Md. Jamal Uddin, Assistant Professor, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and preparation of the thesis.

The author also expresses heartfelt thanks to all the teachers of the Department of Horticulture and Postharvest Technology, SAU, for their valuable suggestions, instuctions and encouragement during the study period. The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

EFFECT OF SPACING AND HARVESTING INTERVAL ON THE GROWTH AND YIELD OF INDIAN SPINACH

By

A. B. M. JAMIUL ISLAM

ABSTRACT

Present experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka, during the period from March to July 2007. The experiment consisted with two factors. Factor A: Four plant spacing viz. S_1: 50 cm × 30 cm, S_2: 50 cm × 40 cm, S_3: 50 cm × 50 cm and S_4: 50 cm × 60 cm and factor B: Three harvesting intervals viz. H_1: 10 days, H_2: 15 days and H_3: 20 days. In case of plant spacing, the longest plant (34.48 cm), maximum number of branches (6.25) and the highest yield (22.69t/ha) was recorded from S_3, while all the above parameter was lowest at S_1. For harvesting intervals, the longest plant at harvest (41.63 cm), maximum number of branches per plant (6.01) and the highest yield (21.57 t/ha) was recorded from H_2 and was the lowest at H_1. For combined effect, the longest plant (44.45 cm), maximum number of branches per plant (6.48) and the highest yield (23.73 t/ha) was from S_3H_2 and all the above parameters were lowest at S_1H_1. So, 50 cm× 50 cm plant spacing and harvesting interval of 15 days were more effective for growth and yield of Indian Spinach.

TABLE OF CONTENTS

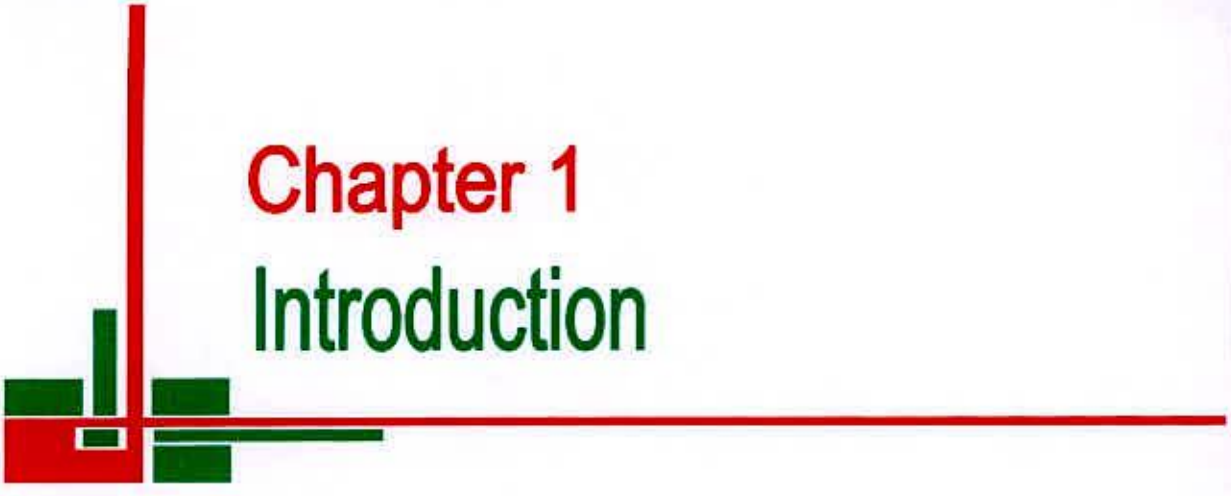
LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATION

Agril.	=	Agriculture
@	=	At the rate of
^{0}C	=	Degree Celsius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
cv.	=	Cultivar
DAS	=	Days after sowing
Dept.	=	Department
DMRT	=	Duncan's MULTIPLE Range Test
et al.	=	And others
Fig.	=	Figure
FYM	=	Farm Yard Manure
G	=	Gram
ha	=	Hectare
HI	=	Harvest Index
Hort.	=	Horticulture
i.e.	=	That is
J.	=	Journal
K	=	Potassium
Kg	=	Kilogram
L	=	Litre
LAD	=	Leaf Area Duration
LAI	=	Leaf Area Index
LSD	=	Least Significant Difference
meq	=	Mill equilibrium
mg	=	Milligram
ml	=	Milliliter
MP	=	Murate of Potash
N	=	Nitrogen
P	=	Phosphorus
ppm	=	Parts per million
q/ha	=	Quintal per hectare
RCBD	=	Randomized Complete Block Design
Res.	=	Research
S.	=	Soil
Sci.	=	Science
SRDI	=	Soil Resources and Development Institute
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
viz.	=	Namely



Chapter 1
Introduction

Chapter I

INTRODUCTION

Indian spinach (*Basella alba* L.) commonly known as "poi" belongs to the family Basellaceae. 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 and fruit is enclosed in fleshy perianth. There are mainly two distinct types, *Basella alba* and *Basella rubra,* one with green leaves, petioles and stems and the other with reddish petioles and stems.

Basellaceae is a popular summer leafy vegetable widely cultivated in Bangladesh and India. It is very popular vegetable in Bangladesh. Both the green and red cultivars are consumed as vegetables. 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.

Nutritive value of Indian spinach is very high with a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and that of water (Ghosh and Guha, 1933). The plant is reported to contain moisture 93%, Protein 1.2%, Iron 1.4%, Calcium 0.15%, Vitamin A 3250 IU/100g. In addition to these, *Basella alba* contains 16g fluoride/100g and nitrate content is 764 ppm on dry weight basis (Sanni, 1983). There was no loss of nitrate

even after 48 hrs of cold storage. Moreover, it is anadyne, sedative, diuretic and expectorant (Kallo, 1986).

Plant spacing is an 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 up to 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.

Harvesting interval can also influence the yield of Indian Spinach. It has been recommended to start harvesting the crop at the 30th day after sowing (Anon., 1983). The leaves and tender stems are the edible portion of this crop. Naturally hard fibrous shoots are unfit for its consumption. For the production of Indian Spinach harvesting time is particularly important when several harvestings are done from a single plant.

So plant spacing and the harvesting interval are to be taken into consideration simultaneously for attaining good quality and reasonable yield. One can not

sacrifice much to achieve the other. Moreover, harvesting interval is correlated with the economic return by ensuring the highest market price.

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

1. To determine the suitable plant spacing for optimum growth and higher yield.

2. To determine the optimum schedule of harvesting interval for attaining quality and the maximum yield.

3. To find out the suitable combination of plant spacing and harvesting interval for attaining desirable growth and yield.

Chapter 2

Review of literature

Chapter II

REVIEW OF LITERATURE

Indian Spinach is one of the important vegetables grown in Bangladesh as well as in many other countries of the world. The crop has received conventional less attention of the researchers on its various aspects because normally it grows with less care or management practices. For that a very few studies on growth, yield and development of Indian Spinach have been carried out in our country as well as in many other countries of the world. Hence, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important works and researches related to the plant spacing and harvesting interval so far done at home and abroad on different vegetable crops production including Indian Spinach has been reviewed in this chapter under the following headings.

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 up to a certain level and then decreased. With highest spacing per plant yield increased up to 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 rows 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 harvesting 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 spacing 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).

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 harvesting 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 were sown in for the 1st experiment with 4 spacing (60 × 45, 60 × 60, 90 × 45 and 90 × 60, cm) and in the second experiment with 5 spacing (45 × 45, 60 × 45, 60 × 60, 90 × 45, 90 × 60). These spacing 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, and 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 harvesting index. These parameters, and seed yield, were all positively correlated with light interception.

Hill (1990) conducted an experiment 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 spacing 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.

2.2 Effect of harvesting intervals

Kasture *et al.* (2002) conducted an experiment at the main Horticulture garden during the rabi season of 1997-98, to study the effect of four levels of cuttings and two Indian spinach cultivars on seed yield and quality. Regarding the cutting levels, one cutting level was found to be significantly superior over the other levels in respect to seed yield per plant, seed yield per plot and per hectare.

Kasture *et al.* (2000) carried out an experiment to study the response of levels of cutting on the growth of green leaves of Indian spinach of the cultivars. All Green and Pusa Jyoti were significantly superior over all Green with respect of length of petiole and average leaf area per plant. As a response to cutting, All Green produced greater numbers of leaves compared with Pusa Jyoti. However, height of plant was similar in both varieties.

Tindal (1983) conducted an experiment to study the effect of harvesting interval on the yield of Kangkong. At the time of harvesting, two things are to be taken into consideration simultaneously i) good quality and ii) reasonable yield. In wider harvesting interval, higher yield per harvesting is obtained, but most of the foliage became fibrous and unfit for consumption. In kangkong, three to four harvestings could be obtained from one plant.

Rashid (1993) was carried an experiment with Gimakalmi. In a trial after three weeks from first harvesting, the ratoon of Gimakalmi became fit for harvesting, and by following this practice, maximum yield was obtained.

Awal (1989) carried out an experiment at IPSA, Salna, Gazipur during Kharif season of 1986 to study the effect of four manuring doses (0, 10, 30 and 60 t/ha of cow dung) and harvesting frequency (17, 21 and 25 days) on growth and yield of Gimakalmi. The total yield was highest (68.82 t/ha) at 25 days harvesting frequency which was statistically similar to that (65.82 t/ha) produced by 17 days harvesting frequency. Although 25 days harvesting frequency produced the highest yield, most of the foliage became fibrous and unfit for consumption.

Rahman *et al.* (1985) conducted an experiment to see the effect of spacing and harvesting interval on the growth and yield of Indian spinach (Puisak) at the Central Research Station of BARI at Joydevpur. They reported that the highest number of shoots per plant was obtained from the quicker harvesting (8 days interval) and this was reflected as the highest yield (41.11 t/ha), while yield per hectare decreased with the increase of harvesting interval.

Rahman and Hossain (1985) studied the growth and yield of Indian spinach under trellis vs non-trellis when harvesting at different intervals. First harvesting of shoots was done after 35 days of sowing, and subsequent harvesting was done at intervals of 8, 12 and 16 days from first harvesting. Harvesting at different intervals showed wide variation in the weight of shoot per plant. The highest shoot weight (0.95 kg/plant) from the quickest harvesting interval of 8 days contributed towards the highest yield (20.32 t/ha) and yield gradually decreased with the increase of harvesting interval.

Anon. (1983) conducted an experiment to study the effect of harvesting interval on the yield of Gimakalmi, first harvesting should be done after 30 days of seed sowing and the subsequent harvesting should be done at 15 days interval from first harvesting for obtaining the good quality and maximum yield of Gimakalmi.

Anon. (1982) carried out a study on adaptability and performance of kanghong (Ipomoea reptans), the maximum yield was obtained at the second harvesting. Thereafter, the yield decreased. It was also observed that after 4th harvesting, the yield declined abruptly and the foliage was no longer tender to be consumed as vegetable

Singh and Chatterjee (1968) found increased yield at the lower frequency of cutting of 12 perennial grasses. When the frequency of cutting grasses was reduced from 8 to 4 weeks, the mean number of tillers and leaves and total dry matter yield were reduced to half and the leaf area to a quarter (Hill and Pearson, 1985). It was reported by Wolf *et al.* (1962) that the productivity of many grass species decreases with increasing clippling frequency. Beaty *et al.* (1965) mentioned that 5 weeks harvesting frequency produced 46% more yield than two weeks harvesting frequency.

Oakes (1966) found increased forage yield with increasing harvesting interval although the protein content of forage crop decreased. Moline and Wedin (1963) found that reduced yield of alfalfa due to early first harvesting was compensated for by the increased yield of dry matter of the second harvesting. They found an increase in the crude with advanced maturity of alfalfa.

Chapter 3

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 2007 to find out the effect of plant spacing and harvesting interval 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 Characteristics of soil

Experimental site belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and had dark grey terrace soil. Selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). Characteristics of the soil under the experimental plot were analyzed in Soil Testing Laboratory, SRDI, Khamarbari, and Dhaka. Details of the recorded soil characteristics were presented in Appendix I.

3.3 Weather condition of the experimental site

Experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or 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 II.

3.4 Planting materials

Indian Spinach seed was used as the planting material and the seed were collected from Siddique Bazar, Gulistan, and Dhaka. Seed rate was @ 1000 g/ha.

3.5 Treatment of the experiment

The experiment had of two factors. Details were presented below:

Factor A: Four levels of spacing

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

Factor A: Three levels of harvesting interval

i. H_1: Harvesting at 10 days interval
ii. H_2: Harvesting at 15 days interval
iii. H_3: Harvesting at 20 days interval

There were 12 (4 × 3) treatment combinations such as S_1H_1, S_1H_2, S_1H_3, S_2H_1, S_2H_2, S_2H_3, S_3H_1, S_3H_2, S_2H_3, S_4H_1, S_4H_2 and S_4H_3.

3.6 Design and layout of the experiment

Two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area 24.5 m × 20.0 m was divided into three equal blocks. Layout of the experiment was prepared for distributing the treatment combinations in every individual plot of each block. Each block was divided into

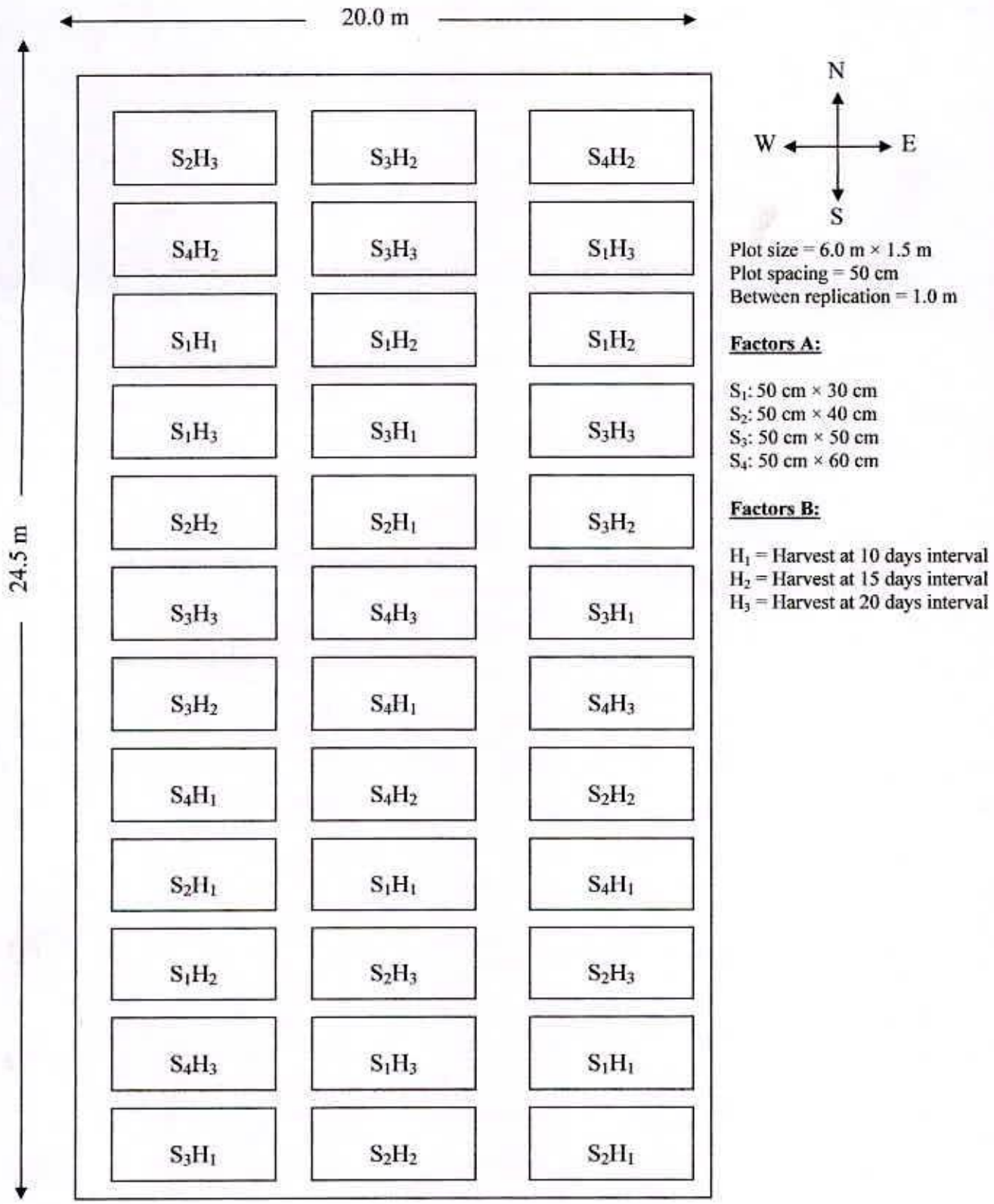


Figure 1. Layout of the experimental plot

12 plot where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. Size of the each plot was 6.0 m × 1.5 m. Distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively (Figure 1).

3.7 Land preparation

The plot selected for conducting the experiment was opened in the first week of March 2007 with a power tiller, and was kept exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth condition. Weeds and stubbles were removed, and finally a desirable tilth of soil was obtained for sowing seeds of Indian Spinach. Experimental plot was partitioned into unit plots in accordance with the experimental design

3.8 Application of manure and fertilizers

Recommended doses of well-decomposed cow dung and chemical fertilizers were mixed with the soil of each unit plot. Fertilizers of N and K_2O as urea and MP were applied, respectively. Entire amounts of MP were applied during the final preparation of land. Urea was applied in three equal installments at 15, 30 and 45 days after seed sowing of Indian Spinach. Well-rotten cow dung 10 t/ha also applied during final land preparation. The amount of manure and fertilizers were used as shown in Table 1 (Rashid, 1993).

Table 1. Dose of fertilizers applied in Indian Spinach field

Fertilizers	Dose/ha
Cow dung	10 tons
Nitrogen (as urea)	200 kg
P_2O_5 (as TSP)	100 kg
K_2O (as MP)	80 kg

3.9 Intercultural operation

After emergence of seedlings, various intercultural operations like irrigation, thinning, weeding, top dressing etc were accomplished for better growth and development of the Indian Spinach seedlings.

3.9.1 Irrigation and drainage

Over-head 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.

3.9.2 Weeding

Weeding was done to keep the plots free from weeds and for better aeration of soil, which ultimately ensured better 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.

3.9.3 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 3 equal installments at 15, 25 and 35 DAS. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthling up operation was done immediately after top-dressing with nitrogen fertilizer.

3.10 Plant protection

For controlling leaf caterpillars, Nogos @ 1 ml/L water were applied 2 times at an interval of 10 days starting soon after the appearance of infestation. There was no appreciable attack of disease.

3.11 Harvesting

Harvesting was done from all plots at 30 days of sowing of Indian Spinach seeds. The border plants were not included in harvesting. The plants were cut at a height of 2 cm from the ground level and data were recorded on several characters. The crop was allowed to grow and the subsequent harvestings were done at three intervals i.e. after 10, 15 and 20 days of the first harvesting. Thus up to 90 DAS harvesting were done according to the treatment of harvesting interval. For 10 days interval harvesting was done 30, 40, 50, 60, 70, 80 and 90 DAS. For 15 days interval harvesting was done at 30, 45, 60, 75 and 90 DAS and for 20 days interval harvesting was done at 30, 50, 70 and 90 DAS. Details were presented in Appendix III to XII.

3.12 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Ten plants were randomly selected from each unit plot for the collection of data according to the harvesting interval. The whole plot crop was harvesting to record per plot data. The average value for each recorded character was estimated by adding different harvesting data and dividing the total number of harvesting period. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.12.1 Plant height (cm)

Plant height was measured in centimeter (cm) from the ground level to the tip of the plant at each harvesting and the average was calculated from 10 sample plants.

3.12.2 Number of branches per plant

Total number of branches was counted from the randomly selected plants and their average was calculated as the umber of branches per plant.

3.12.3 Number of leaves per plant

Total number of leaf was counted from the sampled plants and their average was calculated as the number of leaves per plant.

3.12.4 Fresh weight of leaves per plant (g)

Leaves from sampled selected plants were separated and weighed. The average was calculated to get the weight of per plant in gram (g)

3.12.5 Fresh weight of stems per plant (g)

Stem from sampled selected plants were separated and weighed. The average was calculated to get the weight of stem per plant in gram (g)

3.12.6 Fresh weight of plant

Fresh weight from ten randomly selected plants were separated and weighed. The average was calculated to get the weight of individual plant and was expressed in gram (g)

3.12.7 Dry matter content of plant

Fresh foliage of the randomly selected plants was dried in the sun followed by drying in an electrical oven at 72^0 C for 48 hrs. The dry matter contents of plants were computed by according to the following formula

$$\% \text{ Dry matter of leaves} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100 \quad (g)$$

3.12.8 Foliage coverage

Foliage coverage was estimated by "Yofida method" at the time of harvesting and expressed in percentage.

3.12.9 Yield per hectare

Per plot yield was converted into yield per hectare and it was expressed in metric ton (mt.) per hectare.

3.13 Statistical analysis

Data obtained for different characters were statistically analyzed to find out the significance of the difference for plant spacing and harvesting interval on yield and yield contributing characters of Indian Spinach. Mean values of all the recorded characters were evaluated and analysis of variance was performed by 'F' (variance ratio) test. Significance of the difference among the treatment of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

Present experiment was conducted to determine the effect of plant spacing and harvesting interval on growth and yield of Indian spinach. Data on different yield contributing characters and yield were recorded to find out the optimum plant spacing and harvesting interval. At 10 days interval harvesting was done at 30, 40, 50, 60, 70, 80 and 90 DAS. For 15 days interval harvesting was done at 30, 45, 60, 75 and 90 DAS and for 20 days interval harvesting was done at 30, 50, 70 and 90 DAS. Average value for each recorded character was estimated by adding different harvested data by dividing the total number of harvesting period. Analysis of variance of the data on different yield components and yield are given in Appendix XIII-XV. Results have been presented and discussed, and possible interpretations are given under the following headings:

4.1 Plant height

Significant effect of spacing and harvesting intervals was found on the plant height (Appendix XIII). Plant spacing S_3 gave the longest (34.48 cm) plant which was statistically similar with S_2 (32.91 cm) and S_4, while the shortest (30.45 cm) plant was observed from S_1 (Figure 2). These results indicated that both S_4 and S_1 spacing reduced plant height of Indian spinach. Variations in plant height among different spacing were prominent. Similar result was also reported by Rai (1981). 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 Bruemmer and Roe (1979), Rashid *et al.* (1981), Anon., (1982) and Islam *et al.* (1984)

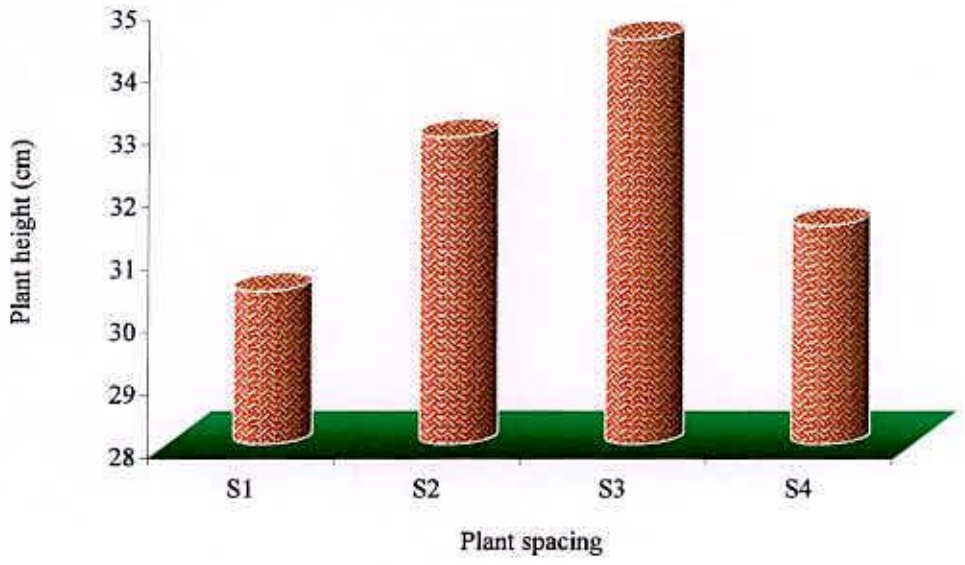


Figure 2. Effect of plant spacing on plant height of Indian spinach

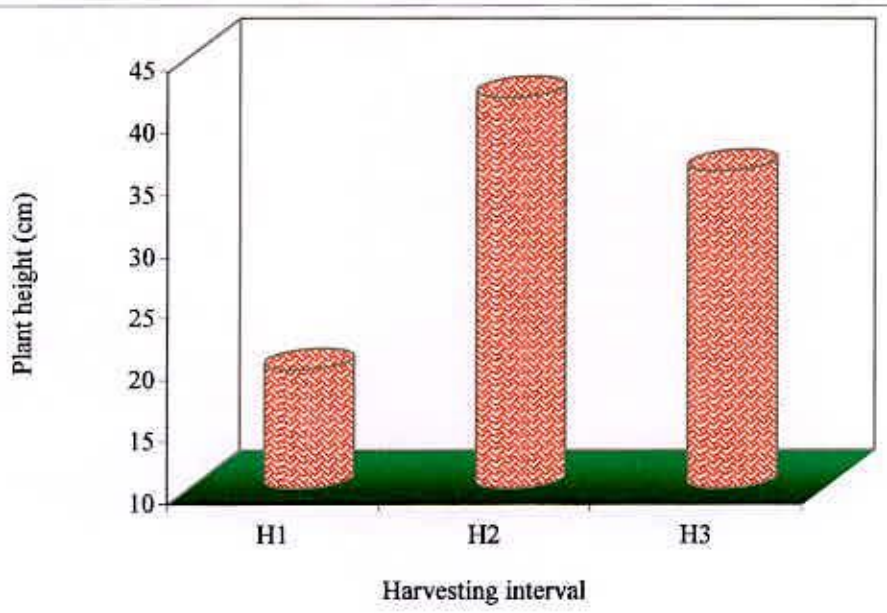


Figure 3. Effect of harvesting interval on plant height of Indian spinach

Different harvesting interval showed different plant heights under the present trial. Harvesting interval at 15 days (H_2) gave the longest (41.63 cm) plant height which was closely (35.76 cm) followed by H_3 at 20 days harvesting interval and the shortest (19.62 cm) plant was recorded from H_1 at 15 days harvesting interval (Figure 3). This finding was in agreement with the report of Sehunphan and Postel (1958), Wiggans *et al.* (1963), Purushothman (1978), and Hossain (1990) in leafy vegetable.

The longest (44.45 cm) plant was recorded from S_3H_2 (50 cm × 50 cm plant spacing and harvesting at 15 days interval). On the other hand the lowest (18.21 cm) plant was found from S_1H_1 (50 cm × 30 cm plant spacing and harvesting at 10 days interval) treatment (Table 4). All the spacing treatments gave the lowest plant height at the subsequent harvests at 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and attained the maximum height at 20 days interval but the average was highest for 15 days interval harvesting.

4.2 Number of branches per plant

Number of branches per plant significantly affected by plant spacing (Appendix XIII). The maximum (6.25) number of branches per plant was recorded from S_3 and the minimum (5.58) was recorded from S_1 (Table 2). In each harvest, maximum number of branches per plant was found from the S_3, while the minimum was recorded from S_1. Plants grown with S_3 received higher amount of light, nutrient and water enhancing more number of branches per plant and the reverse happened to plants grown with S_1. This finding coincided with that of Verma *et al.* (1969), Islam *et al.* (1984) and Hamid *et al.* (1986).

37222
05/11/13

Ar 101
(...) 13/09/09

Table 2. Main effect of plant spacing on number of branches per plant, number of leaves per plant, fresh weight of leaves per plant, fresh weight of stem per plant, dry matter content and foliage coverage of Indian spinach

Treatment	Number of		Fresh weight		Dry matter content (%)	Foliage coverage (%)
	branches per plant	leaves per plant	of leaves per plant(g)	of stem per plant (g)		
S_1	5.58 c	35.55 b	52.42 c	64.05 c	11.89 c	77.11b
S_2	5.89 b	38.09 ab	56.87 b	69.19 ab	13.53b	77.64 b
S_3	6.25 a	40.58 a	61.47 a	71.48 a	15.00 a	84.35 a
S_4	5.85 b	37.14 b	56.90 b	67.86 b	13.76 b	78.81 b
$LSD_{(0.05)}$	**0.264**	**2.809**	**2.875**	**3.047**	**0.526**	**3.035**
CV(%)	**4.58**	**7.59**	**5.16**	**4.57**	**8.97**	**9.91**

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

25

Table 3. Main effect of harvesting interval on number of branches per plant, number of leaves per plant, fresh weight of leaves per plant, fresh weight of stem per plant, dry matter content and foliage coverage of Indian spinach

Treatment	Number of		Fresh weight of		Dry matter content (%)	Foliage coverage (%)
	branches per plant	leaves per plant	leaves per plant(g)	stem per plant (g)		
H_1	5.66 b	36.19 b	47.97 c	64.39 c	13.14 b	75.18 c
H_2	6.01 a	40.39 a	65.19 a	72.80 a	14.03 a	83.25 a
H_3	6.00 a	36.94 b	57.59 b	67.25 b	13.46 b	80.00 b
$LSD_{(0.05)}$	**0.229**	**2.433**	**2.486**	**2.639**	**0.455**	**2.629**
CV(%)	**4.58**	**7.59**	**5.16**	**4.57**	**8.97**	**9.91**

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

Number of branches per plant showed significant differences on different harvesting interval. The maximum (6.01) number of branches per plant was recorded from H_2, while the minimum (5.66) number of branches per plant was obtained from H_3 (Table 3). Number of branches per plant gradually increased with the increase of harvesting interval and the highest number of branches per plant was produced at 15 days interval. This finding coincided with that of Westgate *et al.* (1958), More (1965) and Awal (1989). At 10 days interval, plants did not get enough time for their growth and development, and thus remained small with less number of branches during harvest. On the contrary, plants of 20 days interval got enough time for their growth and were found to produce the highest number of branches per plant.

The maximum (6.48) number of branches per plant was recorded from S_3H_2. On the other hand the minimum (5.44) number of branches per plant was recorded from S_1H_1 (Table 4). All the spacing treatments revealed the lowest number of branches per plant at the subsequent harvests at 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and produced the maximum number of branches per plant at 20 days interval but the average was highest for 15 days interval harvesting period.

4.3 Number of leaves per plant

Number of leaves per plant was significantly affected by different plant spacing (Appendix XIII). Plant spacing S_3 gave the maximum (40.58) number of leaves per plant which was statistically identical with S_2 (38.09) and the minimum (35.55) number of leaves per plant was recorded from S_1 which was statistically similar (37.14) to S_4 (Table 2).

Similar trends of result were also obtained by Smith and Salaman (1947), Chowdhury *et al.* (1974), Bhore and Patil (1978), Anon, (1984), Miah (1987) Zaman and Rahman (1988) and Etman (1993). Plants grown with S_4 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 S_1.

Number of leaves per plant under the present trial showed variation for different harvesting interval. Harvesting interval H_2 gave the maximum (40.39) number of leaves per plant. On the other hand, the minimum (36.19) number of leaves per plant was obtained from H_1 which was statistically similar (36.94) to H_3 (Table 3). The minimum number of leaves per plant was produced at 10 days interval. Number of leaves per plant gradually increased with the increase of interval and the highest number of leaves per plant was produced at 15 days interval. At 10 days interval, plants did not get enough time for their growth and development, and thus remained short with less branches and leaves during harvest. On the contrary, plants of 15 days interval got enough time for their growth and development and were found to be tallest with maximum branches and leaves per plant. Although 20 days interval the plants got more time but did not show the maximum number of leaves per plant.

The maximum (43.86) number of leaves per plant was found from S_3H_2 and the minimum (34.05) number of leaves per plant was recorded from S_1H_1 (Table 4). All the spacing treatments revealed the lowest number of leaves per plant at the subsequent harvests of 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and produced the maximum number of leaves per plant at 15 days interval.

4.4 Fresh weight of leaves per plant

Fresh weight of leaves per plant was significantly influenced by plant spacing (Appendix XIV). Plant spacing S_3 gave the maximum (61.47 g) fresh weight of leaves per plant while the minimum (52.42 g) fresh weight of leaves per plant was recorded from S_1 (Table 2). The variations in fresh weight of leaves per plant among the spacing treatments were prominent. Similar trend of results was also reported by Rai (1981).

Different harvesting interval showed different fresh weight of leaves per plant under the present trial. Harvesting interval H_2 gave the maximum (65.19 g) fresh weight of leaves per plant. On the other hand the minimum (47.97 g) fresh weight of leaves per plant was recorded from H_1 (Table 3).

The maximum (71.18 g) fresh weight of leaves per plant was recorded from S_3H_2, while the minimum (42.01 g) fresh weight of leaves per plant was obtained from S_1H_1 (Table 4). All the spacing treatments gave the minimum fresh weight of leaves per plant at the subsequent harvests at 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and produced the maximum fresh weight of leaves per plant 15 days interval harvesting period.

4.5 Fresh weight of stem per plant

Fresh weight of stem per plant was significantly affected by plant spacing (Appendix XIV). The maximum (71.48 g) fresh weight of stem per plant was obtained from S_3 which was statistically identical (69.19 g) to S_2 and the minimum (64.05 g) fresh weight of stem per plant was recorded from S_1 (Table 2). Each increase in spacing significantly increased the fresh weight of stem which was also observed by Beaty *et al.*

(1965), Islam *et al.* (1984), Rahman *et al.* (1985) and Hamid *et al.* (1986) and Dhillon *et al.* (1987).

Different harvesting interval showed different fresh weight of stem per plant under the present experiment. Harvesting interval H_2 gave the maximum (72.80 g) fresh weight of stem per plant. On the other hand, the minimum (64.39 g) fresh weight of stem per plant was recorded from H_1 (Table 3). This finding was in conformity with that of Anon., (1980), Hamid *et al.* (1986) and Awal (1989). Among the harvesting intervals, 15 days interval gave the highest fresh weight of stem per plant.

The maximum (75.91 g) fresh weight of stem per plant was found from S_3H_2. On the other hand, the minimum (61.84 g) fresh weight of stem per plant was recorded from S_1H_1 (Table 4). All the spacing treatments revealed the lowest fresh weight of stem per plant at the subsequent harvests at 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and produced the maximum fresh weight of stem per plant at 15 days interval.

4.6 Fresh weight of plant

Fresh weight of plant was significantly affected by plant spacing used in this experiment (Appendix XIV). Plant spacing S_3 gave the maximum (132.95 g) fresh weight of plant which was closely followed by S_2 (126.06 g) and S_4 (124.76 g), respectively and the minimum (116.47 g) fresh weight of plant was recorded from S_1 (Figure 4). Similar trend of results was also reported by Rai (1981), Hossain (1980). 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 Anon., (1982) and Islam *et al.* (1984).

Different harvesting interval showed different fresh weight of plant under the present trial. Harvesting interval H_2 gave the maximum (137.99 g) fresh weight of plant which was closely followed by H_3 (121.98 g). On the other hand, the minimum (115.21 g) fresh weight of plant was recorded from H_1 (Figure 5).

The maximum (147.09 g) fresh weight of plant was obtained from S_3H_2 and the minimum (103.85 g) fresh weight of plant was recorded from S_1H_1 (Table 4). All the spacing treatments revealed the lowest fresh weight of plant at the subsequent harvests of 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and produced maximum fresh weight of plant at 15 days interval.

4.7 Dry matter content of plant

Dry matter content of plant was significantly affected by plant spacing (Appendix XIV). The maximum (15.00%) dry matter content was recorded from S_3 and the minimum (11.89%) dry matter content was found from S_1 (Table 2). Similar trends of result were also reported by Rai (1981). Plants grown with S_4 spacing received higher amount of light nutrient and water and the reverse happened to plants grown with closest spacing. This finding coincided with Anon. (1982) and Islam *et al.* (1984), Aditya *et al.* (1995).

Different harvesting interval showed variation in dry matter content under the present trial. Harvesting interval H_2 gave the maximum (14.03%) dry matter content which was followed (13.46%) by H_3. On the other hand, the minimum (13.14%) dry matter content

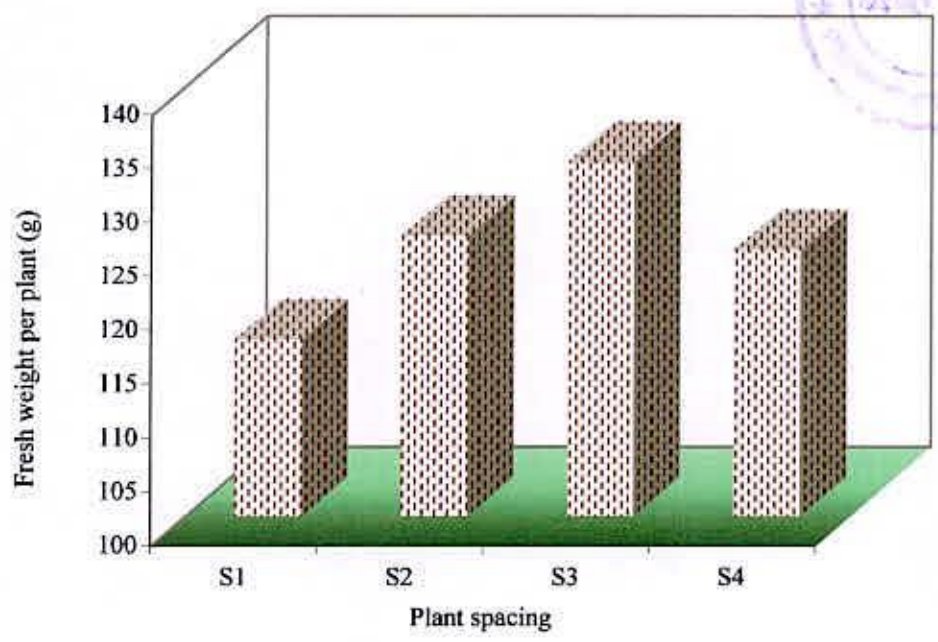


Figure 4. Effect of plant spacing on fresh weight per plant of Indian spinach

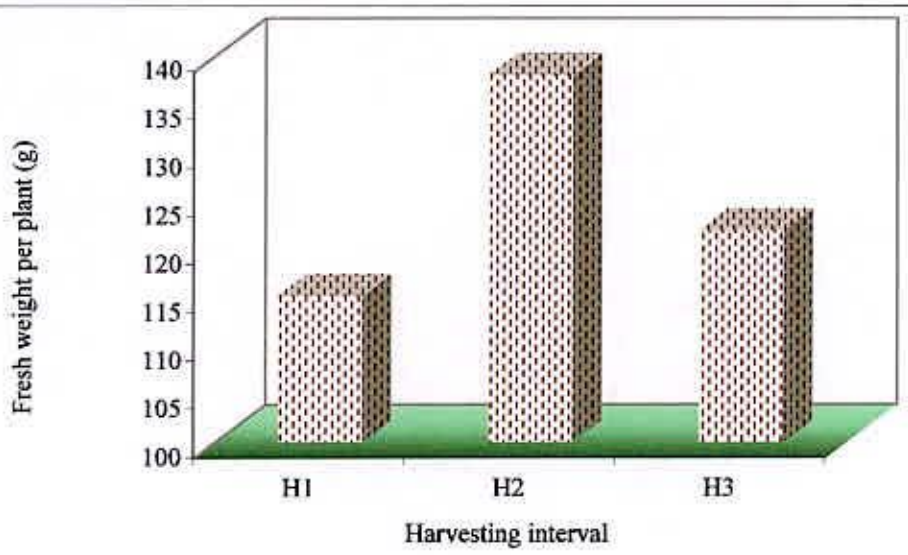


Figure 5. Effect of harvest interval on fresh weight per plant of Indian spinach

was recorded from H_1 (Table 3). This finding was in agreement with the report of Purushothaman (1978) who conducted experiment with leafy vegetable.

The maximum (16.03%) dry matter content was recorded from S_3H_2, while the minimum (11.12%) dry matter content was recorded from S_1H_1 (Table 4). All the spacing treatments revealed the lowest dry matter content at the subsequent harvests of 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and attained maximum dry matter content at 20 days interval but the average was highest for 15 days interval harvesting period.

4.8 Foliage coverage

Foliage coverage by plant was affected significantly by plant spacing (Appendix XV). The highest (84.35%) foliage coverage was recorded from S_3 and the lowest (77.11%) foliage coverage was recorded from S_1 which was statistically similar to S_2 (77.64) and S_4 (78.81) (Table 2).

Different harvesting interval showed significant effect on foliage coverage under the present experiment. Harvesting interval H_2 gave the highest (83.25%) foliage coverage. On the other hand, the lowest (75.18%) foliage coverage was noted from H_1 (Table 3). This finding was in agreement with the report of Purushothaman (1978) who conducted trial with leafy vegetable.

The highest (90.00%) foliage coverage was recorded from S_3H_2 and the lowest (71.43%) foliage coverage was obtained from S_1H_1 (Table 4). All the spacing treatments revealed the lowest foliage coverage at the subsequent harvests of 10 days interval. With the increase of harvesting interval, plants obtained longer time for their

growth and development, and attained the maximum foliage coverage at 20 days interval but the average was highest for 15 days interval harvesting period.

4.9 Yield per hectare

Yield per hectare was affected significantly by different plant spacing (Appendix XV). The highest (22.69 t/ha) yield was recorded from S_3 which was closely followed by S_2 (21.11 t/ha) and S_4 (20.55 t/ha), while the lowest (19.47 t/ha) yield was recorded from S_1 (Figure 6).

Different harvesting interval showed different yield per hectare under the present trial. Harvesting interval H_2 gave the highest (21.57 t/ha) yield. On the other hand the lowest (20.54 t/ha) yield was recorded from H_1 (Figure 7). This finding was supported by Oakes (1966), Cervato (1969). Among three harvesting intervals, 15 days interval gave the highest total yield per hectare. This finding was supported by Anonymous (1983). Although maximum harvests were done in case of 10 days interval, but total yield per plot was minimum. This was due to the fact that plants did not get sufficient time for more vegetative growth and that was why 10 days interval gave fewer yields per hectare. In case of 20 days harvesting interval, although plants got maximum time for vegetative growth and each harvest gave maximum yield per hectare, but the total yield was not maximum because of the least harvests done in this interval.

Similar result was also stated by Rahman and Awal (1989). After first harvest, 2nd harvest gave the maximum yield per hectare at each harvesting interval and then the total yield per hectare gradually decreased which was also stated by Anonymous (1982).

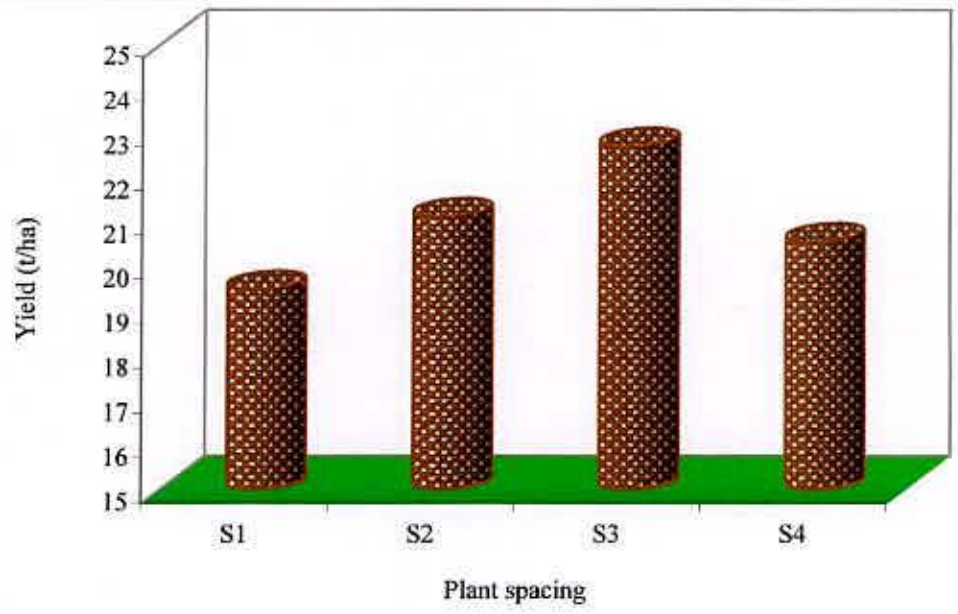


Figure 6. Effect of plant spacing on yield per hectare of Indian spinach

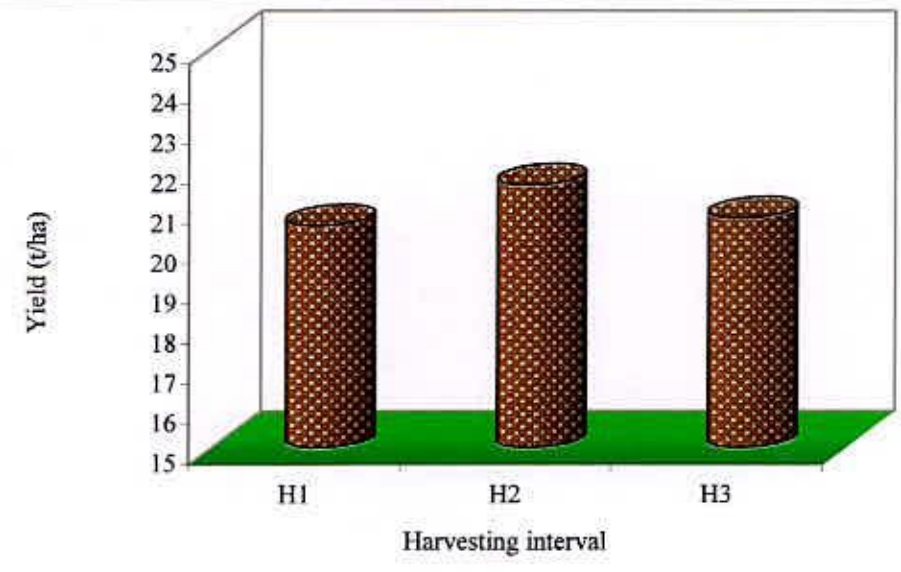


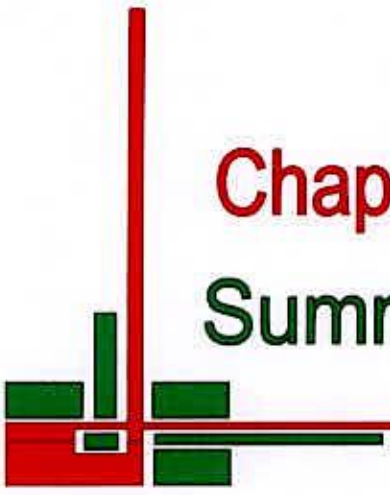
Figure 7. Effect of harvest ing interval on yield per hectare of Indian spinach

Table 4. Interaction effect of plant spacing and harvesting interval on plant height, number of branches, number of leaves, fresh sweight of leaves, fresh weight of stem, fresh weight of plant per plant, foliage coverage, dry matter content and yield per hectare of Indian spinach

Treatment		Plant height(cm)	Number of		Fresh weight of			Foliage coverage (%)	Dry matter content (%)	Yield (t/ha)
			Branches per plant	Leaves per plant	Leaves per plant(g)	Stem per plant (g)	Plant (g)			
S_1	H_1	18.21d	5.44 e	34.05 c	42.01 h	61.84 d	103.85f	71.43 e	11.12 e	18.19d
	H_2	39.11abc	5.64 cde	37.70 bc	61.06 bcd	68.59 bc	129.65c	84.00 b	12.38 d	20.11c
	H_3	34.04c	5.66 cde	34.91 bc	54.19 ef	61.72 d	115.91e	77.50 cd	12.17 d	20.11c
S_2	H_1	19.95d	5.77 cde	36.61 bc	48.31 g	68.48 bc	116.79e	73.57 de	13.33 c	20.44c
	H_2	42.12ab	6.04 abcd	40.39 ab	63.57 bc	73.24 ab	136.81b	79.00 bcd	13.67 bc	21.54bc
	H_3	36.65bc	5.87 bcde	37.27 bc	58.73 cde	65.84 cd	127.57cd	78.75 bcd	13.60 bc	21.35ab
S_3	H_1	21.16d	5.91 bcde	39.01abc	53.00 fg	70.55 abc	123.55cd	79.29 bcd	14.55 b	21.78ab
	H_2	44.45a	6.48 a	43.86 a	71.18 a	75.91 a	147.09a	90.00 a	16.03 a	23.73a
	H_3	37.82bc	6.37 ab	38.86abc	60.23 bcd	67.98 bc	128.21c	83.75 b	14.43 b	21.54bc
S_4	H_1	29.14d	5.52 de	35.08 bc	48.55 g	68.11 bc	116.66e	76.43 cde	13.57 bc	20.78c
	H_2	40.84ab	5.89 bcde	39.62abc	64.95 b	73.44 ab	138.39b	79.25 bc	14.05 bc	20.90c
	H_3	34..53c	6.14 abc	36.71bc	57.19def	62.03 d	119.22de	80.00 bc	13.66 bc	19.98c
$LSD_{(0.05)}$		**5.025**	**0.458**	**4.866**	**4.973**	**5.277**	**6.436**	**0.910**	**5.257**	**1.508**
CV(%)		**9.18**	**4.58**	**7.59**	**5.16**	**4.57**	**3.04**	**8.97**	**9.91**	**4.25**

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

The highest (23.73 t/ha) yield was recorded from S_3H_2 and the lowest (18.19 t/ha) yield was obtained from S_1H_1 (Table 4). All the spacing treatments revealed the lowest yield per hectare at the subsequent harvests of 10 days interval. With the increase of harvesting interval, plants obtained longer time for their growth and development, and attained the maximum yield per hectare at 20 days interval but the average was highest for 15 days harvesting interval.



Chapter 5

Summary & conclusion

Chapter V

SUMMARY AND CONCLUSION

Present experiment was conducted to investigate the effect of different plant spacing and harvesting intervals on the growth and yield of Indian Spinach at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from March '07 to July '07. There were four levels of plant spacing viz. S_1: 50 cm× 30 cm, S_2: 50 cm × 40 cm, S_3: 50 cm × 50 cm and S_4: 50 cm × 60 cm and three levels of harvest intervals viz. 10 days, 15 days and 20 days as treatments of the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Crop was allowed to grow and the subsequent harvests were done at three intervals i.e. after 10, 15 and 20 days of the first harvest. Thus starting from 30 DAS up to 90 DAS harvests were done according to the treatment of harvest interval. For 10 days interval harvesting was done at 30, 40, 50, 60, 70, 80 and 90 DAS. For 15 days interval harvesting was done at 30, 45, 60, 75 and 90 DAS and for 20 days interval harvesting was done at 30, 50, 70 and 90 DAS. Data on yield components were collected from 10 randomly selected plants from each plot except the total yield which was determined by taking weights of all plants harvested from each plot.

The longest (34.48 cm) plant per harvest was recorded from plant spacing S_3 (50 cm × 50 cm) and the shortest (30.45 cm) plant was recorded from S_1 as plant spacing 50 cm × 30 cm. The maximum (6.25) number of branches per plant was found from S_3, while the minimum (5.58) was recorded from S_1. Plant spacing S_3 gave the maximum (40.58) number of leaves per plant and the minimum (35.55) was recorded

from S_1. Plant spacing S_3 gave the maximum (61.47 g) fresh weight of leaves per plant and the minimum (52.42 g) was recorded from S_1. The maximum (71.48 g) fresh weight of stem per plant was obtained from S_3 and the minimum (64.05 g) was recorded from S_1. Plant spacing S_3 gave the maximum (132.95 g) fresh weight of plant and the minimum (116.47 g) fresh weight of plant was noted from S_1. The maximum (15.00%) dry matter content was recorded from S_3 and the minimum (11.89%) was recorded from S_1. The highest (84.35%) foliage coverage was recorded from S_3 and the lowest (77.11%) was recorded from S_1. The highest (22.69 t/ha) yield was found from S_3 and the lowest (19.47 t/ha) was recorded from S_1.

Harvest interval at 15 days (H_2) gave the longest (41.63 cm) plant per harvest and the shortest (19.62 cm) plant was found from H_1 as 10 days harvesting interval. The maximum (6.01) number of branches per plant was recorded from H_2 and the minimum (5.66) was recorded from H_1. Harvest interval H_2 gave the maximum (40.39) number of leaves per plant. On the other hand the minimum (36.19) was recorded from H_1. Harvest interval H_2 gave the maximum (65.19 g) fresh weight of leaves per plant. On the other hand the minimum (47.97 g) fresh weight of leaves per plant was obtained from H_1. Harvest interval H_2 gave the maximum (72.80 g) fresh weight of stem per plant, while the minimum (64.39 g) was recorded from H_1. Harvest interval H_2 gave the maximum (137.99 g) fresh weight of plant and the minimum (115.21 g) was recorded from H_1. Harvest interval H_2 gave the maximum (14.03%) dry matter content and the minimum (13.14%) was recorded from H_1. Harvest interval H_2 gave the highest (83.25%) foliage coverage and the lowest

(75.18%) was recorded from H_1. Harvest interval H_2 gave the highest (21.57 t/ha) yield and the lowest (20.54 t/ha) was recorded from H_1.

The longest (44.45 cm) plant was obtained from S_3H_2 (50 cm × 50 cm plant spacing and harvesting at 15 days interval) while the shortest (18.21 cm) plant was recorded from the treatment combination of S_1H_1 (50 cm × 30 cm plant spacing and harvesting at 10 days interval). The maximum (6.48) number of branches per plant was recorded from S_3H_2 and the minimum (5.44) number of branches per plant was found S_1H_1. The maximum (43.86) number of leaves per plant was obtained from S_3H_2 and the minimum (34.05) was noted from S_1H_1. The maximum (71.18 g) fresh weight of leaves per plant was recorded from S_3H_2, while the minimum (42.01 g) fresh weight of leaves per plant was recorded from S_1H_1. The maximum (75.91 g) fresh weight of stem per plant was noted from S_3H_2. On the other hand the minimum (61.84 g) was recorded from S_1H_1. The maximum (147.09 g) fresh weight of plant was recorded from S_3H_2 and the minimum (103.85 g) was found from S_1H_1. The maximum (16.03%) dry matter content was noted from S_3H_2 and the minimum (11.12%) was recorded from S_1H_1. The highest (90.00%) foliage coverage was obtained from S_3H_2 and the lowest (71.43%) was recorded from S_1H_1. The highest (23.73 t/ha) yield was obtained from S_3H_2 and the lowest (18.19 t/ha) was recorded from the treatment combination S_1H_1.

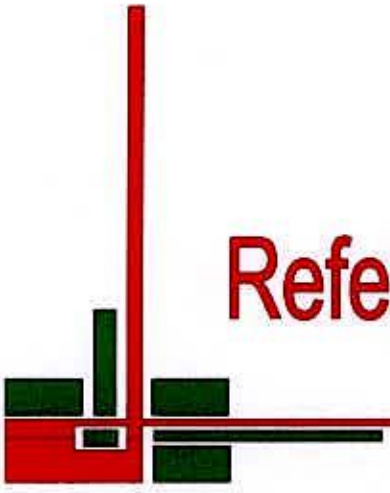
Conclusion:

Among the treatment combination plant spacing S_3 (50cm× 50 cm) and harvesting interval H_2 (15 days) 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. The study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;

2. Other combination of plant spacing and harvesting intervals may be included for further study.



References

REFERENCES

Abbasdokht, K., Jaenaksorn, T. and Ikeda, H. 2003. Possibility of substituting soil less fertilizer with soil fertilizer for growing leafy vegetables in hydroponics. *Acta Hort.*, **642**: 345-361.

Aditya, D. K., Sardar, P. K. and Ahmed, S. U. 1995. Effect of spacing and different levels of nitrogen on the production of pak choi (*Brassica chinensis* L.) cv. *Batisak. Prog. Agric.*, **6** (1): 65-69.

Anonymous. 1980. New vegetbles, kangkong andkailan (Bengali). Central Extension Resources Development Institute, Joydebpur, Gazipur, p. 17.

Anonymous. 1982. A study on the adaptability and performance of kangkong (*Ipomoea reptans*). In: An up to date progress report, CVSRC, BARI, Joydebpur, Gazipur. pp. 42-43.

Anonymous. 1983. A Booklet on Gimakalmi- A new summer leafy type vegetable Bengali). CVSRC, BARI, Joydebpur, Gazipur.

Anonymous. 1984. Effect of time of sowing on the yield performance of Batisak. In: Annual Report of CVSRC, BARI, Joydebpur, Gazipur. pp. 3-4.

Anonymous. 1989. Annual Weather Report, Meteorological Station, Dhaka. Bangladesh.

Awal, M. A. 1989. Growth and yield of Gimakalmi as influenced by plant spacing and harvest frequency. M. Sc. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 81.

Bali, A. S., Shah, M. H. and Badrul, H. 2000. Effect of organic manure on Chinese cabbage under different levels of nitrogen and phosphorus. *Indian J. Agron.*, **45** (1): 174-178.

Bansal, G. L., Rana, M. C. and Upadhyay, R. G. 1995. Response of grain amaranth (*Amaranthus hypochondriacus*) to plant density. *Indian J. Agric. Sci.* **65** (11): 818-820.

Beaty, E. R., Smith, Y. C., Creery, R. A. M., Ethredge, W. J. and Kenneth B. 1965. Effect of cutting height and frequency on forage production of summer annuals. *Agron. J.*, **57**(3): 277-279.

Bhore, D. P. and Patil, S. S. D. 1978. Comparative efficiency of soil and foliar application of nitrogen on yield of leafy vegetables. *J. Maharashtra Agril. Univ.*, **3**(1): 65.

Bose, T. K. and Som, M. G. 1990. Vegetable crops in India. Naya Prakash, Calcutta, India. pp. 687-691.

Bruemmer, J. H. and Roe, B. 1979. Effect of nitrogenous fertilizer on the yield and chemical composition of water spinach (*Ipomoea aquatia*). *Proc. Florida Hort. Sci.* pp. 140-143.

Burkill, I. H. 1935. A Dictionary of the Economic Products of the Malay Peninsula, London. pp 55.

Cervato, A. 1969. The manuring of spinach in the results of four year's experimental work. An. Eac. agrar., Coure Milano, **10**: 389-421.

Chowdhury, R, M., Rashid, M. and Hossain, A. 1974. A study on the effect of different spacings and levels of nitrogen on spinach. *Bangladesh Hort.*, **2** (2): 39-43.

Damrong, C. and Krung, S. 1994. Effect of plant spacing on yield of Chinese cabbage in off season. Tropical Vegetable Research Center, Bangkok. 1994. pp. 142-146.

Das, N. R. and Ghosh, N. 1999. Effect of sowing time and nitrogen level on seed yield of amaranth. *Horticulture J.*, **12** (2): 77-82.

Davey, K. 1965. Analysis of some food staffs of East Pakistan *Journal of Biology and Agricultural Science*. **9**:25-29.

Dhillon, K. S., Dhillon, S. K., Singh, B. and Kansal, B. D. 1987. Effect of different levels of nitrogen on yield and chemical composition of spinach (*Spinacea oleracea* L.). *J. Research*, Punjab Agril. Univ., **24** (1):31-36.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. 1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. pp. 118.

Etman, A. 1993. Response of spinach to soil and Plant spacing. *Annals Agril. Sci.*, **38** (2): 667-673.

FAO. 1988. Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **42**: 190-193.

Ghosh, S. and Guha, A. 1933. Vegetable production in India. *Indian J. Med. Res.* **21** (2). pp. 447.

Goh, K.M. and Vityakon, P. 1983. Effects of fertilizers on vegetable production. Yield of spinach and beet root as affected by rates and forms of nitrogenous fertilizers. *New Zealand J. Agril. Res*, **26** (3): 349-356.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., *A Willey Int. Sci.*, Pub., pp. 28-192.

Gupta, V. K. and Arvind, K. 1995. Influence of planting geometry on seed yield, harvest index and quality of Chinese cabbage. *New-Agriculturist.* **6**(2): 225-226.

Gupta, V. K. and Panda, P. K. 1995. Influence of plant spacing on yield attributes and yield if Chinese cabbage. *Current-Agricultural-Research.* **8**(2): 76-78.

Hamid, M. M., Saha, M. C., Rahman, A. K. M. M. and Hossain, S. M. M. 1986. Effect of plant spacing on growth and yield of spinach. In: P Horticulture Research Report on Vegetable Crops. BARI, Joydebpur, Gazipur.

Hill, J. J. and Pearson, C. J. 1985. Primary growth and re-growth responses of temperate grasses to different temperatures and cutting frequencies. *Australian J. Agric. Res.*, **36**(1): 25-34.

Hill, T. R. 1990. Effect of plant spacing and nitrogenous fertiliser on the yield and plant conformation of Chinese cabbage (Brassica campestris ssp. pekinensis). *Australian-J. Experimental Agril.*, **30**: 3, 437-439.

Hossain, M. M. 1980. Improved variety of Kalmi or kangkong. (Bengali). Krishikatha, **40**(8): 284-287.

Hossain, M. Z. 1990. Effects of nitrogen andsulphur on growth, yield and nutrient content of rice. M.Sc. thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh . pp 17.

Idris, K. M., Islam, A. T. M. T., Chowdhury M. S. and Huq, A. K. M. M. 1979. Detail soil survey, Bangladesh Agricultural University Farm, Mymensingh. Department of Soil Survey, Govt. of the People`s Republic of Bangladesh. pp. 118.

Islam, A. B. Z., Siddique, M. A. and Hossain, M. M. 1984. The influence of planting material and plant spacing on the yield of kangkong (*Ipomoea aquatica*). *Thai. J. Agric. Sci.*, **17**(2): 81-87.

Jehangir, S., Ganai, B. A., Bali, A. S. and Mir, A. H. 1999. Response of Chinese cabbage varieties to row spacing. *Applied-Biological-Research.* **1**(2): 159-161.

Kallo, J. 1986. Vegetables crop in India. Naya Prokash, Calcuta. pp. 692-708.

Kasture, V. M., P. S. Chauhan, V. N. Patil, R. S., Shivankar and R. R. Rathod. 2002. Effect of cuttings on seed yield and quality of Indian spinach. Bioved. **13**(1/2): 109-111.

Kasture, V. M., P. S. Chauhan, V. N. Patil, R. S., Shivankar and K. N. Wankhede. 2000. Effect of cuttings on the vegetative growth of Indian spinach. Research on Crops. **1**(3): 416-417.

Kler, D. S., Kaur, H., Sarbjeet, S. 1992. Relationships among light interception, yield contributing characters and yield of Chinese cabbage crop. *Environment and Ecology*. **10** (4): 896-899.

Koay, Y. and Chua, Z. 1979. Commercial Lettuce production. University of Wisconsin Coop. Exl. Ser. 2340. pp. 1-83.

Lee, S. K. 1983. Effect of sowing time and spacing levels on seed production of pea cultivar. *Seed-Research*. **30**: 1, 88-91.

Miah, M. G. 1987. Adaptability trial of Batisak under different levels of fertilizer. In: Research Report On-Farm Research Division, BARI, Mymensingh, Bangladesh. pp. 1-7.

Missinga, M. and Currie, J. K. 2002. Yield of gimakalmi grown with different organic compounds and pig manure. *Hort. Brasileira*. Brazil, **12**(2): 42-74.

Moline, W. J. and Wedin, W. E. 1963. Evaluation of the effects of cutting date on yield and nutritive value of alfa-alfa with rabbit feeding trials and chemical analysis. *Agron. J.* **55**(3): 319-321.

Moore, J. W., Murray D. S. and Westerman, R. B. 2004. Effect of spacing on the harvesting and yield of amaranth. *J. Agril Science*. **52**: 2, 107-118.

More, A. W. 1965. The influence of fertilization and cutting a tropical grasses legume pasture. *Expt. Agric.*, 1(3): 193: 200.

Norman, J. C. and Shongwe, V. D. 1993. Influence of some cultural practices on the yield and quality of amaranth. *Advances in Horticultural Sci.*, 7: 4.

Oakes, A. J. 1966. Effect of nitrogen fertilization and harvest frequency on yield and composition of Panicum maximum Jaca. in dry tropics. *Agron. J.*, **58** (1): 75-77.

Park, K. W., Han, K. S. and Won, J. H. 1993. Effect of propagation method, planting density and fertilizer level on the growth of water spinach (*Impomoea aquatia*). *J. Korean Soc. Hort. Sci.*, **34**(4): 241-247.

Purushothaman, V. 1978. Effect of plant Spacing and levels on yield of some leafy vegetables in Malaysia. *Malaysia Agril. J.* **51** (5): 366-374.

Quasem M. A. and Hossain, S. M. 1995. Effect of spacing and different levels of nitrogenous fertilizers on the growth and yield of Stem Amaranth. In: Horticulture Research Report on Vegetable Crops. BARI, Joydebpur, Gazipur. pp. 37.

Rahman, A. and Awal, A. E. 1989. Evaluation of local stem amaranth germplasm. pp. 49. A Research Report (1994-1995) on Vegetables Improvement. BARI, Joydebpur, Gazipur.

Rahman, A. K. M. M. and Hossain, S. M. M. 1985. Effect of spacing and harvesting interval on the growth and yield of Indian spinach. In: Horticulture Research Report on Vegetable Crops. BARI, Joydebpur, Gazipur. pp. 28.

Rahman, A. K. M. M., Hossain, S. M. M. and Haque, M. M. 1985. A study on the growth and yield of Indian spinach under trellis vs non-trellis when harvested at different intervals. In: Horticulture Research Report on Vegetable Crops. BARI, Joydebpur, Gazipur. pp. 29-31.

Rai, M. M. 1981. Principles of Soil Science. Machillan India Limited, Calcutta. pp. 179-182.

Rashid, A., Ahad, M. A. and Tasaki, S. 1981. A study on the acclimatization, adaptability and performance of kangkong (*Ipomoea aquqtica*). Bulletin of vegetable section of Citrus and Vegetable Seed Research Institute, Joydebpur, Gazipur. pp. 10.

Rashid. M. M. 1993. Shabji Chash. Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. pp. 254.

Rodionova, M. V. 1989. The effect of mineral fertilizers on the productivity and quality of spinach. In: Pri menenie Udobreniipod Ovoshchnye Kul tury Votkrytom Izashchishennom Grunte. Moscow, USSR. pp. 75-79.

Salunkhe, D. K., Desai, B. B. and Bhat, N. R. 1980. Vegetable and Seed Production. Agricole Publishing Academy, New Delhi, India. pp. 329.

Sanni, S. B. 1983. Vegetable cultivation. *J. Sci. Food and Agric.*, **32**: 686-687.

Santos, B. M., Dusky, J. A., Stall, W. M., Bewick, T. A. and Shilling, D. G. 2003. Mechanisms of interference of smooth pigweed and common purslane on lettuce as influenced by phosphorous fertility. *Weed Science*. **52** (1): 78-82.

Schunphan,W. and Postel, W. 1958. Effect of manuring and climate on content of essential amino acids. *Qual. Plant Maveg.*, **3/4**: 45-61.

Shinohara, S. 1978. Production prospects of short period leafy vegetables of South-East Asia during rainy season in Bangladesh. Central Extension Resources Development Institute, Joydebpur, Gazipur. pp. 36-38.

Shinohara, S. 1980. Book for Development of Vegetable Horticulture with Capable Seed Production in Bangladesh. Central Extension Resources Development Institute, Joydebpur, Gazipur. pp 218.

Singh, R. D. and Chatterjee, B. N. 1968. Herbage growth in pure grass swards. *Expt. Agric.* **4**(2): 117-125.

Smith, J. B. and Salaman, M. 1947. Optimum Soil nitrate levels for celery, carrots, spinach, onion and beets at different growth levels. Bull. Rhade Islan Agric. Expt. Stat., pp. 27.

Somos, D. G. 1954. Mechanisms of interference of smooth pigweed and common purslane on lettuce as influenced by phosphorous fertility. *Weed Science.* **12** (1): 12-27.

Tindal, K. A. 1983. Effect of harvesting interval on the yield of Kangkong. *Thai. J. Agric. Sci.*, **15** (3): 52-53

UNDP. 1988. Land Resource Apprisal of Bangladesh for Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy, pp. 577.

Verma, A. N., Srivastava, D. C. and Sharma, R. K. 1969. Effect of nitrogen supply on growth, yield, ascorbic acid andoxalic acid content in spinach (*Spinacea oleracea*). *Plant Sci.*, **1**: 189-91.

Vogel, H. A. and Paschold, P. P. 1989. Effect of different levels of urea fertilizer and plant spacing on growth and yield of gimakalmi. *Dirasat*, **16** (9): 88-105.

Westgate, P. J., Forbes, R. B. and Thomas, J. R. 1958. Improvement on the cultural practices for leafy vegetable crops. Ann. Report *Florida Agric. Expt. Sta.* pp. 87-88.

Wiggans, S. C., Marshall, C. E. and Odell, G. V. 1963. Cultural studies with spinach. Bull. *Okla. Agric. Stat.* pp. 606-27.

Wolf, D. D., Larson, K. L. and Smith, D. 1962. Grass alfa-alfa yields and food storage of associated alfa-alfa as influenced by height and frequency of cutting. *Crop Sci.*,**12** (4): 363-364.

Zaman, S. M. and Rahman, M. M. 1988. Pilot production program of Batisak. In: Research Report On-Farm Research Division, BARI, Mymensingh, Bangladesh. pp. 31-35.


Appendices

APPENDICES

Appendix I. Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	33.23
Silt	60.59
Clay	6.17
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.17
Organic carbon (%)	1.44
Total nitrogen (%)	0.08
Available P (ppm)	21.3
Exchangeable K (%)	0.19

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March to July 2007

Month	Air temperature (^{0}C)		RH (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
March	29.55	18.25	61.51	24	225.4
April	33.74	23.87	69.41	185	234.6
May	34.7	25.90	70.00	185	241.8
June	33.40	26.80	91.00	279	96.0
July	31.52	25.35	88.00	233	127.1

Source : Dhaka metrological center

Appendix III. Effect of plant spacing and harvesting interval on plant height of Indian Spinach at different times of harvesting

Treatment		Plant height (cm)									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	22.35	19.48	--	26.45	15.22	12.05	--	19.45	12.45	18.21
	H_2	22.24	--	33.25	--	56.84	--	46.82	--	36.42	39.11
	H_3	22.38	--	--	45.31	--	37.55	--	--	30.91	34.04
S_2	H_1	24.08	23.25	--	27.33	15.32	14.69	--	22.05	12.92	19.95
	H_2	24.84	--	35.45	--	59.42	--	51.46	--	39.42	42.12
	H_3	24.39	--		47.45	--	39.42	--	--	35.33	36.65
S_3	H_1	25.02	24.22		28.06	15.91	15.62	--	23.47	15.82	21.16
	H_2	25.45	--	39.84	--	61.42	--	52.04	--	43.51	44.45
	H_3	25.36	--		47.45	--	41.55	--	--	36.92	37.82
S_4	H_1	23.84	22.84		25.12	15.84	15.38	--	17.92	13.05	19.14
	H_2	23.02	--	35.39	--	57.55	--	49.81	--	38.45	40.84
	H_3	23.56	--	--	43.08	--	40.81	--	--	30.68	34.53

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix IV. Effect of plant spacing and harvesting interval on number of branches per plant of Indian Spinach at different times of harvesting

Treatment		Number of branches per plant at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	3.84	6.15	--	7.12	6.75	6.05	--	4.15	4.05	5.44
	H_2	3.91	--	7.14	--	6.45	--	5.55	--	5.15	5.64
	H_3	3.87	--	--	8.02	--	5.54	--	--	5.22	5.66
S_2	H_1	4.12	6.28	--	8.15	5.64	6.95	--	4.98	4.25	5.77
	H_2	4.05	--	7.55	--	6.88	--	6.02	--	5.68	6.04
	H_3	4.28	--	--	8.64	--	5.02	--	--	5.55	5.87
S_3	H_1	4.67	7.10	--	6.95	5.95	4.56	--	7.15	5.02	5.91
	H_2	4.75	--	8.02	--	7.22	--	6.25	--	6.15	6.48
	H_3	4.69	--	--	8.15	--	5.78	--	--	6.84	6.37
S_4	H_1	4.02	6.95	--	6.74	6.15	4.25	--	6.28	4.22	5.52
	H_2	4.15	--	7.55	--	6.33	--	5.84	--	5.56	5.89
	H_3	4.28	--	--	9.15	--	5.22	--	--	5.92	6.14

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix V. Effect of plant spacing and harvesting interval on number of leaves per plant of Indian Spinach at different times of harvesting

Treatment		Number of leaves per plant at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	18.45	32.85	--	45.15	53.48	40.15	--	27.84	20.44	34.05
	H_2	18.64	--	32.15	--	55.92	--	45.33	--	36.45	37.70
	H_3	18.54	--	--	50.05	--	39.55	--	--	31.48	34.91
S_2	H_1	19.33	35.94	--	49.22	55.84	43.58	--	29.43	22.94	36.61
	H_2	19.15	--	36.22	--	58.05	--	50.00	--	38.55	40.39
	H_3	19.65	--	--	53.15	--	42.81	--	--	33.45	37.27
S_3	H_1	20.94	39.55	--	50.04	60.33	45.94	--	31.25	25.05	39.01
	H_2	21.45	--	40.15	--	63.45	--	54.12	--	40.12	43.86
	H_3	20.84	--	--	56.22	--	43.25	--	--	35.12	38.86
S_4	H_1	20.05	35.42	--	50.42	44.15	39.45	--	32.42	23.64	35.08
	H_2	20.64	--	39.25	--	60.22	--	51.45	--	26.55	39.62
	H_3	21.05	--	--	53.62	--	40.33	--	--	31.84	36.71

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix VI. Effect of plant spacing and harvesting interval on foliage coverage of Indian Spinach at different times of harvesting

Treatment		Foliage coverage (%) at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	65.00	70.00	--	75.00	75.00	85.00	--	70.00	60.00	71.43
	H_2	70.00	--	100.00	--	100.00	--	85.00	--	65.00	84.00
	H_3	65.00	--	--	90.00	--	90.00	--	--	65.00	77.50
S_2	H_1	65.00	80.00	--	80.00	80.00	80.00	--	65.00	65.00	73.57
	H_2	70.00	--	95.00	--	90.00	--	70.00	--	70.00	79.00
	H_3	75.00	--	--	85.00	--	85.00	--	--	70.00	78.75
S_3	H_1	70.00	70.00	--	90.00	90.00	85.00	--	75.00	75.00	79.29
	H_2	75.00	--	100.00	--	95.00	--	95.00	--	85.00	90.00
	H_3	65.00	--	--	95.00	--	95.00	--	--	80.00	83.75
S_4	H_1	70.00	70.00	--	85.00	80.00	85.00	--	80.00	65.00	76.43
	H_2	65.00	--	90.00	--	90.00	--	80.00	--	75.00	80.00
	H_3	70.00	--	--	95.00	--	90.00	--	--	65.00	80.00

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix VII. Effect of plant spacing and harvesting interval on fresh weight of leaves per plant of Indian Spinach at different times of harvesting

Treatment		Fresh weight of leaves per plant (g) at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	31.22	48.22	--	49.25	49.25	40.15	--	39.55	36.45	42.01
	H_2	32.05	--	65.84	--	81.44	--	72.48	--	53.48	61.06
	H_3	32.35	--	--	70.42	--	65.22	--	--	48.78	54.19
S_2	H_1	35.84	49.15	--	56.84	53.84	54.15	--	45.21	43.15	48.31
	H_2	35.22	--	63.58	--	84.78	--	75.48	--	58.78	63.57
	H_3	34.08	--	--	79.45	--	70.55	--	--	50.84	58.73
S_3	H_1	38.56	54.25	--	62.05	59.84	55.89	--	53.48	46.94	53.00
	H_2	39.64	--	74.18	--	92.55	--	85.74	--	63.78	71.18
	H_3	40.22	--	--	78.33	--	65.42	--	--	56.94	60.23
S_4	H_1	37.15	50.94	--	56.05	55.04	52.15	--	45.84	42.66	48.55
	H_2	36.90	--	66.55	--	81.45	--	81.22	--	58.64	64.95
	H_3	37.04	--	--	76.00	--	63.22	--	--	52.48	57.19

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix VIII. Effect of plant spacing and harvesting interval on fresh weight of stem of Indian Spinach at different times of harvesting

Treatment		Fresh weight of stem per plant (g) at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	75.55	74.15	--	84.15	68.45	55.84	--	62.58	12.13	61.84
	H_2	78.42	--	95.45	--	74.10	--	81.22	--	13.78	68.59
	H_3	76.22	--	--	92.55	--	64.87	--	--	13.22	61.72
S_2	H_1	81.45	78.33	--	95.48	80.22	59.54	--	68.94	15.43	68.48
	H_2	80.22	--	97.45	--	84.15	--	87.49	--	16.89	73.24
	H_3	82.00	--	--	99.48	--	65.78	--	--	16.11	65.84
S_3	H_1	85.78	82.58	--	89.65	76.55	68.94	--	72.48	17.84	70.55
	H_2	84.22	--	99.84	--	80.40	--	95.55	--	19.55	75.91
	H_3	87.05	--	--	94.15	--	71.84	--	--	18.89	67.98
S_4	H_1	78.42	77.05	--	87.40	82.50	67.15	--	67.94	16.28	68.11
	H_2	77.55	--	95.33	--	78.45	--	98.88	--	17.00	73.44
	H_3	76.45	--	--	91.15	--	61.48	--	--	19.05	62.03

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix IX. Effect of plant spacing and harvesting interval on fresh weight per plant of Indian Spinach at different times of harvesting

Treatment		Fresh weight per plant (g) at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	106.77	122.37	--	133.40	117.70	95.99	--	102.13	48.58	103.85
	H_2	110.47	--	161.29	--	155.54	--	153.70	--	67.26	129.65
	H_3	108.57	--	--	162.97	--	130.09	--	--	62.00	115.91
S_2	H_1	117.29	127.48	--	152.32	134.06	113.69	--	114.15	58.58	116.80
	H_2	115.44	--	161.03	--	168.93	--	162.97	--	75.67	136.81
	H_3	116.08	--	--	178.93	--	136.33	--	--	66.95	124.57
S_3	H_1	124.34	136.83	--	151.70	136.39	124.83	--	125.96	64.78	123.55
	H_2	123.86	--	174.02	--	172.95	--	181.29	--	83.33	147.09
	H_3	127.27	--	--	172.48	--	137.26	--	--	75.83	128.21
S_4	H_1	115.57	127.99	--	143.45	137.54	119.30	--	113.78	58.94	116.65
	H_2	114.45	--	161.88	--	159.90	--	180.10	--	75.64	138.39
	H_3	113.49	--	--	167.15	--	124.70	--	--	71.53	119.22

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix X. Effect of plant spacing and harvesting interval on dry matter content per plant of Indian Spinach at different times of harvesting

Treatment		Dry matter content (%) in plant at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	9.45	10.45	--	10.55	10.84	11.48	--	12.48	12.58	11.12
	H_2	9.78	--	12.48	--	13.66	--	12.55	--	13.44	12.38
	H_3	9.91	--	--	11.48	--	13.25	--	--	14.05	12.17
S_2	H_1	9.85	12.22	--	13.48	12.89	14.64	--	14.98	15.22	13.33
	H_2	10.33	--	13.05	--	13.45	--	14.36	--	17.15	13.67
	H_3	10.05	--	--	12.84	--	15.02	--	--	16.48	13.60
S_3	H_1	11.15	12.84	--	13.55	13.55	16.22	--	16.22	18.32	14.55
	H_2	11.84	--	16.42	--	16.48	--	16.55	--	18.85	16.03
	H_3	12.05	--	--	14.22	--	13.89	--	--	17.55	14.43
S_4	H_1	10.55	11.62	--	12.84	12.64	13.74	--	16.48	17.12	13.57
	H_2	10.33	--	12.84	--	14.33	--	15.89	--	16.85	14.05
	H_3	10.35	--	--	13.55	--	14.28	--	--	16.45	13.66

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix XI. Effect of plant spacing and harvesting interval on yield per hectare of Indian Spinach at different times of harvesting

Treatment		Yield per hectare (t) at									
		30DAS	40DAS	45DAS	50DAS	60DAS	70DAS	75DAS	80DAS	90DAS	Average per harvest
S_1	H_1	14.38	18.95	--	22.95	21.79	17.56	--	16.10	15.66	18.20
	H_2	15.03	--	21.87	--	24.46	--	21.81	--	17.43	20.12
	H_3	13.96	--	--	24.97	--	23.77	--	--	17.77	20.12
S_2	H_1	16.10	19.52	--	25.62	24.67	24.04	--	15.66	17.43	20.43
	H_2	16.48	--	24.67	--	25.81	--	24.46	--	16.30	21.54
	H_3	16.15	--	--	27.71	--	23.49	--	--	18.06	21.35
S_3	H_1	18.19	21.81	--	29.05	25.62	26.36	--	18.38	20.10	22.79
	H_2	18.02	--	26.06	--	26.55	--	25.94	--	22.13	23.74
	H_3	18.17	--	--	26.02	--	22.00	--	--	19.96	21.54
S_4	H_1	16.72	20.65	--	25.22	22.95	24.46	--	18.76	16.65	20.77
	H_2	16.29	--	23.49	--	22.76	--	23.90	--	18.00	20.89
	H_3	15.92	--	--	24.46	--	23.66	--	--	15.87	19.98

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

H_1: Harvest at 10 days interval
H_2: Harvest at 15 days interval
H_3: Harvest at 20 days interval

Appendix XII. Analysis of variance of the data on plant height, number of branches and leaves per plant of Indian Spinach as influenced by plant spacing and harvesting interval

Source of variation	Degrees of freedom	Mean square		
		Plant height	Number of branches per plant	Number of leaves per plant
Replication	2	5.288	0.032	7.363
Plant spacing (A)	3	27.438*	0.689**	39.826**
Harvesting interval (B)	2	1559.556**	0.494**	60.363**
Interaction (A×B)	6	0.968NS	0.058 NS	0.977 NS
Error	22	8.807	0.073	8.257

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

Appendix XIII. Analysis of variance of the data on fresh weight of leaves and stem per plant, fresh weight per plant and dry matter content of Indian Spinach as influenced by plant spacing and harvesting interval

Source of variation	Degrees of freedom	Mean square			
		Fresh weight of leaves per plant (g)	Fresh weight of stem per plant (g)	Fresh weight of plant (g)	Dry matter content (%)
Replication	2	0.508	15.413	21.520	0.472
Plant spacing (A)	3	122.866**	87.173**	411.377**	14.736**
Harvesting interval (B)	2	893.894**	219.083**	1641.184**	2.436**
Interaction (A×B)	6	7.008 NS	5.463 NS	17.864**	0.535**
Error	22	8.624	9.712	14.445	0.289

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

Appendix XIV. Analysis of variance of the data on foliage coverage and yield per hectare of Indian Spinach as influenced by plant spacing and harvesting interval

Source of variation	Degrees of freedom	Mean square	
		Foliage coverage (%)	Yield (t/ha)
Replication	2	0.010	0.284
Plant spacing (A)	3	99.418**	16.134**
Harvesting interval (B)	2	197.840**	3.534*
Interaction (A×B)	6	16.158**	1.859**
Error	22	9.639	0.793

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