EFFECT OF CULTIVAR AND ROW SPACING ON THE GROWTH AND YIELD OF LENTIL

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MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled "**Effect of Cultivar and Row Spacing on the Growth and Yield of Lentil**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Kaniz Fatema**, Registration number: **04-01478** 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 duly been acknowledged.

Dated:
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EFFECT OF CULTIVAR AND ROW SPACING ON THE GROWTH AND YIELD OF LENTIL

ABSTRACT

The experiment was carried out at farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2008 to April 2009 to find out the effect of cultivar and row spacing on growth and yield of lentil. The experiment consisted of two factors, viz., Factor A: Cultivar (4 levels) - C_1: BARI Masur-3, C_2: BARI Masur-4, C_3: BARI Masur-5 and C_4: BARI Masur-6; Factor B: Row spacing (4 levels) - S_1: Row spacing – 20 cm, S_2: Row spacing – 25 cm, S_3: Row spacing – 30 cm and S_4: Row spacing – 35 cm. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on growth parameters of the studied crop were recorded after every 10 days starting from 30 DAS to 70 DAS and at harvest. Among the 4 cultivars, C_4 (BARI Masur-6) produced the highest height in plant, maximum number of branches plant^{-1} and maximum dry matter plant^{-1} at every recording day, whereas the corresponding lowest values were obtained from the cultivar C_1 (BARI Masur-3). In row spacing S_1 (20 cm) obtained the highest value in plant height, number of branches plant^{-1} and in dry matter accumulation while the corresponding lowest values were obtained from the row spacing S_4 (35 cm). In respect of yield and yield contributing characters such as number of pods plant^{-1}, pod length, grain yield and straw yield, the cultivar C_4 (BARI Masur-6) also had the highest values which were 48.26 plant^{-1}, 3.26 cm, 2.14 t ha^{-1} and 2.81 t ha^{-1}, respectively, while the cultivar C_1 (BARI Masur-3) gave the lowest values which were 40.21 plant^{-1}, 2.89 cm, 1.64 t ha^{-1} and 2.17 t ha^{-1}, respectively. In combination effect of cultivars and spacing, the combination of C_1 (BARI Masur-3) and row spacing S_1 (20 cm) performed the worst obtaining the lowest values in all growth and yield parameter while BARI Masur-6 with row spacing 20 cm obtained the highest value in plant height, BARI Masur-5 with row spacing 30 cm on number of branches plant^{-1} and BARI Masur-6 with row spacing 30 cm in yield and yield contributing characters. The highest grain and Stover yield obtained in the combination effect of study were 2.27 t ha^{-1} and 3.02 t ha^{-1}, respectively while the corresponding lowest values were 1.36 t ha^{-1} and 1.69 t ha^{-1}.

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CHAPTER 1

INTRODUCTION

Lentil, mungbean, grass pea, blackgram, chickpea, field pea and cowpea are the common pulse crops in Bangladesh. The crop group included under pulses is important because it provides a cheap source of easily digestible dietary protein for the human being. Pulse supplies about four times as much protein and eight times as riboflavin and the caloric value of it is equal to rice (Anonymous, 1966). Moreover, pulse is known as poor man's meat. It is a versatile source of nutrients for man, animal and soil (Miah, 1976). According to FAO (1999) a minimum requirement of pulse is 80 g per head per day, whereas it is only 14.19 g in Bangladesh context (BBS, 2008). This is because of the fact that the production of pulses is not adequate to meet the national demand.

Lentil (*Lens Culinaris*) is one of the major pulse crops in Bangladesh, which ranks third among the lentil growing countries of Asia pacific region (FAO, 2004). It is the second most important pulse crop in area and production, but stands first in the consumers' preference in this country (Ezzat *et al*., 2005). In 2006-2007 it was grown on 134,642 ha of land producing 115,370 tones of grain, with an average yield of 857 kg ha^{-1} which contributed to 33% of the total pulse production (BBS, 2008). In Bangladesh lentil cultivation is mostly concentrated in the Gangetic Flood Plain of western part of the country. Domestic pulse production satisfies less than 50 percent of the country's demands. The rest about 140,000 tons, need to be imported at a cost of about US$ 32.2 million per annum.

Nutritionally, lentil is very rich and complementary to any cereal crops including rice. It's grain contains 59.8% carbohydrate, 25.8% protein, 10% moisture, 4% mineral and 3% vitamin (Khan, 1981; Kaul, 1982). Sufficient amount of vitamins viz. vitamin-A 16I U; thiamine 0.23 mg and vitamin C 2.5 mg are available from a gram of lentil (Anonymous, 1976) and it forms a balanced diet when supplemented with cereals (Abu-Shakra and Tannous, 1981). In spite of so many advantages, in Bangladesh lentil is generally grown under minimum fertility and management practices. Considering yield and nutritive value, lentil is better than the traditional legume and other cereals. Moreover, this crop fits well in the cropping pattern of Bangladesh. The research work in this direction is limited and fragmentary in Bangladesh.

The development of high potential genotypes with good, stable yield and higher protein content is important to improve production status of this crop. More work is needed for making a tangible improvement of this crop. Lack of quality seeds of high yielding varieties and optimum spacing are also two major limiting factors hindering the productivity of lentil. The existing varieties in Bangladesh are mostly low yielding. The average yield of lentil in Bangladesh is gradually declining. Several factors are responsible for low yield of lentil, such as, less attention on cultural practices, lack of pest control measures, post-harvest losses, the use of traditional varieties or landraces with low genetic potential and instability of yield. The development of high yielding and high protein containing legume with other desirable characters is needed to improve the yield status of this crop.

A number of agronomic practices have been found to influence the yield of vegetable crops (Boztok, 1985). The productivity of this crop is very poor in Bangladesh compared to that in the other countries of the world. 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 increase the number of leaves and branches with healthy foliage. Densely planted crops obstruct the proper growth and development. On the other hand, wider spacing ensures the basic requirements but decreases the total number of plants as well as yield. The 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 lentil cultivation is scanty. But still to day there is few research works available focusing on the effects of cultivar and row spacing on the growth and yield of lentil production in Bangladesh. Considering above facts, the present study was undertaken with the following objectives:

i. To investigate the growth and yield performance of the four latest lentil cultivars and

ii. To investigate the effect of row spacing on the growth and yield of different cultivars of lentil, and thereby to identify optimum row spacing .

CHAPTER 2

REVIEW OF LITERATURE

Lentil is one of the important pulse crops and the crop has conventional less concentration by the researchers on various aspects because normally it grows without less care or management practices. For that a very few studies regarding growth, development and yield of lentil have been carried out in our country as well as many other countries of the world. So the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works regarding the cultivar and row spacing so far been done at home and abroad on genotypes of this crop and some other varieties and their findings have been reviewed in this chapter under the following headings-

2.1 Yield contributing characters and yield of lentil cultivar/genotypes

A study was conducted by Hakim *et al*. (2006) in Mansehra, Pakistan, during rabi 2004-05 using 13 diverse genotypes of lentil: PL-339319, FLIP-97-28L, FLIP-99-IL, FLIP-2002-IL, FLIP-2002-16L, FLIP-2003-10L, FLIP-2003-13L, 81-S-15-28, FLIP-2004-5L, FLIP-2004-30L, Shenaz-96, Masoor-93 and Masoor-local. Genetic variances, heritability and correlations among different traits (days to flowering and maturity, plant height, pods per plant, seeds per pod, 1000-seed weight and yield) were studied. Differences for all the traits were found statistically significant. Days to flowering ranged from 123 (FLIP-2002-1L) to 131 (Shiraz) while days to maturity ranged from 172 (PL-339319) to 184 days (FLIP-2004-30L). The tallest plants (48.0 cm) were produced by FLIP-2004-30L, while the shortest plants (31.3 cm) were produced by 81-S-15-28 (31.3 cm). Pods per plant varied significantly from 29 (FLIP-2004-5L) to 52 (Masoor-93). Data on 1000-seed weight ranged from 22 g (FLIP-97-28L) to 40 g (FLIP-2003-13L). The highest seed yield of 1713 kg/ha was obtained from the plots of Masoor-93, followed by FLIP-99-IL with 1622 kg/ha.

Small-seeded (twenty-five) and bold-seeded (eighteen) genotypes of lentil were evaluated by Vinay *et al*. (2006) at mid-altitudes in North-Western Himalayas in winter seasons of 2002-03 and 2003-04 to understand and compare the contribution of various characters to yield. Seed yield was positively associated with pod length, plant height and maturity in both the lentil types. Plant height showed more of direct contribution towards yield than indirect contribution. A significant shift in the association between yields with pods/plant, flowering and maturity was observed. In small-seeded lentil all the characters were important with an emphasis on delayed maturity and tall plant habit, while in bold-seeded lentil, pod length, delayed maturity and tall plant type were important with more emphasis on tall plant type.

An experiment was conducted by Gupta *et al*. (2006) with forty lentil genotypes for genotype × environment interaction and phenotypic stability under 8 diverse environments in Ghaziabad, Uttar Pradesh, India during 1998-99 and 1999-200. Eleven different growth and yield characters were evaluated: days to 50% flowering, days to maturity, primary branch number per plant, secondary branch number per plant, pod number per plant, 100-seed weight, plant height, seed number per plant, biological yield/plant, harvest index and seed yield/plant. High yielding and stable genotypes included JLS-1, PL 639, PL 81-64, E 153, L3685, Sehore 74-3, PL 81-49, PL-81-67, L4605, L263, PL 4 and P 22127.

Experiments were conducted by Ezzat *et al.* (2005) to evaluate 30 exotic and Egyptian lentil genotypes for earliness, yield, yield components, seed protein content, hydration coefficient before and after cooking, total soluble solids and seed cook ability characters. Correlation and factor analysis procedures were used to determine the contributing characters in yield variation. Field experiments were conducted at Giza Research Station, Egypt during 2001/02 and 2002/03. Genotypes FLIP 88-42L, PKVL-1, FLIP 96-52L, FLIP 97-30L, FLIP 97-33L and Sinai 1 were the earliest in flowering and maturity. FLIP 88-34L had the highest number of pods and seeds per plant, and produced the highest seed yield/fed recording 4.10 ardab, surpassing Giza 9 by 35%.

Shrestha *et al.* (2005) carried out an experiment with nineteen diverse lentil genotypes, 8 originating from South Asia, 6 from West Asia, and 5 crossbreds using parents from South Asia and West Asia (or other Mediterranean environments), were evaluated for growth, phenology, yield, and yield components at Khumaltar in the mid-hill region of Nepal. Additionally, dry matter production, partitioning, root growth and water use of 8 selected genotypes from the 3 groups were measured at key phenological stages. The seed yield of the West Asian genotypes was only 330 kg/ha, whereas the South Asian genotypes produced a mean seed yield of 1270 kg/ha. The crossbreds had a significantly greater seed yield (1550 kg/ha) than the South Asian genotypes. The high seed yield of both the South Asian and crossbred genotypes was associated with rapid ground cover, early flowering and maturity, a long reproductive period, a greater number of seeds and pods, high total dry matter, greater harvest index.

Turk *et al*. (2004) carried out an experiment with the aim to (I) investigate the response of 3 lentil cultivars, i.e. FLIP 86-16 L (large seeds), FLIP 89-31 L (small seeds) and FLIP 95-3L (small seeds), to osmotic stress during germination and seedling growth; (ii) identify characters that can be used for screening genotypes; and (iii) determine the effects of cultivars on yield and yield components of rainfed lentil in arid (150 mm rainfall) and semiarid (364 mm) regions in Jordan. Large-seeded cultivars exhibited higher percentage of germination and germination speed under moisture stress than did the small-seeded cultivars. Germination speed was more sensitive to change in osmotic potential than percent germination. Root and shoot weights of all cultivars were reduced when osmotic potential was decreased, but the extent of reduction in root growth was less than that for shoots. Lentil plants at the semi-arid location (Houfa) had greater seed yield, 1000-seed weight and plant height than those grown at the arid location (JUST). Lentil plants from large-seeded cultivars had greater seed yield, 1000-seed weight and plant height than those from small-seeded cultivars.

The genetic variability, heritability and genetic advance for earliness and seed yield characters were studied by Hamdi *et al*. (2003) in 24 lentil genotypes at Sids Research Station in 1997/98 and 1998/99, and at Giza Research Station in

1998/99 season, in Egypt. The environments (season and location) showed major effects on the performance of genotypes. High phenotypic variation was observed for number of pods and seeds per plant. Considering wide variability, heritability and genetic advance, progress could be expected from selection for number of seeds per plant and seed yield per plant. The early-maturing genotypes Sina 1, FLIP 87-21L and FLIP 92-54L could be recommended for planting in case the earliness in maturity is more important than seed yield. On the other hand, high-yielding genotypes FLIP 89-71L, FLIP 95-68L, 89503, FLIP 92-48L and FLIP 95-50L could be recommended for planting in case high yield potential is more important than earliness in maturity.

Seventy-two genotypes of lentil, collected from 11 locations in India, were subjected to stability analysis of seed yield and its components in a field experiment conducted in Hisar, Haryana, India during the winter seasons of 1995-96, 1996-97 and 1997-98 by Solanki (2001). Seven genotypes (LH91-9, LH 84-8, L 9-12, LH 94-5, PL 81-17, LH 92-63 and LH 92-65) showed high yields and were stable over a wide range of environments; L 4603, IPL 71, LH 94-12, LH 92-78 and L 4146 were responsive to superior environments, and IPL 76 and LH 90-110 to inferior environments. The stability of genotypes for grain yield in the superior or inferior environment was impaired by the stability of different yield-contributing traits.

An experiment was conducted by Tomar *et al*. (2000) with lentil cultivars Pant L 209, Pant L 639, Pant L 406 and T36 were evaluated for yield, protein yield and nutrient uptake under 2 sowing methods (20-cm row spacing with 60 kg seed rate and 30 cm row spacing with 45 kg seed rate), in a field in Uttar Pradesh, India, during the winter seasons of 1994-95 and 1995-96. The effect of 4 diammonium phosphate (DAP) levels (0, 50, 100 and 150 kg/ha) on the performance of the genotypes was also investigated. Pant L 639 gave the best performance for crop yield, nutrient uptake and protein yield. Narrow row spacing (20 cm) with high (60 kg) seed rate produced higher yield than wider row spacing (30 cm) with normal seed rate (45 kg). Increasing DAP concentrations significantly increased seed yield, protein yield and nutrient uptake.

Lentil mutants ML-432/8, ML-18, ML-20 and ML-22 and L-5 (parent variety) were evaluated by Dutta *et al*. (1998) in field trials for nitrate reduction and photo harvest capacity in relation to growth potential and seed yield. The results demonstrated that seed yield did not depend on leaf area/plant, leaf area ratio or specific leaf weight. Although seed yield of mutant ML-18 was less than that of mutants with lower values of ML-432/8, ML-22 and ML-20.

Bred by individual selection in progeny from a cross between the Canadian variety Laird and the Russian variety Tadzhikskaya 95, Nadezhda is suitable for mechanized growing and harvesting reported by Mikhov *et al*. (1997). In trials during 1989-92 it gave a mean yield of 235 kg/da. The seeds, with a 1000-seed weight of 29.8 g, contain 27.2% protein and have good cooking quality.

A study was undertaken by Geletu *et al*. (1995) to assess the seed yield stability of 10 later maturing lentil varieties at 22 environments in the highlands of Ethiopia.

The higher yielding varieties, except NEL357, were affected by changes in environment, and these varieties showed better adaptation to good environments. The average yielding varieties had wider adaptation. The lower yielding varieties were less affected by environmental changes and performed well under poorer environments.

Correlation and path coefficient analyses at the phenotypic and genotypic levels were performed on F_5 sergeants of two lentil crosses grown during 1988-90 by Esmail *et al*. (1994). The results indicated that seed yield/plant was negatively correlated with time to maturity at the phenotypic and genotypic levels in ILL5584 × Precoz and at the phenotypic level in Giza 370 × Precoz. At both levels, seed yield was positively correlated with seed protein content in ILL5584 x Precoz. Seed yield was also positively correlated with branching, pods/plant, seeds/pod, seed weight and biological yield/plant at both levels in both crosses. Branching, pods/plant and seeds/pod were the most important characters affecting yield variation.

Pant Lentil 4, a small seeded lentil variety recommended for the North-Western Plains of India, was developed by Singh *et al*. (1994) through pedigree selection in a 3-way cross (UPL175 x (Pant L 184 x P288)). It had consistently higher seed yield and resistance to rust (*Uromyces fabae*), wilt (*Fusarium oxysporum*) and blight (*Ascochyta lentis*) than other cultivars in trials over 4 years at several locations. It produced an average yield of 1720 kg/ha, compared to the national average of 727 kg/ha.

An experiment was carried out by Thakur and Bajpai (1993) with 700 accessions to study the adaptability of the crop to local conditions. An analysis of variance revealed a wide range of variability for all characters studied with the exception of number of secondary branches and number of pods/plant. High phenotypic coefficients of variation were obtained for seed yield, number of secondary branches, number of pods and biological yield/plant.

2.2 Yield contributing characters and yield of lentil for plant spacing

Field trials on different row spacings (15, 20, 25, 30 and 35 cm) and dates of sowing (15 and 25 October, and 5, 15 and 25 November) were conducted by Lal *et al*. (2006) during the 2000/01 and 2001/02 rabi seasons in Bihar, India, with lentil cultivars Sehore 74-3 and SLC-5 to determine yield of lentil. In Sehore 74-3, maximum (860.5 kg/ha) was recorded in 25 cm spacing.

A field experiment was conducted Inderjit *et al*. (2005) on sandy-loam soil of Gurdaspur, Punjab, India, during the 1998-2000 winter season (rabi) to study the effect of different sowing dates, row spacings and seed rates on the productivity of lentil cv. LG 308 . There was a significant reduction in seed yield with delay in sowing from 10 November to 10 December. Lentil sown on 10 November (14.6 q/ha) outyielded the crop sown on 25 November and 10 December by a margin of 12.8 and 90.1%, respectively. The crop sown on 10 November recorded higher net income (Rs 1826/ha) and benefit : cost ratio (0.23) than 25 November-sown crop which in turn recorded Rs 5797/ha higher net returns and 0.75 higher benefit : cost ratio. Row spacing of 20 cm (12.3 q/ha) resulted in 4.2 and 9.5% more seed yield than closer (17.5 cm) and wider (22.5 cm) row spacings, respectively. Row spacing of 20 cm recorded Rs 680 and Rs 1047/ha higher net returns and benefit : cost ratio to the tune of 0.10 and 0.12 over row spacings of 17.5 cm and 22.5 cm, respectively. Seed yield (13.6 q/ha) of lentil sown at row spacing of 20 cm using 37.5 kg seed/ha was significantly higher than all other combinations of seed rates and row spacings.

An experiment was conducted by Ezzat *et al*. (2005) in Gemmiza (Gharbia) and Mataana (Qena), Egypt, during the 2001/02 and 2002/03 winter seasons to study the effect of plant density (200, 300, 400 and 500 plants per m^2) on the performance of newly-released lentil cultivars Sinai 1, Giza 4 and Giza 51, and local cv. Giza 9. The combined analysis of variance indicated highly significant differences among seasons, locations, cultivars and plant densities for all studied characters, except days to flowering and maturity for season, number of pods per plant for location, and 100-seed weight for plant density. The significance and magnitude of interaction effects varied widely. However, at Mataana, Sinai 1 flowered and matured at the same time as Giza 9. Seed weight per plant and yield components as number of pods and seeds per plant were significantly higher in low plant densities than under high plant densities due to better growth and development of individual plants.

A field experiment was consecutively conducted by Muhammad *et al*. (2002) during 1993-94 and 1994-95 to investigate the effect of sowing date (7 November, 6 December), irrigation (nil, full irrigation, irrigation at podding) and population density (100, 150, 200 plant per m^2) on lentil seed yield and its components at the Crop Production and Water Management Research Area, University of Agriculture, Faisalabad, Pakistan. A population density of 150 plant per m^2 out-yielded in seed yield over 100 or 200 plant m^{-2} in both the years. This positive response to early sowing, higher density or fully irrigated crop was the direct consequence of improvement in all the yield components.

Lentil cultivars Pant L 209, Pant L 639, Pant L 406 and T36 were evaluated by Tomar *et al*. (2000) for yield, protein yield and nutrient uptake under 2 sowing methods (20 cm row spacing with 60 kg seed rate and 30 cm row spacing with 45 kg seed rate), in a field in Uttar Pradesh, India, during the winter seasons of 1994-95 and 1995-96. The effect of 4 diammonium phosphate (DAP) levels (0, 50, 100 and 150 kg/ha) on the performance of the genotypes was also investigated. Narrow row spacing (20 cm) with high (60 kg) seed rate produced higher yield than wider row spacing (30 cm) with normal seed rate (45 kg).

An experiment was conducted by Singh and Verma (1999) at Bichpuri, Uttar Pradesh, India during the winter seasons of 1993-94 and 1994-95 to evaluate lentil cultivars (T 36, Pant L 406, K 75 or LH 84-8), sowing rate (30, 45 or 60 kg seeds/ha) and row spacing (20 or 30 cm). The small-seeded cultivar Pant L 406 had the highest mean yield (1786 kg/ha) at a sowing rate of 45 kg/ha and 20-cm row spacing, followed by LH 84-8 (1631 kg/ha). Row spacing had no significant effect on yield, while 45 kg seeds/ha gave significant yield increases over 30 and 60 kg seeds/ha. The interaction between sowing rate and cultivar was significant during both seasons. The benefit : cost ratio was maximum (1.76) in Pant L 406 sown at 20-cm row spacing and 45 kg seeds/ha. At 60 kg seeds/ha, K 75 and LH 84-8 had significantly higher protein content than Pant L 406.

The effect of population density on dry matter (DM) accumulation over time, and grain yield and its components of four grain legumes was examined in a field experiment at Lincoln University Canterbury, New Zealand, in the 1998-99 season by Ayaz *et al*. (1999). The four legumes were sown at four different populations viz. lentils cv. Rajah (15, 150, 300 and 600 plants/m^2), desi chickpeas (5, 50, 100 and 200 plants per m^2), peas cv. Beacon and lupins (*Lupinus angustifolius*) cv. Fest (10, 100, 200 and 400 plants per m^2). The experiment was a split plot design with three replications. The trial was sown on 30 October 1998 and the species were harvested on different dates depending on their physiological maturity. Lupins produced the most DM (878 g per m^2) and DM was less affected by population than the other species. Lentil DM was highly dependent upon population and ranged from 186 to 513 g per m^2 at the lowest and highest population. Chickpeas and pea DM were also affected by population. Chickpeas produced from 430-869 g DM per m^2 as population increased and peas from 292-670 g DM per m^2. Lupins grain yield was least affected by population, being 323 and 434 g per m^2 at the lowest and highest populations. Lentil seed yield had a higher dependency on population than the other species and it was 91 and 304 g per m^2 at the low and the highest populations. The species by population interaction showed that in all four species, the mean seed weight, pods per plant and seeds per pod were inversely related to plant density.

In a field experiment in Mymensingh, Bangladesh, 10 lentil genotypes were grown by Chowdhury *et al*. (1998) at 15 cm row spacing and seed inoculated with Rhizobium or given N or P fertilizer, or were grown at 30 cm row spacing with Rhizobium + N + P. The cultivar Bm 513 gave a significantly higher yield than any of the other genotypes. Yield was highest with Rhizobium, nodule number and nodule weight were highest with Rhizobium alone or with N + P, while plant height and pods per plant were highest with Rhizobium + N + P.

Dutta *et al*. (1998) carried out a field trial in 1994/95 in Mymensingh, Bangladesh, lentil. L-5 were grown at row spacings of 20, 25 or 30 cm and intra-row spacings of 3, 4, 6 or 8 cm. Chlorophyll a/b ratio was higher at low plant densities. Higher densities gave higher seed yields despite the favourable effect of lower densities on net assimilation rate, crop growth rate, chlorophyll a/b ratio, branches/plant, pods/plant and seed yield/plant.

An experiment was conducted by Tanyolac and Sepetoglu (1996) with a small-seeded lentil line introduced from ICARDA was grown at Bornova, Turkey at 20 or 30 cm row spacing and plant densities of 200, 300 or 400 seeds per m^2. The highest number of missing plants was given by 400 plants per m^2 (55.5 missing plants/m^2), due to increased plant competition.

In field trials was conducted by Sharma (1996) in the winter seasons of 1982-84 at Lakhaoti, Uttar Pradesh, India, lentil Pant L 639 was sown at a rate of 20, 40 or 60 kg seed/ha in rows 20 or 30 cm apart and was given Rhizobium inoculation, 20 kg N, 50 kg P_2O_5, inoculation + N and/or P fertilizer or N + P fertilizers alone.

Average seed yield increased with sowing rate and decreased with increase in row spacing. Inoculation + N + P gave the highest seed yield of 1803 kg/ha. Inoculation alone gave a higher seed yield than N or P alone. Mean net profit increased with sowing rate, decreased with increase in row spacing and it was highest with inoculation + N + P.

Singh and Verma (1996) conducted a field experiment during the winter season of 1988/89 at Gorakhpur, Uttar Pradesh, 7 lentil cultivars were grown in rows 20, 25 or 30 cm apart. Seed yields were highest at the row spacings 25 (1.56 t/ha) and 30 cm (1.55 t). The highest yielding cultivar was Pant L 209 (1.84 t).

Singh *et al*. (1994) observed from a field trials in 1987-89 on clay loam soil at Shalimar, Jammu and Kashmir, lentil Precese sown in rows 20, 25 and 30 cm apart gave seed yields of 1.15, 1.38 and 1.34 t/ha, respectively. Sowing at rates of 30, 35, 40 and 45 kg/ha gave seed yields of 1.07, 1.25, 1.44 and 1.40 t/ha, respectively.

Field trials were conducted by Boerboom and Young (1995) on Palouse silt loam at Pullman during 1990 and 1991 to evaluate the efficacy of increased crop densities and post plant tillage as non-chemical methods to supplement metribuzin for improved broadleaf weed control in dry pea cv. Columbian and lentil cv. Brewer. The effects of 50, 100, and 150% of recommended 220 kg/ha pea and 67 kg/ha lentil sowing rates and two dates of rotary hoeing and harrowing on peas, lentils, and broadleaf weeds were studied with and without metribuzin. Under favourable growing conditions, crop competition gave 72 and 99% weed control in peas, and 33 and 70% weed control in lentils with the 50 and 150% sowing rates, resp. Under less favorable conditions, control was 21 to 39% with the low and high pea and lentil sowing rates. At recommended sowing rates, metribuzin gave greater than 90% control in either crop or year.

In a field trial in 1985-86 at Faisalabad, 4 lentil cultivars (9-6, AARIL355, AARIL496 and AARIL344) were tested by Bukhtiar *et al*. (1992) at four row spacings (20, 25, 30 and 35 cm) under irrigated conditions. Maximum seed yield was obtained in AARIL344 at 20 cm now spacing (1786 kg/ha) followed by 25 cm row spacing (1450 kg/ha). Cv. 9-6 and AARIL496 gave higher yields (ca.1340 kg/ha) at 20 cm row spacing than cv. AARIL355. Seed yields in all the four cultivars decreased with increasing row spacing. However, AARIL344 gave greater seed yield than all other varieties at all row spacings. Large seeded cultivar, AARIL355 gave poor yield at 20 (734 kg/ha) to 35 cm (400 kg/ha) row spacings.

From the above presented past research work it is revealed that optimum plant spacing ensures judicious use of natural resources and makes the intercultural operations easier. It helps increase the number of leaves, branches and healthy foliage as well as maximum yield.

CHAPTER 3

MATERIALS AND METHODS

The field experiment was conducted to find out the effect of cultivar and row spacing on the growth and yield of lentil (*Lens culinaris*) during the period from October 2008 to April 2009 at the Sher-e-Bangla Agricultural University Farm. The details of materials and methods that were used for the conducting the experiment are presented below:

3.1 Experimental site

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon., 1989).

3.2 Climatic condition

The climatic condition of experimental site was subtropical, characterized by three distinct seasons like 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). Meteorological data related to the temperature, relative humidity and rainfall during the experimental period was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and has been presented in Appendix I.

3.3 Soil of the experimental field

The soil of the experimental field belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and is shallow red brown terrace soil. The land of the selected experimental plot is medium high under the Tejgaon series. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix II.

3.4 Planting material

BARI Masur-3, BARI Masur-4, BARI Masur-5 and BARI Masur-6 this four lentil cultivar were used as the test crop as well as a factor of this experiment. The seeds were collected from the Pulse Seed Division, Bangladesh Agricultural Research Institute, Joydevpur, Gajipur. Details of these cultivars are presented below as per BARI publications:

3.4.1 BARI Masur-3

BARI Masur-3 is a recommended cross variety of lentil. It grows in rabi season and was released 1985. It is resistant to diseases, insects and other pests especially to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield of this variety is 1.9-2.0 t ha^{-1}. Seeds contain 25.50% protein and 59.60% carbohydrate (Anon., 1999).

3.4.2 BARI Masur-4

BARI Masur-4 is a recommended variety of lentil. It grows in rabi season and was released by BARI in the year 1996. This variety is resistant to diseases, insects and pests especially to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.9-2.0 t ha^{-1}. Seeds contain 25.80% protein and 59.80% carbohydrate (Anon., 1999).

3.4.3 BARI Masur-5

BARI Masur-5 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. It is resistant to diseases, insects and other pests. This variety is also resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 2.1-2.2 t ha^{-1}. Seeds contain 26.93% protein and 59.90% carbohydrate (Anon., 2008).

3.4.4 BARI Masur-6

BARI Masur-6 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. The variety is resistant to diseases, insects and other pests. It is also resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 2.2-2.3 t ha^{-1}. Seeds contain 27.12% protein and 59.40% carbohydrate (Anon., 2008).

3.5 Preparation of land

The land was first opened with the tractor drawn disc plough at the 1st week of October. Then the soil was ploughed and cross ploughed. Ploughed soil was then brought into desirable fine tilth by the operations of ploughing, harrowing followed by laddering. The stubble and weeds were removed from the land for easy germination of lentil seedlings. The first ploughing and the final land preparation were done on 15 October and 25 October 2008, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before seed sowing and the basal dose of fertilizers was incorporated thoroughly with the soil.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, Urea, TSP and MP was applied as basal dose at the time of land preparation.

Table 1. Dose of fertilizers in lentil field (Anon., 1999)

Fertilizers and Manures	Dose/ha
Cowdung	10 tonnes
Urea	50 kg
TSP	80 kg
MP	40 kg

3.7 Treatments of the experiment

The experiment consists of two factors. The details were presented below-

Factor A: Cultivar (4 cultivars)

C_1: BARI Masur-3

C_2: BARI Masur-4

C_3: BARI Masur-5

C_4: BARI Masur-6

Factor B: Spacing: row to row (4 levels)

S_1: Row spacing - 20 cm

S_2: Row spacing - 25 cm

S_3: Row spacing - 30 cm

S_4: Row spacing - 35 cm

There were as a whole 16 treatment combinations for the experiment they were C_1S_1, C_1S_2, C_1S_3, C_1S_4, C_2S_1, C_2S_2, C_2S_3, C_2S_4, C_3S_1, C_3S_2, C_3S_3, C_3S_4, C_4S_1, C_4S_2, C_4S_3 and C_4S_4.

3.8 Experimental design and lay out

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 44.50 m × 11.50 m was divided into three equal blocks. Each block was divided into 16 plots, where 16 treatment combinations were allocated at random. There were 48 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

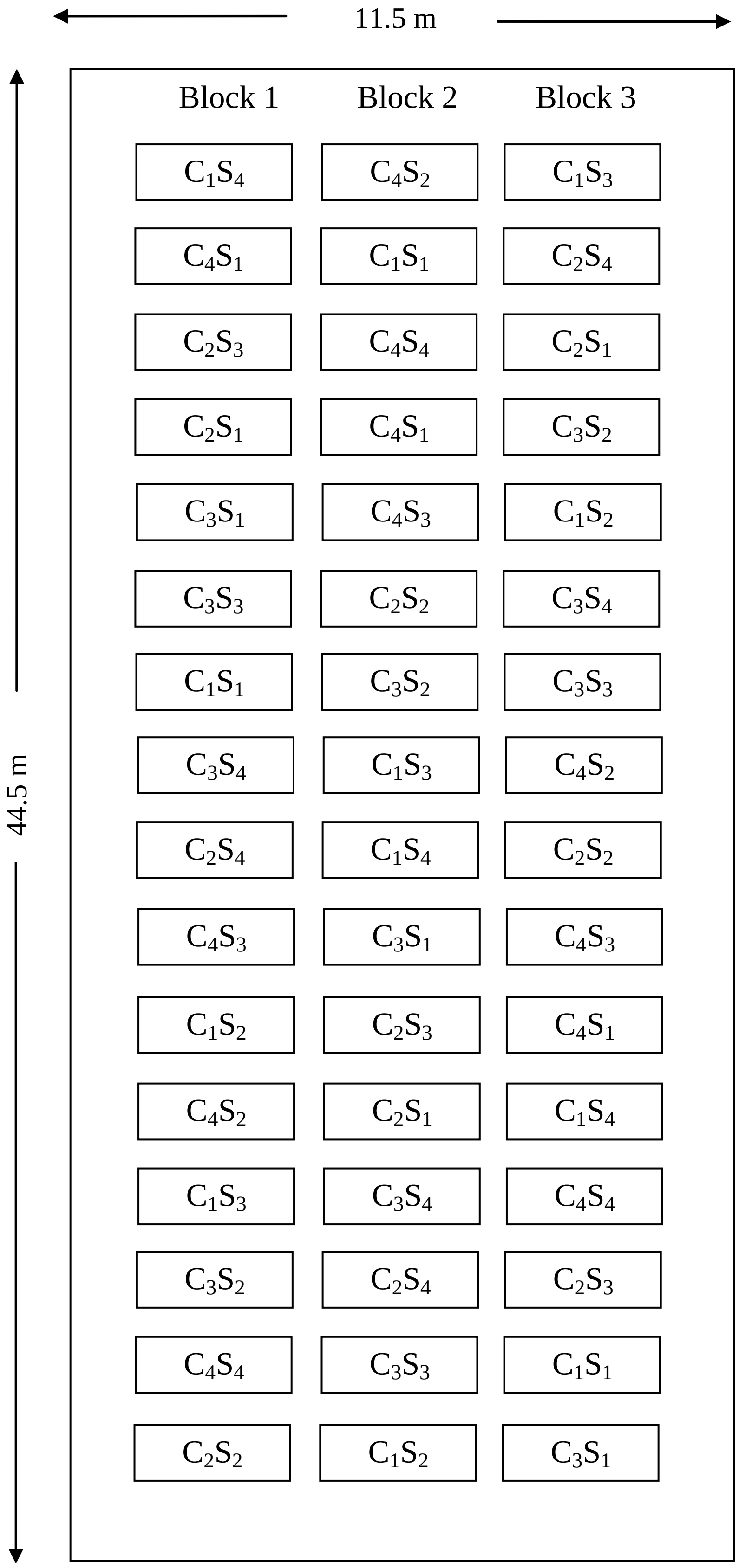
3.9 Seed sowing

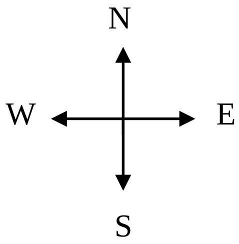
The lentil seeds were sown at November 20 in 2008. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Line to line distance was maintained as per treatment and plant to plant distance was 8-10 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 15 DAS and second was done at 15 days after sowing maintain 10 cm between plants to obtain proper plant population in each plot.





Plot size = 3.0 m ×2.0 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

Factor A:

V_1: BARI Masur-3

V_2: BARI Masur-4

V_3: BARI Masur-5

V_4: BARI Masur-6

Factor B:

S_1: Row spacing – 20 cm

S_2: Row spacing – 25 cm

S_3: Row spacing – 30 cm

S_4: Row spacing – 35 cm

Figure 1. Field layout of the experimental plot in the Randomized Complete Block Design (RCBD)

3.10.2 Irrigation and weeding

Irrigation was done at 20 and 30 DAS. The crop field was weeded twice; first weeding was done at 15 DAS and second at 30 DAS.

3.10.3 Protection against pests

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors attacked the young plants and at latter stage pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1litre ha^{-1} for two times.

3.11 Crop sampling and data collection

Ten plants from each plot were randomly marked inside the central row of each plot with the help of sample card for data collection.

3.12 Harvest and post harvest operations

Harvesting was done at 24th April, 2009 when 90% of the pods became brown to golden brown in color**.** Before harvesting 10 sample plants from each plot was marked and harvested for recording the data on different yield contributing characters. The matured pods were collected by hand picking from the entire plot and plot yield was converted into t ha^{-1}.

3.13 Data collection

The following data were recorded

i. Plant height (cm)
ii. Number of branches $plant^{-1}$
iii. Dry matter content in plant (g)

iv. Days to 1st flowering

v. Days to 80% pod maturity

vi. Number of pods plant^{-1}

vii. Pod length (cm)

viii. Weight of 1000 seeds (g)

ix. Seed yield (t ha^{-1})

x. Stover yield (t ha^{-1})

3.14 Procedure of data collection

3.14.1 Plant height

The plant heights of 10 randomly selected plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Data were recorded from the inner rows of each plot starting from 30 to 60 DAS at 10 day intervals and at harvest.

3.14.2 Number of branches plant^{-1}

The branches were counted from selected plants starting from 30 DAS to 60 DAS at 10-day intervals and at harvest. The total branches of 10 plants were averaged to have number of branches plant^{-1}.

3.14.3 Dry matter content in plant

Ten sample plants from each plot were uprooted at 10-day starting from 30 DAS to 70 DAS. The uprooted plants were gently washed with tap water, thereafter soaked with paper towel. Then fresh weight was taken immediately after soaking.

After taking fresh weight, the sample plants including root, stem, stem and pods were oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight was taken. The average weight of 10 plants was termed as dry matter plant^{-1}.

3.14.4 Days to 1st flowering

Days to 1st flowering were measured by counting the number of days required to start flower initiation in each plot.

3.14.5 Days to 80% pod maturity

Days to 80% pod maturity were measured by counting the number of days required to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves and stem and dark grey colour of pods.

3.14.6 Pods per plant

Number of total pods of ten randomly selected plants from each plot was counted and the mean number expressed on per plant basis.

3.14.7 Pod length

Pod length of ten randomly selected plants from the inner rows of each plot was counted and the mean length was expressed on per pod basis.

3.14.8 Weight of 1000-seeds

One thousand cleaned dried seeds were counted randomly from the total seeds collected from the ten randomly selected plants and were weighed by a digital electronic balance. The weight was expressed in gram (g).

3.14.9 Seed yield

The seeds collected from 6.0 m^2 of each plot were sun dried properly. The weight of seeds was taken and the yield was expressed in t ha^{-1}.

3.14.10 Stover yield

The Stover collected from 6.0 m^2 of each plot was sun dried properly. The weight of stover was taken and the yield was expressed in t ha^{-1}.

3.15 Estimated growth parameter

Using the data on the leaf area and dry matter, the following growth parameters were derived (Hunt, 1978):

Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \quad g\ m^{-2} day^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1} \quad (g\ g^{-1} day^{-1})$$

Where,

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (time T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Natural logarithm

3.16 Statistical analyses

The data on different parameters as well as yield of lentil were statistically analyzed to find out the significant differences among the effects of different cultivars, row spacing and their interactions on these parameters. The mean values of all the characters were calculated and analyses of variance were performed by the 'F' (variance ratio) test. The significance of the differences were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

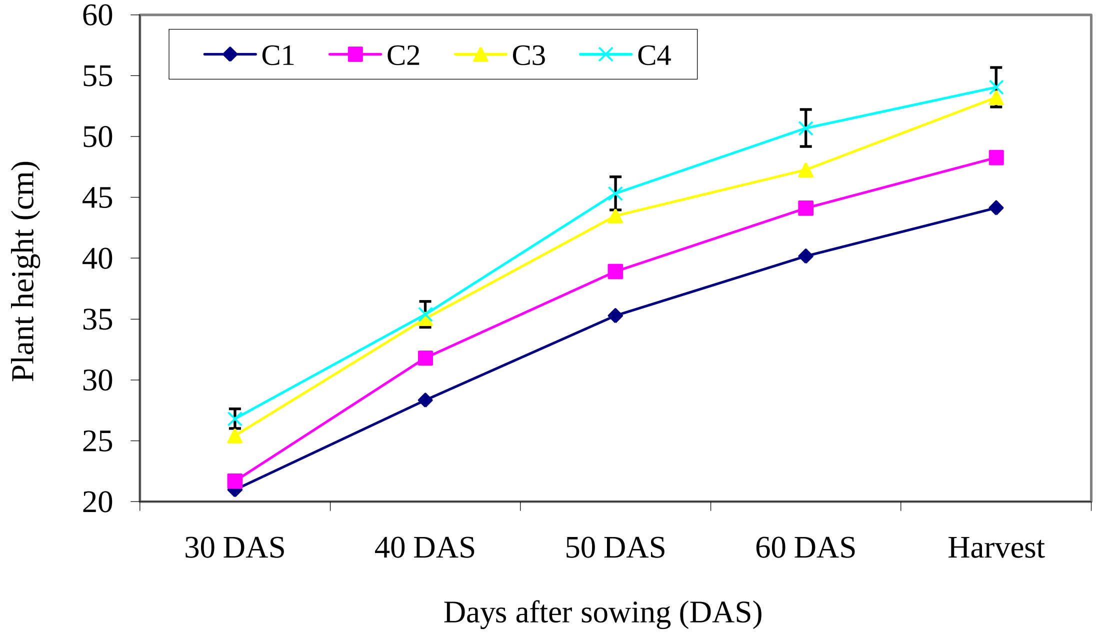
The present experiment was conducted to determine the effect of cultivar and row spacing on the growth and yield of lentil. Data on yield contributing characters and yield were recorded to find out the suitable cultivar and row spacing for lentil cultivation. The analyses of variance (ANOVA) of the data on different yield contributing characters, yield, CGR and RGR are presented in Appendices III-VIII. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1 Plant height

Plant height of lentil showed statistically significant variation due to different cultivars at 30, 40, 50, 60 DAS and at harvest (Figure 2). At 30 DAS, the tallest plants (26.82 cm) were recorded from C_4 (BARI Masur-6) which was statistically similar (25.42 cm) with C_3 (BARI Masur-5) and closely followed (21.69 cm) by C_2 (BARI Masur-4), whereas the shortest plant (20.97 cm) was found from C_1 (BARI Masur-3). At 40 DAS, the longest plant was obtained from C_4 (35.39 cm) which was statistically similar with C_3 (35.05 cm) and closely followed by C_2 (31.82 cm), again the shortest plant was observed from C_1 (28.35 cm). At 50 DAS, the longest plant was recorded from C_4 (45.33 cm) which was statistically similar with C_3 (43.49 cm) and closely followed by C_2 (38.90 cm), while the shortest plant was found from C_1 (35.28 cm). At 60 DAS, the longest plant was recorded from

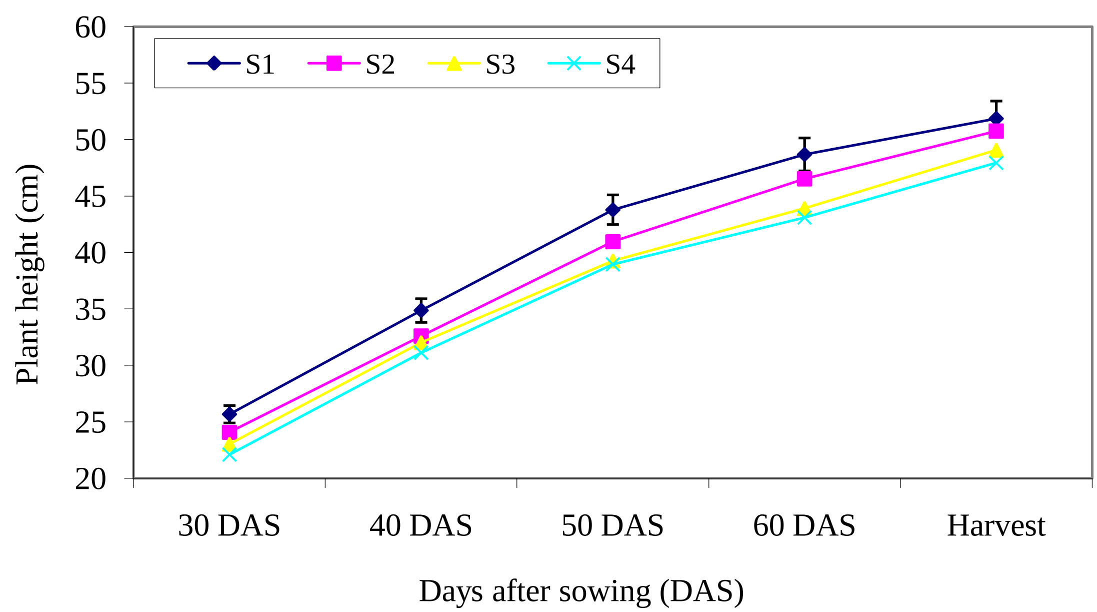
C_4 (50.70 cm) which was closely followed by C_3 (47.26 cm) and the shortest plant was recorded from C_1 (40.17 cm) which was followed by C_2 (44.11). At harvest, the longest plant was obtained from C_4 (54.05 cm) which was statistically similar with C_3 (53.21 cm) and closely followed by C_2 (48.26 cm), while the shortest plant was found from C_1 (44.13 cm).

Statistically significant variation was recorded for different row spacing of lentil in terms of plant height at 30, 40, 50, 60 DAS and harvest (Figure 3). At 30 DAS, the longest plant (25.67 cm) was obtained from S_1 (row spacing - 20 cm) which was statistically similar (24.10 cm) with S_2 (row spacing - 25 cm), while the shortest plant (22.10 cm) was found from S_4 (row spacing - 35 cm) which was statistically identical (23.03 cm) with S_3 (row spacing - 30 cm). At 40 DAS, the longest plant was recorded from S_1 (34.86 cm), again the shortest plant from S_4 (31.12 cm) which was statistically identical with S_3 (32.02 cm) and S_2 (32.60 cm). At 50 DAS, the longest plant was observed from S_1 (43.79 cm) which was statistically identical with S_2 (40.98 cm), while the shortest plant from S_4 (38.95 cm) which was statistically similar with S_3 (39.27 cm). At 60 DAS, the longest plant was found from S_1 (48.69 cm) which was statistically identical with S_2 (46.52 cm), while the shortest plant from S_4 (43.10 cm) which was statistically similar with S_3 (43.92 cm). At harvest, the longest plant was obtained from S_1 (51.86 cm) which was statistically identical with S_2 (50.75 cm). On the other hand, the shortest plant was observed from S_4 (47.96 cm) which was statistically similar with S_3 (49.08 cm).



C_1: BARI Masur-3 C_2: BARI Masur-4
C_3: BARI Masur-5 C_4: BARI Masur-6

Figure 2. Effect of cultivars on plant height of lentil (SE = 0.869, 0.692, 1.200, 0.837 and 0.749)



S_1: Row spacing - 20 cm S_2: Row spacing - 25 cm
S_3: Row spacing - 30 cm S_4: Row spacing - 35 cm

Interaction effect of cultivar and row spacing showed significant variation in terms of plant height of lentil at 30, 40, 50, 60 DAS and harvest (Table 2). The longest plant (32.10 cm, 40.95 cm, 52.37 cm, 57.43 cm and 57.85 cm) was recorded from C_4S_1 (BARI Masur-6 and row spacing – 20 cm) and the shortest plant (16.52 cm, 25.38 cm, 30.79 cm, 36.85 cm and 42.01 cm) was obtained from C_1S_1 (BARI Masur-3 and row spacing – 20 cm) for 30, 40, 50, 60 DAS and at harvest, respectively.

It is revealed that plant height varied from different cultivars of lentil under the present experiment. Similar results were also recorded by the different researchers earlier. Solanki (2001) reported different plant heights for different genotypes. Hanlan *et al*. (2006) reported 0.3 to 0.44 m plant height for different cultivars of lentil. Hamdi *et al*. (2003), Geletu *et al*. (1995), Thakur and Bajpai (1993) also reported different plant height for different cultivar from their earlier experiment. It is observed that both closer row spacings of lentil in the present experiment increased plant height but wider plant spacing reduced the same. The variations in plant height for different row spacing treatments were prominent and differences also significant. 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 Ezzat *et al*. (2005), Muhammad *et al*. (2002), Ayaz *et al*. (1999), Chowdhury *et al*. (1998), Singh and Verma (1996). Interaction effect of cultivar and row spacing also greatly influenced plant height under this experiment.

Table 2. Interaction effect of cultivar and row spacing on plant height of lentil

Treatment	Plant height (cm) at				
	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
C_1S_1	16.52 f	25.38 h	30.79 f	36.85 h	42.01 gh
C_1S_2	25.24 bcde	32.88 cdef	39.55 cde	44.06 cdefg	47.69 def
C_1S_3	20.83 def	28.78 fgh	36.48 cdef	41.08 fgh	45.65 efgh
C_1S_4	21.28 def	26.36 gh	34.28 ef	38.68 gh	41.15 h
C_2S_1	24.86 bcde	35.04 bcd	42.58 bcd	47.48 cde	53.18 abc
C_2S_2	21.78 def	31.61 def	40.30 cde	46.11 cdef	49.25 cde
C_2S_3	20.04 ef	29.86 efg	35.00 def	40.23 gh	44.36 fgh
C_2S_4	20.06 ef	30.78 def	37.74 cdef	42.60 efg	46.24 efg
C_3S_1	29.21 ab	38.07 ab	49.44 ab	53.01 ab	55.39 ab
C_3S_2	22.95 cde	32.31 def	41.54 cde	47.03 cde	52.25 abcd
C_3S_3	27.64 abc	36.97 abc	42.96 bcd	45.78 cdef	53.64 abc
C_3S_4	21.88 cdef	32.84 cdef	40.00 cde	43.23 defg	51.57 bcd
C_4S_1	32.10 a	40.95 a	52.37 a	57.43 a	57.85 a
C_4S_2	26.41 bcd	33.62 cde	42.52 bcd	48.90 bc	53.80 abc
C_4S_3	23.60 bcde	32.47 cdef	42.65 bcd	48.60 bcd	52.65 abc
C_4S_4	25.17 bcde	34.50 bcd	43.78 bc	47.89 bcd	52.90 abc
SE	1.738	1.384	2.400	1.674	1.499
Significance level	0.01	0.01	0.05	0.01	0.05
CV(%)	12.69	7.34	10.20	6.36	5.20

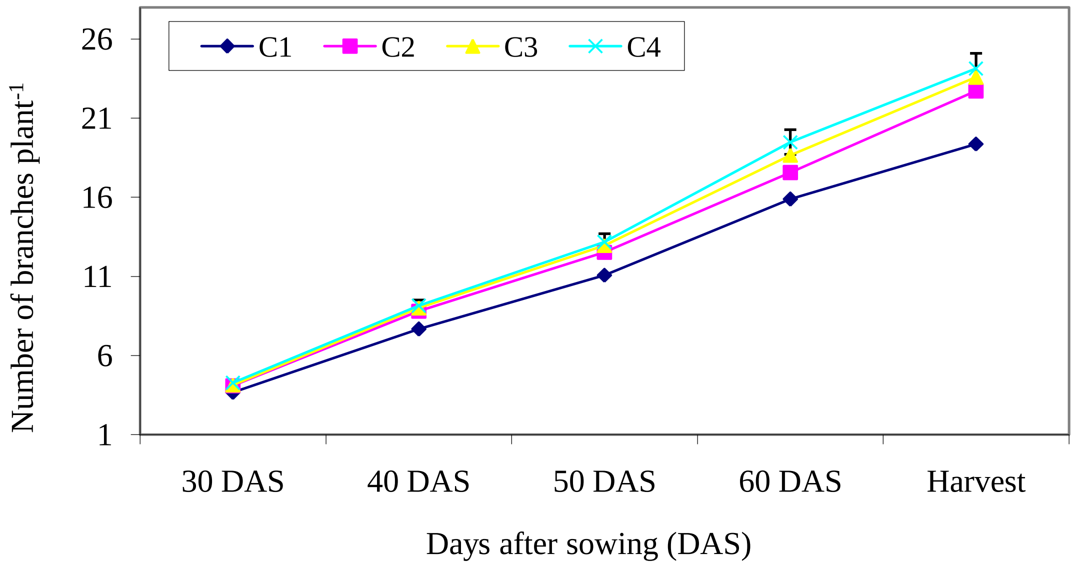
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability

C_1: BARI Masur-3 S_1: Row spacing - 20 cm
C_2: BARI Masur-4 S_2: Row spacing - 25 cm
C_3: BARI Masur-5 S_3: Row spacing - 30 cm
C_4: BARI Masur-6 S_4: Row spacing - 35 cm

4.2 Branches per plant

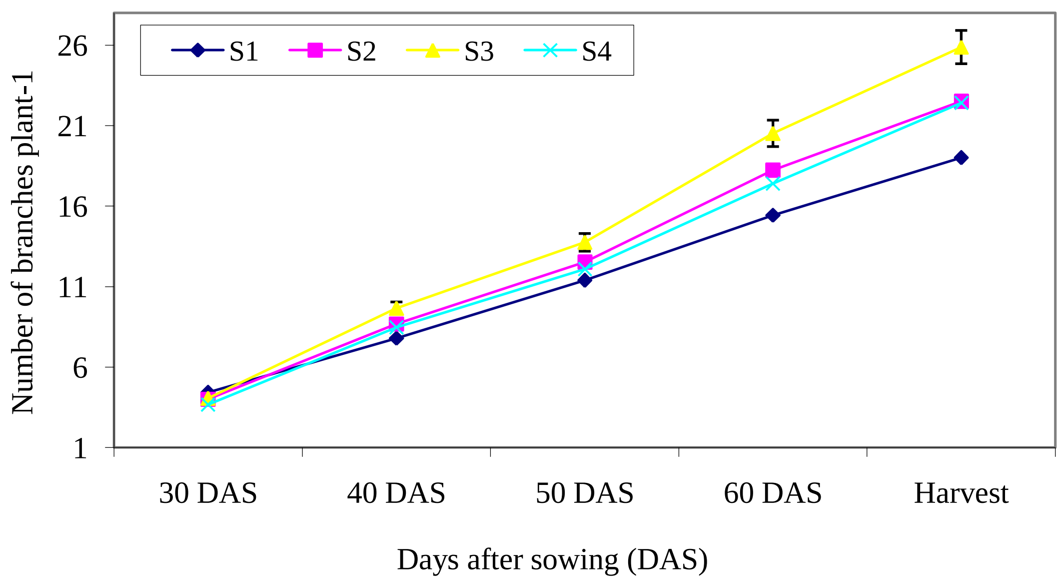
Different cultivar showed statistically significant differences for branches plant^{-1} of lentil at 30, 40, 50, 60 DAS and harvest (Figure 4). The study reveals that throughout the growing period i.e. from 30 DAS onwards to harvest of lentil BARI Masur-6 (C_4) performed the best producing the highest number of branches plant^{-1} ranging from 4.27-24.13 branches plant^{-1}, while the least performance was showed by the variety BARI Masur-3 (C_1) from producing the respective branch ranging from 3.67-22.71. Of course BARI Masur-5 and BARI Masur-4 produced the identical number of branches with BARI Masur-6 at every regarding DAS except at 60 DAS where it was statistically insignificant.

Number of branches plant^{-1} differed significantly for different row spacing of lentil at 30, 40, 50, 60 DAS and harvest (Figure 5). At the initial stage of the crop growth the closest spacing (20 cm) was found to bear the highest number of branches (4.43) and the widest spacing (S_4) was the reverse producing the number of branches (3.67). But at the later period with the advancement of growth almost reverse was the position i.e. the closest spacing (20 cm) bared the lowest number of branches at every reversing days, while S_3 (30 cm) the last but the widest spacing produced the highest number of branches plant^{-1}. From 40 DAS to harvesting the respective highest number of branches were 9.66, 13.75, 20.52 and 25.88 where the respective lowest number of branches were 7.80, 11.39, 15.44 and 19.01 of course the C_2, the medium spacings (25 cm) produced the identical number of branches with the C_3 (30 cm) the highest at every recording DAS except 30 DAS. Dutta *et al*. (1998) reported that higher densities gave higher seed yields despite the favourable effect of lower densities on branches/plant.



C_1: BARI Masur-3 C_2: BARI Masur-4
C_3: BARI Masur-5 C_4: BARI Masur-6

Figure 4. Effect of cultivars on number of branches plant^{-1} of lentil (SE = 0.068, 0.115, 0.117, 0.358 and 0.528)



S_1: Row spacing - 20 cm S_2: Row spacing - 25 cm
S_3: Row spacing - 30 cm S_4: Row spacing - 35 cm

Figure 5. Effect of row spacing on number of branches plant^{-1} of lentil (SE = 0.068, 0.115, 0.117, 0.358 and 0.528)

Cultivar and row spacing of lentil showed significant interaction effect in terms of number of branches plant^{-1} at 30, 40, 50, 60 DAS and harvest (Table 3). The maximum number of branches plant^{-1} (4.83, 9.97, 14.53, 22.33 and 27.47) was found from C_3S_3 (BARI Masur-5 and row spacing – 30 cm), while the minimum number (3.23, 6.17, 9.43, 11.30 and 12.90) was recorded from C_1S_1 (BARI Masur-3 and row spacing – 20 cm) for 30, 40, 50, 60 DAS and at harvest, respectively. It was revealed that number of branches plant^{-1} showed significant differences for different cultivar, row spacing and their interaction effect of lentil under the present experiment.

4.3 Total dry matter content in plant (g)

Though statistically significant differences was recorded for total dry matter content of lentil plant due to different cultivar at 30, 40, 50, 60 and 70 DAS (Table 4) but variety to variety variation was not remarkable. At 30 DAS, the highest dry matter content in plant (5.76 g) was recorded from C_4 (BARI Masur-6) which was statistically similar (5.67 g and 5.54 g) with C_3 (BARI Masur-5) and C_2 (BARI Masur-4), whereas the lowest (5.35 g) was observed from C_1 (BARI Masur-3). At 40 DAS, the highest dry matter content in plant was recorded from C_3 (8.21 g) which was statistically similar with C_4 (8.19 g) and C_2 (7.92 g). On the other hand, the lowest was found from C_1 (7.70 g). At 50 DAS, the highest dry matter content in plant was obtained from C_4 (9.18 g) which was statistically similar with C_3 (9.05 g) and closely followed by C_2 (8.73 g), while the lowest from C_1 (8.34 g). At 60 DAS, the highest dry matter content in plant was recorded from C_3 (10.03 g) which was statistically similar with C_4 (9.80 g), whereas the lowest

Table 3. Interaction effect of cultivar and row spacing on number of branches per plant of lentil

Treatment	Number of branches plant^{-1} at				
	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
C_1S_1	3.23 g	6.17 h	9.43 i	11.30 g	12.90 h
C_1S_2	3.80 def	7.87 fg	11.07 gh	17.43 cdef	21.07 defg
C_1S_3	3.93 def	9.30 abc	13.03 bcd	18.73 cd	24.70 abc
C_1S_4	3.73 f	7.33 g	10.80 h	16.07 ef	18.80 g
C_2S_1	4.63 ab	8.13 ef	11.63 fg	15.50 f	20.13 fg
C_2S_2	4.03 def	8.90 bcd	12.70 bcde	17.77 cdef	22.37 cdef
C_2S_3	4.00 def	9.43 ab	13.34 b	19.73 bc	25.33 abc
C_2S_4	3.73 f	8.77 bcde	12.47 cde	17.23 def	23.00 bcdef
C_3S_1	4.53 abc	8.37 def	12.13 ef	16.77 def	20.83 efg
C_3S_2	4.03 def	8.93 bcd	13.20 bc	18.03 cde	22.80 bcdef
C_3S_3	4.83 a	9.97 a	14.53 a	22.33 a	27.47 a
C_3S_4	3.77 ef	8.80 bcde	12.40 de	17.50 cdef	23.27 bcdef
C_4S_1	4.23 bcd	8.53 cdef	12.37 de	18.20 cde	22.17 cdefg
C_4S_2	4.20 cde	9.07 bcd	13.13 bcd	19.67 bc	23.80 bcde
C_4S_3	4.10 def	9.93 a	14.10 a	21.30 ab	26.00 ab
C_4S_4	3.93 def	9.00 bcd	12.67 bcde	18.80 cd	24.57 abcd
SE	0.135	0.231	0.234	0.716	1.056
Significance level	0.05	0.05	0.01	0.05	0.05
CV(%)	5.80	7.62	8.26	6.93	8.14

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

C_1: BARI Masur-3 — S_1: Row spacing - 20 cm
C_2: BARI Masur-4 — S_2: Row spacing - 25 cm
C_3: BARI Masur-5 — S_3: Row spacing - 30 cm
C_4: BARI Masur-6 — S_4: Row spacing - 35 cm

was found from C_1 (9.13 g) which was statistically similar with C_2 (9.47 g). At 70 DAS, the highest dry matter content in plant was recorded from C_3 (10.94 g) which was statistically similar with C_4 (10.90 g) and C_2 (10.85 g), but the lowest was obtained from C_1 (10.27 g). Throughout the growth period there was observed a progressive increase in dry matter content for 30 DAS onwards to harvest. Gupta *et al*. (2006) reported different dry matter content for different variety earlier from their experiment.

Significant variation was recorded for different row spacing of lentil in dry matter content of plant at 30, 40, 50, 60 and 70 DAS (Table 4). At 30 DAS, the highest dry matter content in plant (6.05 g) was found from S_4 (row spacing - 35 cm) which was closely followed (5.68 g) by S_3 (row spacing - 30 cm), while the lowest (5.21 g) was obtained from S_1 (row spacing - 20 cm) which was statistically identical (5.37 g) with S_2 (row spacing - 25 cm). At 40 DAS, the highest dry matter content in plant was recorded from S_4 (8.32 g) which was statistically identical with S_3 (8.23 g), whereas the lowest from S_1 (7.67 g) which was identical with S_2 (7.80 g). At 50 DAS, the highest dry matter was observed from S_4 (9.28 g) which was closely followed by S_3 (8.99 g), whereas the lowest from S_1 (8.33 g) which was closely followed by S_2 (8.71 g). At 60 DAS, the highest dry matter content in plant was recorded from S_4 (10.16 g) which was closely followed by S_3 (9.75 g) and S_2 (9.50 g), while they were statistically similar, and the lowest from S_1 (9.03 g). At 70 DAS, the highest dry matter content was found from S_4 (11.35 g) which was followed by S_3 (10.84 g) and S_2 (10.70 g) and they were statistically identical and the lowest from S_4 (10.08 g).

Table 4. Effect of cultivar and row spacing on dry matter content per plant of lentil

Treatment	Dry matter content per plant (g)				
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
Cultivar					
C_1	5.35 b	7.70 b	8.34 c	9.13 c	10.27 b
C_2	5.54 ab	7.92 ab	8.73 b	9.47 bc	10.85 a
C_3	5.67 a	8.21 a	9.05 a	10.03 a	10.94 a
C_4	5.76 a	8.19 a	9.18 a	9.80 ab	10.90 a
SE	0.094	0.118	0.091	0.137	0.147
Significance level	0.05	0.01	0.01	0.01	0.01
Row spacing					
S_1	5.21 c	7.67 b	8.33 d	9.03 c	10.08 c
S_2	5.37 c	7.80 b	8.71 c	9.50 b	10.70 b
S_3	5.68 b	8.23 a	8.99 b	9.75 b	10.84 b
S_4	6.05 a	8.32 a	9.28 a	10.16 a	11.35 a
SE	0.094	0.118	0.091	0.137	0.147
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	5.84	7.09	9.58	7.95	10.73

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

C_1: BARI Masur-3 S_1: Row spacing - 20 cm
C_2: BARI Masur-4 S_2: Row spacing - 25 cm
C_3: BARI Masur-5 S_3: Row spacing - 30 cm
C_4: BARI Masur-6 S_4: Row spacing - 35 cm

Dry matter content in plant of lentil varied significantly for the interaction effect of cultivar and row spacing at 30, 40, 50, 60, 70 DAS (Table 5). The highest dry matter content in plant recorded at 30, 40, 50, 60 DAS was respectively (6.81 g, 8.92 g, 10.11 g, 10.99 g and 12.32 g) and each was obtained from C_4S_4 (BARI Masur-6 and row spacing 35 cm). On the other hand, the lowest value (4.28 g, 6.67 g, 7.64 g, 8.30 g and 9.56 g) was recorded from C_1S_1 (BARI Masur-3 and row spacing 20 cm) for 30, 40, 50, 60 and 70 DAS, respectively. At 40, 60 and 70 DAS the highest value obtained from C_4S_4 was statistically similar with the corresponding value obtained from C_3S_3 and C_3S_4. Ezzat *et al*. (2005) reported that dry matter content per plant significantly higher in low plant densities than under high plant densities due to better growth and development of individual plants. Singh and Verma (1999) reported that the interaction between sowing rate and cultivar was significant regarding dry matter content of plant.

4.4 Days to 1st flowering

Days to 1st flowering of lentil showed statistically significant differences due to different cultivar (Figure 6). The maximum days to 1st flowering (56.17) was found from C_1 (BARI Masur-3) which was statistically similar (55.38 and 53.83) with C_2 (BARI Masur-4) and C_4 (BARI Masur-6), while the minimum (52.58) was recorded from C_3 (BARI Masur-5).

Table 5. Interaction effect of cultivar and row spacing on dry matter content plant^{-1} of lentil

Treatment	Dry matter content plant^{-1} (g)				
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
C_1S_1	4.28 e	6.67 e	7.64 g	8.30 e	9.56 f
C_1S_2	5.31 cd	7.84 cd	8.43 ef	9.67 bcd	10.69 cde
C_1S_3	6.15 b	8.07 bcd	8.80 cdef	9.79 bc	11.06 c
C_1S_4	5.67 bcd	8.24 abcd	8.47 ef	8.75 de	9.79 ef
C_2S_1	5.28 cd	7.76 cd	8.38 f	8.89 cde	10.04 def
C_2S_2	5.63 bcd	7.70 cd	8.56 def	9.41 bcd	10.90 cd
C_2S_3	5.43 cd	8.14 bcd	8.98 bcdef	9.76 bc	11.22 bc
C_2S_4	5.82 bc	8.06 bcd	9.01 bcde	9.84 b	11.23 bc
C_3S_1	5.83 bc	8.12 bcd	8.58 def	9.34 bcd	10.34 cdef
C_3S_2	5.38 cd	7.48 d	8.74 def	9.64 bcd	10.69 cde
C_3S_3	5.58 bcd	8.68 ab	9.37 bc	10.08 b	10.69 cde
C_3S_4	5.88 bc	8.32 abc	9.51 b	11.06 a	12.04 ab
C_4S_1	5.47 cd	8.14 bcd	8.72 def	9.57 bcd	10.38 cdef
C_4S_2	5.18 d	8.17 bcd	9.11 bcd	9.28 bcd	10.53 cde
C_4S_3	5.57 bcd	7.78 cd	8.80 cdef	9.38 bcd	10.37 cdef
C_4S_4	6.81 a	8.92 a	10.11 a	10.99 a	12.32 a
SE	0.188	0.235	0.182	0.274	0.293
Significance level	0.01	0.01	0.01	0.01	0.01
CV(%)	5.84	7.09	9.58	7.95	10.73

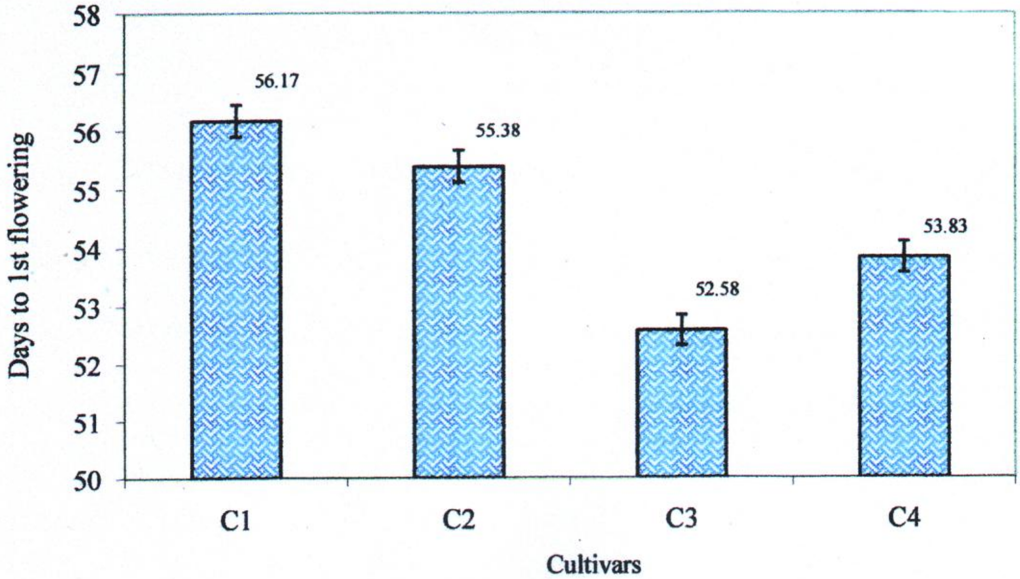
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of probability

C_1: BARI Masur-3 — S_1: Row spacing - 20 cm

C_2: BARI Masur-4 — S_2: Row spacing - 25 cm

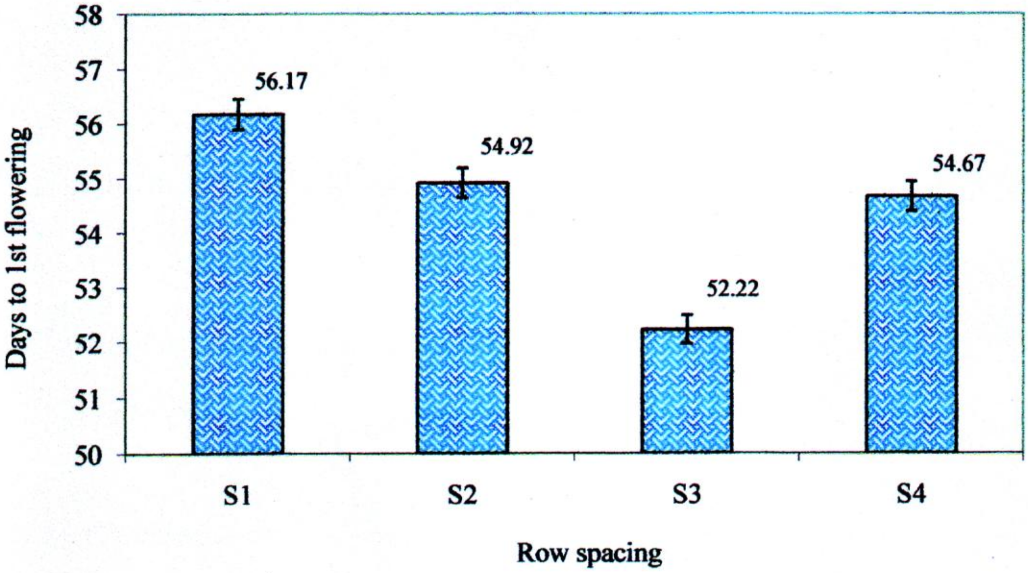
C_3: BARI Masur-5 — S_3: Row spacing - 30 cm

C_4: BARI Masur-6 — S_4: Row spacing - 35 cm



C_1: BARI Masur-3 C_2: BARI Masur-4
C_3: BARI Masur-5 C_4: BARI Masur-6

Figure : 06. Effect of cultivars on days to 1st flowering of lentil (SED= 0.867)



S_1: Row spacing - 20 cm S_2: Row spacing - 25 cm
S_3: Row spacing - 30 cm S_4: Row spacing - 35 cm

Figure:07. Effect of row spacing on days to 1st flowering of lentil (SED= 0.867)

Row spacing of lentil showed significant variation for days to 1st flowering (Figure 7). The maximum days to 1st flowering (56.17) was obtained from S_1 (row spacing - 20 cm) which was statistically similar (54.92 and 54.67) with S_2 (row spacing - 25 cm) and S_4 (row spacing - 35 cm), and the minimum (52.22) was found from S_3 (row spacing - 30 cm). Ezzat *et al*. (2005) reported similar findings.

Interaction effect of cultivar and row spacing showed significant variation for days to 1st flowering (Figure 8). The maximum days to 1st flowering (58.67) was recorded from C_1S_3 (BARI Masur-3 and row spacing – 30 cm), whereas the minimum (48.67) from C_3S_3 (BARI Masur-5 and row spacing – 30 cm).

4.5 Days to 80% pod maturity

Though cultivar of lentil showed statistically significant differences for days to 80% pod maturity (Table 6) but the variation among the varieties was not so much distinct. The maximum days to 80% pod maturity (116.42) was recorded from C_1 (BARI Masur-3) which was similar (114.42) with C_3 (BARI Masur-5) and closely followed (110.08 and 109.67) by C_2 (BARI Masur-4) and C_4 (BARI Masur-6).

Days to 80% pod maturity varied significantly for different row spacing of lentil (Table 6). The maximum days to 80% pod maturity (115.42) was recorded from S_4 (row spacing 35 cm) which was statistically similar (113.75 and 112.67) with S_1 (row spacing 20 cm) and S_2 (row spacing 25 cm), whereas the minimum (108.75) was obtained from S_3 (row spacing 30 cm). Muhammad *et al*. (2002) reported that higher density was the direct consequence of improvement in all the yield components like days to 80% pod maturity.

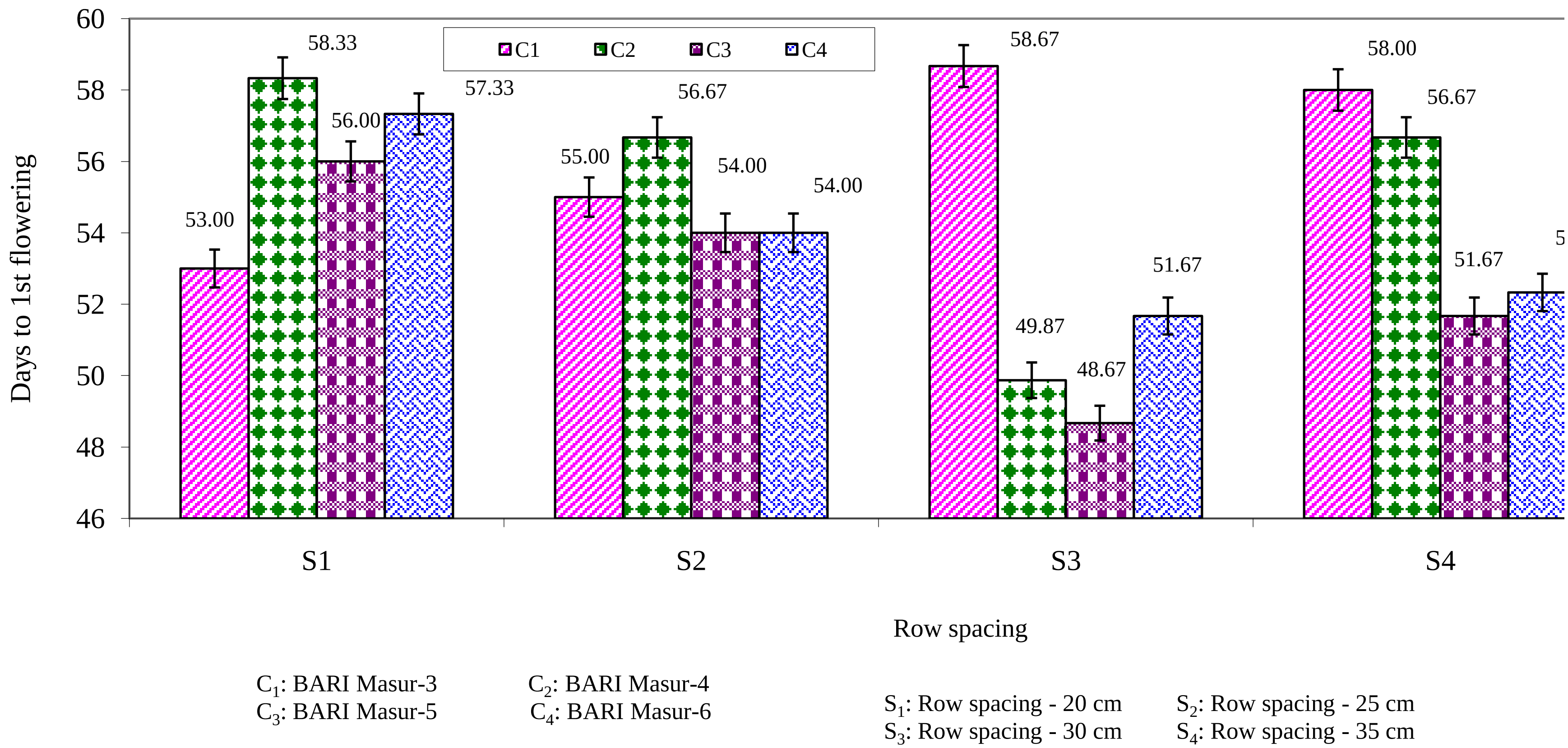


Figure 8. Interaction effect of cultivars and row spacing on days to 1st flowering of lentil (SE = 1.734)

Table 6. Effect of cultivar and row spacing on yield contributing characters and yield of lentil

Treatment	Days to 80% pod maturity	Pods plant^{-1} (No.)	Weight of 1000 seeds (g)	Seed yield (tha^{-1})	Stover yield (tha^{-1})
Cultivar					
C_1	116.42 a	40.21 b	24.49 a	1.64 d	2.17 c
C_2	110.08 b	42.23 b	20.41 c	1.88 c	2.41 b
C_3	114.42 ab	45.80 a	21.65 bc	2.02 b	2.64 a
C_4	109.67 b	48.26 a	22.39 b	2.19 a	2.81 a
SE	1.651	1.028	0.498	0.033	0.058
Significance level	0.01	0.01	0.01	0.01	0.01
Row spacing					
S_1	113.75 ab	42.11 b	21.35 b	1.86 b	2.48 ab
S_2	112.67 ab	44.75 ab	22.20 ab	1.93 b	2.54 ab
S_3	108.75 b	47.36 a	22.41 ab	2.09 a	2.64 a
S_4	115.42 a	42.28 b	22.98 a	1.86 b	2.37 b
SE	1.651	1.028	0.498	0.033	0.058
Significance level	0.05	0.01	NS	0.01	0.05
CV(%)	7.08	8.07	7.76	5.86	7.97

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

C_1: BARI Masur-3　　S_1: Row spacing - 20 cm
C_2: BARI Masur-4　　S_2: Row spacing - 25 cm
C_3: BARI Masur-5　　S_3: Row spacing - 30 cm
C_4: BARI Masur-6　　S_4: Row spacing - 35 cm

Cultivar and row spacing showed significant interaction effect in terms of days to 80% pod maturity of lentil (Table 7). The maximum days to 80% pod maturity (123.67) was observed from C_1S_4 (BARI Masur-3 and row spacing – 35 cm) and the minimum (102.00) from C_2S_3 (BARI Masur-4 and row spacing – 30 cm).

4.6 Number of pods per plant

Number of pods per plant of lentil showed statistically significant variation for different cultivar (Table 6). The maximum number of pods per plant (48.26) was found from C_4 (BARI Masur-6) which was similar (45.80) with C_3 (BARI Masur-5) and closely followed (42.23) by C_2 (BARI Masur-4) and the minimum (40.21) was obtained from C_1 (BARI Masur-3). From the study it reveals that the variety BARI Masur-6 and BARI Masur-5 produced higher number of pods compared to BARI Masur-3 and BARI Masur-4 due to genetic factor.

Significant difference was recorded for different row spacing of lentil in terms of number of pods per plant (Table 6). The maximum number of pods per plant (47.36) was recorded from S_3 (row spacing - 30 cm) which was statistically similar (44.75) with S_2 (row spacing - 25 cm), while the minimum (42.11) from S_1 (row spacing - 20 cm) which was statistically identical (42.28) with S_4 (row spacing - 35 cm). Ezzat *et al*. (2005) reported significantly lower plant densities than under high plant densities due to better growth of individual plants.

Significant variation was recorded due to the interaction effect of cultivar and row spacing for number of pods per plant (Table 7). The maximum number of pods per plant (52.07) was recorded from C_3S_3 (BARI Masur-5 and row spacing 30 cm), whereas the minimum (32.00) was found from C_1S_1 (BARI Masur-3 and row spacing 20 cm).

Table 7. Interaction effect of cultivar and row spacing on yield contributing characters and yield of lentil

Treatment	Days to 80% pod maturity	Pods plant^{-1} (No.)	Weight of 1000 seeds (g)	Seed yield (tha^{-1})	Stover yield (tha^{-1})
C_1S_1	105.00 cde	32.00 f	21.19 cde	1.36 h	1.69 g
C_1S_2	118.00 ab	44.27 bcde	23.93 bc	1.61 g	2.47 bcdef
C_1S_3	119.00 ab	44.30 bcde	27.29 a	1.89 def	2.35 def
C_1S_4	123.67 a	40.27 e	25.53 ab	1.70 fg	2.19 f
C_2S_1	118.00 ab	41.67 de	20.11 de	1.82 ef	2.49 bcdef
C_2S_2	109.33 bcde	42.73 bcde	20.81 cde	1.92 de	2.42 bcdef
C_2S_3	102.00 e	44.17 bcde	18.75 e	1.96 de	2.45 bcdef
C_2S_4	111.00 bcde	40.37 e	21.97 cde	1.80 efg	2.26 ef
C_3S_1	118.00 ab	45.17 bcde	21.69 cde	2.02 cde	2.72 abcd
C_3S_2	113.67 abcd	43.50 bcde	22.19 cd	1.98 de	2.47 bcdef
C_3S_3	110.67 bcde	52.07 a	20.96 cde	2.23 ab	2.98 a
C_3S_4	115.33 abc	42.47 cde	21.74 cde	1.87 def	2.40 cdef
C_4S_1	114.00 abcd	49.60 ab	22.40 bcd	2.24 ab	3.02 a
C_4S_2	109.67 bcde	48.50 abcd	21.87 cde	2.20 abc	2.81 ab
C_4S_3	103.33 de	48.90 abc	22.62 bcd	2.27 a	2.77 abc
C_4S_4	111.67 bcde	46.03 abcde	22.66 bcd	2.06 bcd	2.64 abcde
SE	3.302	2.056	0.996	0.065	0.115
Significance level	0.01	0.01	0.05	0.01	0.01
CV(%)	7.08	8.07	7.76	5.86	7.97

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

C_1: BARI Masur-3 S_1: Row spacing - 20 cm
C_2: BARI Masur-4 S_2: Row spacing - 25 cm
C_3: BARI Masur-5 S_3: Row spacing - 30 cm
C_4: BARI Masur-6 S_4: Row spacing - 35 cm

4.7 Pod length

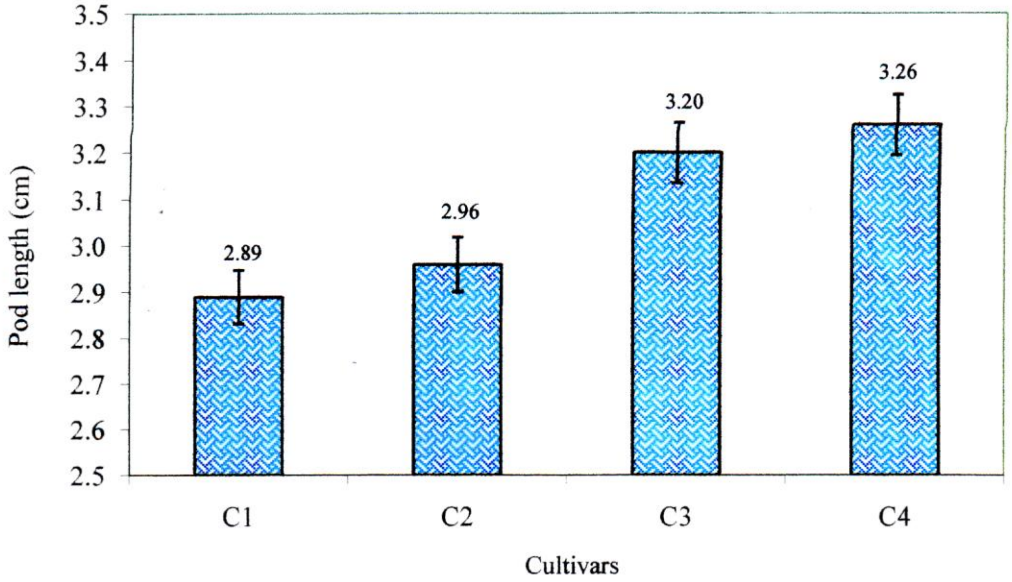
Significant variation was recorded in pod length of lentil due to different cultivar (Figure 9). The longest pod (3.26 cm) was observed from C_4 (BARI Masur-6) which was statistically similar (3.20 cm) with C_3 (BARI Masur-5) and the shortest (2.89 cm) was recorded from C_1 (BARI Masur-3) which was statistically similar (2.96) with C_2 (BARI Masur-4).

Pod length showed significant differences for different row spacing of lentil (Figure 10). The longest pod (3.30 cm) was found from S_3 (row spacing - 30 cm) which was statistically similar (3.11 cm) with S_2 (row spacing - 25 cm), while the shortest pod (2.90 cm) was obtained from S_1 (row spacing - 20 cm) which was statistically identical (3.00 cm) with S_4 (row spacing - 35 cm). Ezzat *et al*. (2005), Chowdhury *et al*. (1998) reported similar findings.

Significant variation was recorded due to the interaction effect of cultivar and row spacing for pod length of lentil (Figure 11). The longest pod (3.63 cm) was found from C_3S_3 (BARI Masur-5 and row spacing – 30 cm), while the lowest (2.22 cm) was attained from C_1S_1 (BARI Masur-3 and row spacing – 20 cm).

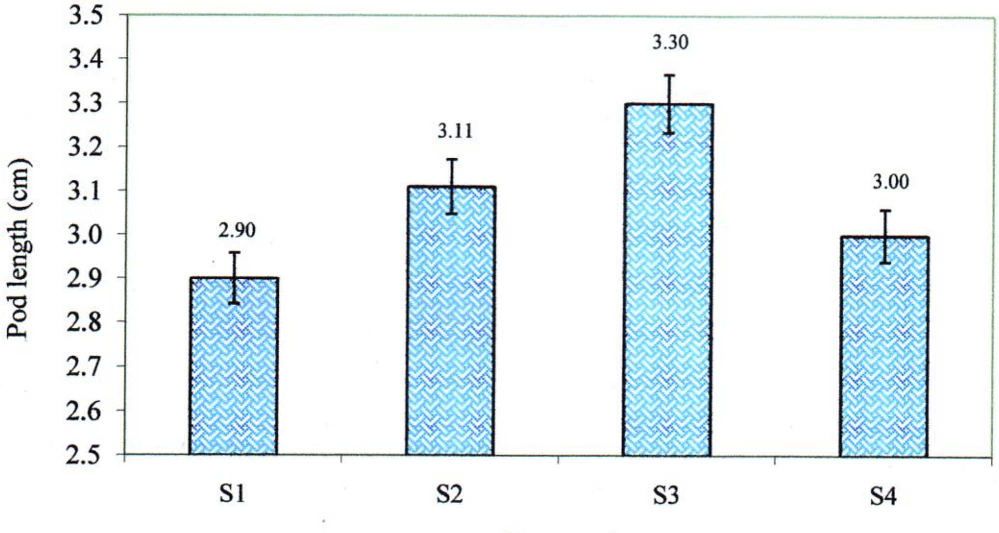
4.8 Weight of 1000 seeds

Weight of 1000 seeds of lentil showed statistically significant variation for different cultivar (Table 6). The highest weight of 1000 seeds (24.49 g) was obtained from C_1 (BARI Masur-3) which was closely followed (22.39 g) by C_4 (BARI Masur-6) and the lowest (20.41 g) was recorded from C_2 (BARI Masur-4) which was statistically similar (21.65 g) with C_3 (BARI Masur-5).



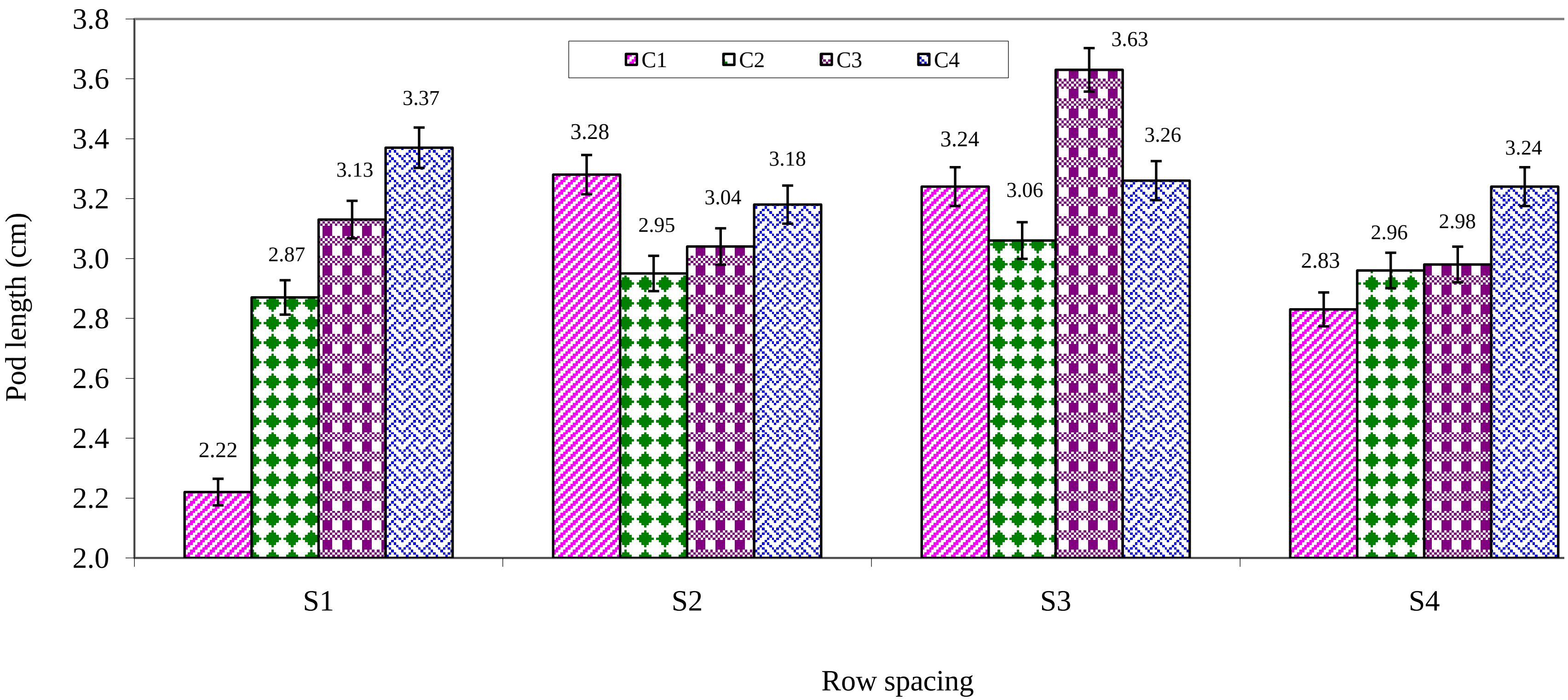
C_1: BARI Masur-3 C_2: BARI Masur-4
C_3: BARI Masur-5 C_4: BARI Masur-6

Figure : **09.** Effect of cultivars on pod length of lentil (SED= 0.087)



S_1: Row spacing - 20 cm S_2: Row spacing - 25 cm
S_3: Row spacing - 30 cm S_4: Row spacing - 35 cm

Figure : 10 Effect of row spacing on pod length (SED=0.087)



C_1: BARI Masur-3 C_2: BARI Masur-4
C_3: BARI Masur-5 C_4: BARI Masur-6

S_1: Row spacing - 20 cm S_2: Row spacing - 25 cm
S_3: Row spacing - 30 cm S_4: Row spacing - 35 cm

Figure 11. Interaction effect of cultivars and row spacing on pod length of lentil (SE = 0.173)

Significant variation was found for different row spacing of lentil in terms of weight of 1000 seeds (Table 6). The highest weight of 1000 seeds (22.98 g) was found from S_4 (row spacing 35 cm) which was statistically similar (22.41 g and 22.20 g) with S_3 (row spacing 30 cm) and S_2 (row spacing 25 cm) while the lowest (21.35 g) was observed from S_1 (row spacing 20 cm).

Interaction effect of cultivar and row spacing showed significant variation in terms of weight of 1000 seeds of lentil (Table 7). The highest weight of 1000 seeds (27.29 g) was attained from C_1S_3 (BARI Masur-3 and row spacing 30 cm), whereas the lowest (18.75 g) was found from C_2S_3 (BARI Masur-4 and row spacing 30 cm). It reveals from the study that the closest spacing (20 cm) exert adverse effect on the size of the pods.

4.9 Seed yield

Significant variation was obtained due to different cultivar for seed yield of lentil (Table 6). The highest seed yield (2.19 t ha^{-1}) was recorded from C_4 (BARI Masur-6) which was closely followed (2.02 t ha^{-1}) by C_3 (BARI Masur-5), while the lowest (1.64 t ha^{-1}) was observed from C_1 (BARI Masur-3) which was closely followed (1.88 t ha^{-1}) by C_2 (BARI Masur-4). Different cultivars produced different yield contributing characters as well as yield. Solanki (2001) reported that grain yield in the superior or inferior environment was impaired by the stability of different yield-contributing traits. Singh *et al*. (1994) recorded an average yield of 1720 kg/ha, compared to the national average of 727 kg/ha from an advanced line.

Row spacing of lentil showed statistically significant variation in terms of seed yield (Table 6). The highest seed yield (2.09 t ha^{-1}) was found from S_3 (row spacing 30 cm), whereas the lowest (1.86 t ha^{-1}) was recorded from S_1 (row spacing 20 cm) and S_4 (row spacing 35 cm) which was statistically identical (1.93 t ha^{-1}) with S_2 (row spacing 30 cm). Optimum spacing ensured optimum vegetative growth that leads to higher yield compared to closest and wider row spacing. Tomar *et al*. (2000) reported that Narrow row spacing (20 cm) with high seed rate produced higher yield than wider row spacing (30-cm). Inderjit *et al*. (2005) reported that row spacing of 20 cm resulted in 4.2 and 9.5% more seed yield than closer (17.5 cm) and wider (22.5 cm) row spacings, respectively. Singh and Verma (1999) reported that row spacing had no significant effect on yield, while 45 kg seeds/ha gave significant yield increases over 30 and 60 kg seeds/ha.

Interaction effect of cultivar and row spacing differed significantly for seed yield of lentil (Table 7). The highest seed yield plant (2.27 t ha^{-1}) was observed from C_4S_3 (BARI Masur-6 and row spacing 30 cm), while the lowest (1.36 t ha^{-1}) was recorded from C_1S_1 (BARI Masur-3 and row spacing 20 cm).

4.10 Stover yield

Stover yield of lentil showed statistically significant differences due to different cultivar (Table 6). The highest stover yield (2.81 t ha^{-1}) was found from C_4 (BARI Masur-6) which was statistically similar (2.64 t ha^{-1}) with C_3 (BARI Masur-5) and closely followed (2.41 t ha^{-1}) by C_2 (BARI Masur-4), whereas the lowest (2.17 t ha^{-1}) was found from C_1 (BARI Masur-3).

Statistically significant differences were observed for different row spacing of lentil in terms of stover yield (Table 6). The highest stover yield (2.64 t ha^{-1}) was found from S_3 (row spacing - 20 cm) which was statistically similar (2.54 t ha^{-1} and 2.48 t ha^{-1}) with S_2 (row spacing - 25 cm) and S_1 (row spacing - 20 cm), while the lowest (2.37 t ha^{-1}) was recorded from S_4 (row spacing - 35 cm). Ezzat *et al*. (2005), Chowdhury *et al*. (1998) reported similar findings.

Interaction effect of cultivar and row spacing showed significant variation in terms of stover yield of lentil (Table 7). The highest stover yield plant (3.02 t ha^{-1}) was found from C_4S_1 (BARI Masur-6 and row spacing – 20 cm) and the lowest (1.69 t ha^{-1}) was obtained from C_1S_1 (BARI Masur-3 and row spacing – 20 cm).

4.11 Crop Growth Rate

Crop Growth Rate (CGR) of lentil did not vary significantly for different cultivar at 30-40, 50-60 and 60-70 DAS but significantly vary for 40-50 DAS (Table 8). At 30-40 DAS, numerically the highest (8.47 g $m^{-2}day^{-1}$) CGR was found from C_3 (BARI Masur-5), whereas the lowest (7.84 g $m^{-2}day^{-1}$) CGR was recorded from C_1 (BARI Masur-3). At 40-50 DAS, numerically the highest (3.30 g $m^{-2}day^{-1}$) CGR was obtained from C_4 (BARI Masur-6), while the lowest (2.11 g $m^{-2}day^{-1}$) from C_1 (BARI Masur-3). At 50-60 DAS, numerically highest (3.27 g $m^{-2}day^{-1}$) CGR was recorded from C_3 (BARI Masur-5) and the lowest (2.47 g $m^{-2}day^{-1}$) from C_2 (BARI Masur-4). At 60-70 DAS, numerically highest (4.57 g $m^{-2}day^{-1}$) CGR was found from C_2 and the lowest (3.03 g $m^{-2}day^{-1}$) CGR from C_3.

Table 8. Effect of cultivar and row spacing on Crop Growth Rate (CGR) of lentil

Treatment	Crop Growth Rate (g $m^{-2}day^{-1}$) at			
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
Cultivar				
C_1	7.84	2.11 b	2.64	3.82 ab
C_2	7.92	2.71 ab	2.47	4.57 a
C_3	8.47	2.80 ab	3.27	3.03 b
C_4	8.12	3.30 a	2.07	3.66 ab
SE	0.559	0.246	0.320	0.367
Significance level	NS	0.01	NS	NS
Row spacing				
S_1	8.20	2.19 b	2.32	3.51
S_2	8.07	3.04 a	2.63	4.03
S_3	8.48	2.52 ab	2.55	3.61
S_4	7.59	3.17 a	2.95	3.95
SE	0.559	0.246	0.320	0.367
Significance level	NS	0.05	NS	NS
CV(%)	23.95	11.24	12.38	9.64

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

C_1: BARI Masur-3 — S_1: Row spacing - 20 cm
C_2: BARI Masur-4 — S_2: Row spacing - 25 cm
C_3: BARI Masur-5 — S_3: Row spacing - 30 cm
C_4: BARI Masur-6 — S_4: Row spacing - 35 cm

Non-significant variation was recorded for CGR due to row spacing at 30-40, 50-60 and 60-70 DAS but significantly differed for 40-50 DAS (Table 8). At 30-40 DAS, numerically the highest (8.48 g $m^{-2}day^{-1}$) CGR was observed from S_3 (row spacing - 30 cm) and the lowest (7.59 g $m^{-2}day^{-1}$) CGR in S_4 (row spacing - 35 cm). At 40-50 DAS, numerically the highest (3.17 g $m^{-2}day^{-1}$) CGR was found from S_4, while the lowest (2.19 g $m^{-2}day^{-1}$) CGR from S_1 (row spacing - 20 cm). At 50-60 DAS, numerically the highest (2.95 g $m^{-2}day^{-1}$) CGR was obtained from S_4 and the lowest (2.32 g $m^{-2}day^{-1}$) CGR was recorded from S_1 (row spacing - 20 cm). At 60-70 DAS, numerically the highest (4.03 g $m^{-2}day^{-1}$) CGR was recorded from S_2, and the lowest (3.51 g $m^{-2}day^{-1}$) CGR from S_1. Dutta *et al*. (1998) reported that higher densities gave higher seed yields despite the favourable effect of lower densities on crop growth rate.

Interaction effect of cultivar and row spacing showed non significant differences for CGR at 30-40, 50-60 and 60-70 DAS but significantly differed for 40-50 DAS (Table 9). At 30-40 DAS, numerically the highest (11.13 g $m^{-2}day^{-1}$) CGR was obtained from C_3S_3 (BARI Masur-5 and row spacing - 30 cm) and the lowest (6.21 g $m^{-2}day^{-1}$) from C_4S_4 (BARI Masur-6 and row spacing - 35 cm) (Table 8).

Table 9. Interaction Effect of cultivar and row spacing on Crop Growth Rate (CGR) of lentil

Treatment	Crop Growth Rate (g $m^{-2}day^{-1}$) at			
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
C_1S_1	7.96	3.24 abcd	2.20	4.19
C_1S_2	8.44	1.97 defg	4.12	3.42
C_1S_3	6.39	2.43 cdef	3.31	4.22
C_1S_4	8.56	0.78 g	0.93	3.47
C_2S_1	8.28	2.07 defg	1.70	3.81
C_2S_2	6.91	2.84 bcdef	2.83	4.99
C_2S_3	9.01	2.79 bcdef	2.61	4.86
C_2S_4	7.48	3.16 bcde	2.76	4.63
C_3S_1	7.63	1.52 efg	2.53	3.33
C_3S_2	6.99	4.20 ab	3.00	3.50
C_3S_3	11.13	1.48 fg	2.38	2.04
C_3S_4	8.11	3.98 abc	5.18	3.25
C_4S_1	8.92	1.91 defg	2.86	2.70
C_4S_2	9.96	3.14 bcde	0.56	4.19
C_4S_3	7.38	3.39 abcd	1.92	3.32
C_4S_4	6.21	4.76 a	2.94	4.44
SE	1.559	0.492	0.640	0.733
Significance level	NS	0.01	NS	NS
CV(%)	23.95	11.24	12.38	9.64

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

C_1: BARI Masur-3 — S_1: Row spacing - 20 cm
C_2: BARI Masur-4 — S_2: Row spacing - 25 cm
C_3: BARI Masur-5 — S_3: Row spacing - 30 cm
C_4: BARI Masur-6 — S_4: Row spacing - 35 cm

4.12 Relative Growth Rate

Non-significant variation was recorded for relative growth rate (RGR) of lentil at 30-40, 40-50, 50-60 and but significantly varied at 60-70 DAS for different cultivar (Table 10). At 60-70 DAS, numerically the highest (0.014 g g^{-1} day^{-1}) RGR was recorded from C_2 and the lowest (0.009 g g^{-1} day^{-1}) RGR was obtained from C_3.

Statistically non-significant variation was recorded for RGR due to row spacing at 30-40, 40-50, 50-60 and 60-70 DAS (Table 10).

Interaction effect of cultivar and row spacing differed non-significantly for RGR at 30-40, 40-50, 50-60 and 60-70 DAS (Table 11).

Table 10. Effect of cultivar and row spacing on Relative Growth Rate (RGR) of lentil

Treatment	Relative growth rate (g g^{-1} day^{-1}) at			
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
Cultivar				
C_1	0.037	0.008	0.009	0.012 ab
C_2	0.036	0.010	0.008	0.014 a
C_3	0.037	0.010	0.010	0.009 c
C_4	0.036	0.011	0.006	0.011 bc
SE	0.003	0.001	0.001	0.001
Significance level	NS	NS	NS	0.05
Row spacing				
S_1	0.039	0.008	0.008	0.011
S_2	0.037	0.011	0.009	0.012
S_3	0.037	0.009	0.008	0.011
S_4	0.032	0.011	0.009	0.011
SE	0.003	0.001	0.001	0.001
Significance level	NS	NS	NS	NS
CV(%)	24.09	13.78	11.05	14.83

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

C_1: BARI Masur-3 S_1: Row spacing - 20 cm
C_2: BARI Masur-4 S_2: Row spacing - 25 cm
C_3: BARI Masur-5 S_3: Row spacing - 30 cm
C_4: BARI Masur-6 S_4: Row spacing - 35 cm

Table 11. Interaction effect of cultivar and row spacing on Relative Growth Rate (RGR) of lentil

Treatment	Relative growth rate (g g^{-1} day^{-1}) at			
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
C_1S_1	0.044	0.014	0.008	0.014
C_1S_2	0.039	0.007	0.014	0.010
C_1S_3	0.027	0.009	0.010	0.012
C_1S_4	0.037	0.003	0.003	0.011
C_2S_1	0.039	0.008	0.006	0.012
C_2S_2	0.031	0.011	0.009	0.015
C_2S_3	0.040	0.010	0.008	0.014
C_2S_4	0.033	0.011	0.009	0.013
C_3S_1	0.033	0.005	0.009	0.010
C_3S_2	0.033	0.016	0.010	0.010
C_3S_3	0.047	0.005	0.007	0.006
C_3S_4	0.035	0.013	0.015	0.008
C_4S_1	0.040	0.007	0.009	0.008
C_4S_2	0.046	0.011	0.002	0.013
C_4S_3	0.034	0.012	0.006	0.010
C_4S_4	0.024	0.015	0.008	0.011
SE	0.005	0.002	0.002	0.002
Significance level	NS	NS	NS	NS
CV(%)	24.09	13.78	11.05	14.83

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

C_1: BARI Masur-3 — S_1: Row spacing - 20 cm

C_2: BARI Masur-4 — S_2: Row spacing - 25 cm

C_3: BARI Masur-5 — S_3: Row spacing - 30 cm

C_4: BARI Masur-6 — S_4: Row spacing - 35 cm

CHAPTER 5

SUMMARY AND CONCLUSION

To study the effect of cultivar and row spacing on growth and yield of lentil the experiment was carried out at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka , Bangladesh during the period from October 2008 to April 2009. The experiment consisted of two factors, viz., Factor A: Cultivar (4 levels) - C_1: BARI Masur-3, C_2: BARI Masur-4, C_3: BARI Masur-5 and C_4: BARI Masur-6; Factor B: Row spacing (4 levels) - S_1: Row spacing 20 cm, S_2: Row spacing 25 cm, S_3: Row spacing 30 cm and S_4: Row spacing 35 cm. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameter, yield attributes and yield were recorded.

At 30, 40, 50, 60 DAS and harvest the longest plant (26.82 cm, 35.39 cm, 45.33 cm, 50.70 cm and 54.05 cm) was recorded from C_4 whereas the shortest plant (20.97 cm, 28.35 cm, 35.28 cm, 40.17 cm and 44.13 cm) was found from C_1. At 30, 40, 50, 60 DAS and harvest the maximum number of branches plant^{-1} (4.27, 9.14, 13.17, 19.49 and 24.13) was recorded from C_4 and the minimum number (3.67, 7.67, 11.08, 15.88 and 19.37) was observed from C_1. At 30 and 50 DAS the highest dry matter content in plant (5.76 g and 9.18) was recorded from C_4 and at 40, 60 and 70 DAS the highest dry matter content in plant (8.21 g, 10.03 g and 10.94 g) was recorded from C_3, whereas the lowest (5.35 g, 7.70 g, 8.34 g, 9.13 g and 10.27 g) was observed from C_1 for respective DAS. The maximum days to 1st flowering (56.17) was found from C_1 whereas the minimum (52.58) was recorded from C_3. The maximum days to 80% pod maturity (116.42) was recorded from C_1 and the lowest (109.67) was recorded from C_4. The maximum number of pods per plant (48.26) was found from C_4, whereas the minimum (40.21) was obtained from C_1. The longest pod (3.26 cm) was observed from C_4 and the shortest (2.89 cm) was recorded from C_1. The highest weight of 1000 seeds (24.49 g) was obtained from C_1, whereas the lowest (20.41 g) was recorded from C_2. The highest seed yield (2.19 t ha^{-1}) was recorded from C_4 and the lowest (1.64 t ha^{-1}) was observed from C_1. The highest stover yield (2.81 t ha^{-1}) was found from C_4, whereas the lowest (2.17 t ha^{-1}) was found from C_1.

At 30, 40, 50, 60 DAS and harvest the longest plant (25.67 cm, 34.86 cm, 43.79 cm, 48.69 cm and 51.86 cm) was obtained from S_1 while the shortest plant (22.10 cm, 31.12 cm, 38.95 cm, 43.10 cm and 47.96 cm) was found from S_4. At 30 DAS, the maximum number of branches $plant^{-1}$ (4.43) was obtained from S_1 whereas the minimum number (3.67) was found from S_4. At 40, 50, 60 DAS and harvest the maximum number of branches $plant^{-1}$ (9.66, 13.75, 20.52 and 25.88) was obtained from S_3 whereas the minimum number (7.80, 11.39, 15.44 and 19.01) was found from S_1. At 30, 40, 50, 60 and 70 DAS the highest dry matter content in plant (6.05 g, 8.32 g, 9.28 g, 10.16 g and 11.35 g) was found from S_4 and the lowest (5.21 g, 7.67 g, 8.33 g, 9.03 g and 10.08 g) was obtained from S_1. The maximum days to 1^{st} flowering (56.17) was obtained from S_1 and the minimum (52.22) was found from S_3. The maximum days to 80% pod maturity (115.42) was recorded from S_4 and the minimum (108.75) was obtained from S_3. The maximum number of pods per plant (47.36) was recorded from S_3 and the minimum (42.11) was obtained from S_1. The longest pod (3.30 cm) was found from and the shortest pod (2.90 cm) was obtained from S_1. The highest weight of 1000 seeds (22.98 g) was found from S_4 and the lowest (21.35 g) was observed from S_1. The highest seed yield (2.09 t ha^{-1}) was found from S_3 and the lowest (1.86 t ha^{-1}) from S_1 and S_4. The highest stover yield (2.64 t ha^{-1}) was found from S_3 and the lowest (2.37 t ha^{-1}) was recorded from S_4.

At 30, 40, 50, 60 DAS and harvest the longest plant (32.10 cm, 40.95 cm, 52.37 cm, 57.43 cm and 57.85 cm) was recorded from C_4S_1 (BARI Masur-6 and row spacing – 20 cm), while the shortest plant (16.52 cm, 25.38 cm, 30.79 cm, 36.85 cm and 42.01 cm) was obtained from C_1S_1. At 30, 40, 50, 60 DAS and harvest the maximum number of branches $plant^{-1}$ (4.83, 9.97, 14.53, 22.33 and 27.47) was found from C_3S_3, while the minimum number (3.23, 6.17, 9.43, 11.30 and 12.90) was recorded from C_1S_1. At 30, 40, 50, 60, 70 the highest dry matter content in plant (6.81 g, 8.92 g, 10.11 g, 10.99 g and 12.32 g) was obtained from C_4S_4 while the lowest (4.28 g, 6.67 g, 7.64 g, 8.30 g and 9.56 g) was recorded from C_1S_1. The maximum days to 1^{st} flowering (58.67) was recorded from C_1S_3, while the minimum (48.67) was obtained from C_3S_3. The maximum days to 80% pod maturity (123.67) was observed from C_1S_4 while the minimum (102.00) was recorded from C_2S_3. The maximum number of pods per plant (52.07) was recorded from C_3S_3, while the minimum (32.00) was found from C_1S_1. The longest pod (3.63 cm) was found from C_3S_3, while the lowest (2.22 cm) was attained from C_1S_1. The highest weight of 1000 seeds (27.29 g) was attained from C_1S_3 while the lowest (18.75 g) was found from C_2S_3. The highest seed yield plant

(2.27 t ha^{-1}) was observed from C_4S_3, while the lowest (1.36 t ha^{-1}) was recorded from C_1S_1. The highest stover yield plant (3.02 t ha^{-1}) was found from C_4S_1, while the lowest (1.69 t ha^{-1}) was obtained from C_1S_1.

Based on the results of the experiment, the following conclusion may be drawn-

1. The cultivar (BARI Masur-6) was identified from the study as a high yielded in lentil cultivation.

2. Row spacing played a vital role in the growth and yield of lentil.

3. Row spacing (30 cm) was identified as proper in achieving potential growth and yield of lentil.

However, these findings need to be further studied and evaluated in different agro-climatic regions of the lentil growing area before final recommendation to the farmer.

REFERENCES

Abu-Shakara, S. and Tannous, R. I. (1981). Nutritional value and quality of lentil. **In**: Lentil, Editors: C. Wabb and G.C.hawtin, CAB. Farnhan Royal, England: 192-202.

Alam, A. Y. 2002. Effect of sowing dates, seeding rates and nitrogen sources on yield, yield components and quality of lentil. *Assiut J. Agril. Sci.* **33**(5): 131-144.

Andrews, M., McKenzie, B. A., Joyce, A. and Andrews, M. E. (2001). The potential of lentil (Lens culinaris) as a grain legume crop in the UK: an assessment based on a crop growth model. *Annals Appl. Biol.* **139**(3): 293-300.

Anonymous. (1966). Ministry of Health. University of Dhaka. National Institute of Health & U. S. Department of Health. Pakistan Nutrition Survey of East Pakistan, **66**: 4-6.

Anonymous. 1976. Nutritional value of lentil and it forms a balanced diet when supplemented with cereals. Rome, Italy, p. 66.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Anonymous. (1999). Lentil Cultivation in Bangladesh. Lentil Blackgram, Mungbean Development Pilot Project. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. pub. 18.

Anonymous. (2008). Musurer Unnota Jath. Strengthening Pulses and oilseeds research project of Bangladesh. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. pub. 20 & 21.

Ayaz, S., McKenzie, B. A. and Hill, G. D. (1999). The effect of plant population on dry matter accumulation, yield and yield components of four grain legumes. *Agronomy New Zealand*. **29**: 9-15

BBS (Bangladesh Bureau of Statistics). (2008). Monthly statistical Bulletin. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. p. 59.

Boerboom, C. M. and Young, F. L. (1995). Effect of postplant tillage and crop density on broadleaf weed control in dry pea (*Pisum sativum*) and lentil (*Lens culinaris*). *Weed Technol*. **9**(1): 99-106.

Boztok, S. (1985). Investigation on the effect of sowing date and verbalisation on seed production in early cauliflower cv. Ege. *Universal Zirrat fakultesi Dergis*. **22**: 89-99.

Bukhtiar, B. A. Naseem, B. A. and Tufail, M.(1992). Effect of row spacing on seed yield of lentil (*Lens culinaris* Medic). *J. Agril. Res. Lahore*. **30**(1): 83-87.

Chowdhury, A. K., Newaz, M. A., Samanta, S. C., and Huda, S. and Ali, M(1998). Response of lentil genotypes to cultural environments on nodulation, growth and yield. *Bangladesh J. Sci. Indust. Res*. **33**(2): 258-262.

Dutta, R. K., Mia, M. A. B., Lahiri, B. P. Uddin, M. M. and Mondal, M. M. A. (1998). Growth and yield of lentil in relation to population pressure. *Lens Newsl*. **25**(1/2): 27-29

Dutta, R. K., Mondal, M. M. A. and Lahiri, B. P. (1998). Physiological evaluation of advance mutants of lentil in relation to growth, nitrate assimilation and photo harvest. *Lens Newsl.* **25**(1/2): 48-51.

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. 118 p.

Esmail, A. M., Mohamed, A. A., Hamdi, A. and Rabie, E. M. 1994. Analysis of yield variation in lentil (*Lens culinaris*). *Annals Agril. Sci.* **32**(3): 1073-1087.

Ezzat, Z. M. Shabaan, M. and Hamdi, A. (2005). Effect of plant density on the performance of three new released lentil varieties. *Egyptian J. Agril. Res*. **83**(1): 167-176.

Ezzat, Z. M., Ashmawy, F. and Morsy, S. M. (2005). Evaluation of some lentil genotypes for earliness, yield, yield components and seed quality. *Egyptian J. Agril. Res.* **83**(1): 151-166.

FAO. (1999). Production Year Book. Food and Agricultural of the United Nations. Rome, Italy. 197-199.

FAO. (2004). Production Year Book. Food and Agricultural of the United Nations. Rome, Italy. 203-205.

Geletu, B., Seifu, T. and Abebe, T. (1995). Stability of seed yield of lentil varieties (*Lens culinaris*) grown in the Ethiopian highlands. *Crop Res. Hisar*. **9**(3): 337-343.

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, K. K., Tejbir, S. and Tomar, R. S. (2006). Genotype × environment interaction for yield and yield contributing characters in lentil (*Lens culinaris*). *Advan. Plant Sci*. **19**(1): 257-262.

Hakim, K., Farhad, A., Ahmad, S, Q. and Akhtar, N. (2006). Variability and correlations of grain yield with other quantitative characters in lentil. *Sarhad J. Agric*. **22**(2): 199-203.

Hamdi, A., El-Ghareib, A. A., Shafey, S. A. and Ibrahim, M. A. M. (2003). Genetic variability, heritability and expected genetic advance for earliness and seed yield from selection in lentil. *Egyptian J. Agril. Res*. **81**(1): 125-138.

Hunt, R. (1978). Plant growth analysis. The institute of Biology's studies in Biology No. 96. Edward Arnold (Publishers) Limited, London, UK.

Inderjit, S., Virender, S. and Sekhon, H. S. (2005). Influence of row spacing and seed rate on seed yield of lentil (*Lens culinaris*) under different sowing dates. *Indian J. Agron*. **50**(4): 308-310

Kaul, A. (1982). Pulses in Bangladesh. BARC (Bangladesh Agricultural Research Council), Farmgate, Dhaka. p.27.

Khan, M. A. A. (1981). The effect of CO_2 enrichment on the pattern of growth and development in pulse and mustard. Ph.D. Dissertation. Royal Vet. Agril Univ. Copenhagen. p. 104.

Lal, H. C., Upadhyay, J. P., Jha, A. K. and Atul, K. (2006). Effect of spacing and date of sowing on rust severity and yield of lentil. J. Res. Birsa Agril. Univ. **18**(1): 89-91.

Miah, A. L. (1976). Grow more pulse to keep your pulse well. Department of Agronomy. Bangladesh Agricultural University, Mymensingh. pp. 11-38.

Mikhov, M., Mikhova, S., Stoyanova, M. and Rodeva, R. (1997). Nadezhda, a new lentil variety. *Rasteniev"dni-Nauki*. **34**(1): 11-13.

Muhammad, A., Abid, H. and Wajid, S. A. (2002). Effect of sowing date, irrigation and plant population on seed yield and components of yield in lentil. *Pakistan J. Agril. Sci.* **39**(2): 119-122.

Sharma, M. C. (1996). Economic response of lentil to seed rate, row spacing, Rhizobium inoculation and chemical fertilization. *Lens Newsl.* **23**(1/2): 15-18.

Shrestha, R., Siddique, K. H. M., Turner, N. C., Turner, D. W. and Berger, J. D. (2005). Growth and seed yield of lentil (*Lens culinaris*) genotypes of West Asian and South Asian origin and crossbreds between the two under rainfed conditions in Nepal. *Australian J. Agril. Res*. **56**(9): 971-981.

Singh, I. S., Singh, J. P., Singh, A. K. and Chauhan, M. P. (1994). Pant Lentil 4: a high yielding, rust-, wilt- and blight-resistant variety for the North-Western Plains of India. *Lens Newsl*. **21**(1): 8-9.

Singh, K. N., Bali, A. S., Ganai, B. A. and Hasan, B. (1994). Optimum spacing and seed rate for lentil (*Lens culinaris*) in Kashmir. *Indian J. Agril. Sci.* **64**(6): 392-393.

Singh, N. B. and Verma, K. K. (1996). Response of lentil (*Lens culinaris*) genotypes to spacing in flood-prone area. *Indian J. Agron*. **41**(4): 657-658.

Singh, R. M. and Verma, R. S. (1999). Effect of seeding rate and row spacing on the yield and quality of lentil (*Lens culinaris*) varieties. *Indian J. Agrono*. **44**(3): 584-587.

Solanki, I. S. (2001). Stability of seed yield and its component characters in lentil (*Lens culinaris*). *Indian J. Agril. Sci*. **71**(6): 414-416.

Tanyolac, B. and Sepetoglu, H. (1996). The effects of the different row spacings and plant densities on the number of missing plants in lentil. *Turkish J. Field Crops*. **1**(1): 20-23.

Thakur, H. K. and; Bajpai, G. C. (1993). Characterization of lentil germplasm for phenological and yield characters. *Indian J. Pulses Res*. **6**(1): 89-91.

Tomar, S. K., Tripathi, P. and Rajput, A. L. (2000). Effect of genotype, seeding method and diammonium phosphate on yield and protein and nutrient uptake by lentil (*Lens culinaris*). *Indian J. Agron*. **45**(1): 148-152.

Turk, M. A., Tawaha, A. R. M. and Lee, K. D. (2004). Seed germination and seedling growth of three lentil cultivars under moisture stress. *Asian J. Plant Sci*. **3**(3): 394-397.

UNDP. (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212, 577.

Vinay, M., Shukla, S. K., Gupta, H. S. and Khati, P. (2006). Yield improvement in small and bold-seeded lentil (*Lens culinaris*) in mid-altitudes of North-western Himalayas. *Crop Improvement*. **33**(2): 181-184.

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2008 to April, 2009

Month	*Air temperature (^{o}C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
October, 2008	29.18	18.26	81	39
November, 2008	25.82	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11
April, 2009	33.2	21.1	61	88

* Monthly average,

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

Appendix II. Characteristics of experimental field soil analyzed in Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
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

Appendix III. Analysis of variance of the data on plant height of lentil as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.332	3.479	8.120	3.206	2.751
Factor A (Cultivar)	3	96.942**	129.647**	247.313**	242.149**	257.015**
Factor B (Row spacing)	3	28.227*	30.466**	58.965*	77.890**	35.918**
Interaction (A×B)	9	34.797**	28.982**	44.259*	32.125**	18.899**
Error	30	9.065	5.742	17.274	8.408	6.736

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

Appendix IV. Analysis of variance of the data on number of branches per plant of lentil as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square				
		Number of branches $plant^{-1}$				
		30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.003	0.032	0.137	0.790	0.158
Factor A (Cultivar)	3	0.793**	5.448**	10.628**	29.166**	54.839**
Factor B (Row spacing)	3	1.182**	7.085**	11.796**	53.148**	94.323**
Interaction (A×B)	9	0.104*	0.411*	0.467**	3.929*	7.961*
Error	30	0.055	0.160	0.165	1.537	3.343

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

Appendix V. Analysis of variance of the data on dry matter content of lentil plant as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square				
		Dry matter content in plant (g) at				
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
Replication	2	0.035	0.026	0.013	0.027	0.099
Factor A (Cultivar)	3	0.371*	0.702**	1.705**	1.858**	1.174**
Factor B (Row spacing)	3	1.622**	1.220**	1.952**	2.707**	3.257**
Interaction (A×B)	9	0.721**	0.635**	0.306**	1.007**	1.204**
Error	30	0.106	0.166	0.100	0.226	0.258

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

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of lentil as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square						
		Days to 1st flowering	Days to 80% pod maturity	Number of pods $plant^{-1}$	Pod length (cm)	Weight of 1000 seeds (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Replication	2	0.141	24.021	0.070	0.028	0.112	0.008	0.025
Factor A (Cultivar)	3	30.703*	131.188**	155.235**	0.386**	35.048**	0.656**	0.921**
Factor B (Row spacing)	3	32.770*	96.299*	73.215**	0.351**	5.474	0.140**	0.146*
Interaction (A×B)	9	26.581**	105.465**	32.821*	0.226*	7.095*	0.039**	0.171**
Error	30	9.021	32.710	12.680	0.090	2.976	0.013	0.040

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

Appendix VII. Analysis of variance of the data on crop growth rate (CGR) of lentil plant as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square			
		Crop Growth Rate (CGR) at			
		30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
Replication	2	0.650	0.141	0.558	1.216
Factor A (Cultivar)	3	0.940	2.879*	3.001	4.814*
Factor B (Row spacing)	3	1.648	2.500*	0.808	0.764
Interaction (A×B)	9	7.399	4.056**	4.825**	1.308
Error	30	3.750	0.727	1.227	1.612

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

Appendix VIII. Analysis of variance of the data on relative growth rate (RGR) of lentil plant as influenced by cultivar and row spacing

Source of variation	Degrees of freedom	Mean square			
		Relative Growth Rate (RGR) at			
		30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS
Replication	2	0.0001	0.0001	0.0001	0.0001
Factor A (Cultivar)	3	0.0001	0.0001	0.0001	0.0001
Factor B (Row spacing)	3	0.0001	0.0001	0.0001	0.0001
Interaction (A×B)	9	0.0001	0.0001**	0.0001	0.0001
Error	30	0.0001	0.0001	0.0001	0.0001

**: Significant at 0.01 level of significance