RESPONSE OF SESAME (*Sesamum indicum* L.) TO NITROGEN FERTILIZER AND PLANT SPACING

A Thesis

By

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MASTER OF SCIENCE
IN
CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR-5200, BANGLADESH

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Submitted to the
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DECEMBER 2018

DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted at research field in the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during February to June 2018 to study the effects of nitrogen fertilizer and spacing on the growth and yield of sesame. The experiment was laid out in a two factorial Randomized Complete Block Design (RCBD) with three replications. The experiment comprised of two of factors such as A: Four nitrogen levels, N_1: 25 kg N/ha (control), N_2: 45 kg N/ha, N_3: 65 kg N/ha and N_4: 85 kg N/ha; B: three plant spacing like, S_1: 5 cm × 40 cm, S_2: 10 cm × 40 cm and S_3: 15 cm × 40 cm. Result revealed that increasing nitrogen level from 25 to 85kgN/ha resulted in significant increase in the days to attain germination, flowering, pod formation, maturity, plant height at different days after sowing, number of branch per plant, plant height at harvest and capsule length but number of capsules per plant, seeds per capsule and yield increased up to 65kgN/ha. Wider plant spacing S_3 (15 cm × 40 cm) significantly increased the the days to attain flowering, pod formation, maturity, number of leaves and capsule length, number of capsules per plant, seeds per capsule. The highest yield (1.29 t/ha) was observed in N_3 (65 kg/ha) and the lowest yield (1.06 t/ha) was observed in N_4 (85 kg N/ha). In case of spacing, the highest yield (1.33 t/ha) was observed in S_1 (5 cm × 40 cm) and the lowest yield (1.0 t/ha) was observed in S_3 (15 cm × 40 cm). Therefore, the higher number of capsules per plant, length of capsule and number of seeds per capsule recorded at wider row spacing of 15 cm × 40 cm was unable to compensate for higher number of threshed capsules obtained at narrow row spacing of 5 cm × 40 cm. Based on the result obtained in this trial, it can be concluded that BARI Til 3 planted at 5 cm × 40 cm. spacing with a nitrogen dose of 65kg/ha produced the highest grain yield of sesame.

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CHAPTER I

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an annual crop which belongs to the family Pedaliaceae and in the genus Sesamum and is the oldest and important cultivated oil seed crop in the world (Purseglove 1974; Dudley *et al*. 2000). It is grown for seed and oil, both for human consumption and has been grown for thousands of years and today its major production areas are the tropics and the subtropics of Asia, Africa, East and Central America. In Bangladesh, it is locally known as til and is the second important edible oil crop (Mondal *et al*. 1997). Sesame is a versatile crop having diversified usage and contains 42-45% oil, 20% protein and 14-20% carbohydrate (BARI 2012). In 2012-2013, the crop covered an area of 78.50 thousand hectares in Bangladesh with the production of 51,000 tons (BBS 2014). The climate and edaphic conditions of Bangladesh are quite suitable for sesame cultivation.

Sesame oil is generally used mostly for edible purpose in confectionaries and for illumination. It is also used for some other purposes such as in manufacture of margarine, soap, paint, perfumery products and drugs and as dispersing agent for different kinds of insecticide. Sesameolin, a constituent of the oil, is used for its synergistic effect in pyrethrum, which increases the toxicity of insecticides (Chaubey *et al*. 2003). The sesame oilcake is a very good cattle feed since it contains protein of high biological value and appreciable quantities of phosphorus and potassium. The cake is also used as manure (Malik *et al*. 2003). Sesame seed may be eaten fried mixed with sugar or in the form of sweetmeats. The use of the seeds for decoration on the surface of breads and cookies is most familiar to the Americans. The crop is cultivated either as a pure stand or as a mixed crop with aus rice, jute, groundnut, millets and sugarcane. Among various oil crops grown in Bangladesh, sesame ranks next to mustard in respect of both cultivated area and production. The crop is grown in both rabi and kharif seasons in Bangladesh but the kharif season covers about two-third of the total sesame area. Khulna, Faridpur, Pabna, Barisal, Rajshahi, Jessore, Comilla, Dhaka, Patuakhali, Rangpur, Sylhet and Mymensingh districts are the leading sesame producing areas of Bangladesh (BARI 2004). Yield and quality of seeds of sesame are very low in Bangladesh. The low yield of sesame in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor 1982). To attain suitable production and quality yield for any crop it is necessary to apply proper management with ensuring the availability of essential nutrient in proper doses. Generally, a considerable amount of fertilizer is required for the growth and development of sesame (Opena *et al*. 1988).

Nitrogen is a structural component of chlorophyll and protein therefore adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it promotes cell division and cell enlargement, resulting in more leaf area and thus ensuring good seed and dry matter yield (Ibrahim *et al*. 2014). An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Yoshizawa *et al*. 1981). On the other hand excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder (Obreza and Vavrina 1993).

The low yield of sesame has been partly attributed to inappropriate plant density, planting time, and pest pressure (weeds, diseases and insect pests) (Gebremichael 2011). The establishment of an adequate plant density is critical for utilization of available growth factors such as water, light, nutrients and carbon-dioxide and to maximize grain yield. Too wide spacing leads to low plant density per unit area and reduces ground cover, whereas too narrow spacing is related to intense competition between plants for growth factors (Singh *et al*. 2004). It is observed that spacing of crop is important for good yield. Harper (1983) reported that with non-tillering (branching) crop varieties, higher yield per plant will give high total yield per hectare once the optimum population is not exceeded. On the other hand, the variation in plant density has been related to the variation in the number of capsules per plant, seed yield per plant and 1000-seed weight (Rahnama and Bakhshandeh 2006), and plant height, number of branches per plant and seed yield (Ngala *et al.* 2013).

Therefore, the present study was undertaken with following objectives-

1. To observe the influence of nitrogen levels on the performance of sesame.
2. To know the effect of plant spacing on yield attributes and yield of sesame.
3. To know the suitable condition of nitrogen and plant spacing for growing sesame in the northern region of Bangladesh

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world sesame is an important and most valuable oil crop. The crop has conventional less attention by the researchers on various aspects because normally it grows without care or management practices. Based on this very few research work related to growth, yield and development of sesame have been carried out in our country. Optimum nitrogen fertilizer and spacing play an important role in improving sesame yield. But research works related to nitrogen and spacing on sesame are limited in Bangladesh. However, some of the important and informative research findings related to the nitrogen fertilizer and spacing on sesame have been reviewed in this chapter under the following headings-

2.1 Effect of nitrogen on sesame

The experiment entitled effect of nitrogen and phosphorus on yield and yield components of sesame were conducted by Ibrahim *et al*. (2014) at New Developmental Farm of the University of Agriculture Peshawar with Nitrogen and phosphorus levels (0, 30, 60, 90 kg ha-1) each were applied. The highest number of pods plant-1 (67), number of seeds pods-1 (54), grain yield (520 kg ha-1), biological yield (2539 kg ha-1), thousand seeds weight (3.91 g) and harvest index (24%) were recorded when higher dose of N i.e. 90 kg ha-1 were used. Similarly the lowest number of pods plant-1 (55), number of seeds pods-1 (50), grain yield

(442 kg ha-1), biological yield (1570 kg ha-1), thousand seed weight (2.94 g), and harvest index (20%) were recorded in control plots.

Shilpi *et al*. (2012) carried out an experiment in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh to determine the effect of nitrogen and sulfur on growth and yield of sesame. The experiment consisted of two factors. 4 levels of nitrogen as N0: 0 kg N ha-1 (control); N1: 40 kg N ha-1; N2: 60 kg N ha-1 and N3: 100 kg N ha-1; and 4 levels of sulfur. Plant height, number of branches plant-1, number of leaves plant-1, seed yield, stover yield were increased significantly with increasing N level upto 60 kg N ha-1. Interaction effects of nitrogen(60 kg N ha-1) and sulphur (40 kg S ha-1) gave the highest number of capsules plant-1 (70.40), length of capsule (3.99 cm), diameter of capsule (2.77 cm), seeds capsule-1 (50.63) and thousand seed weight (12.25 g). The combined application of 60 kg nitrogen and 40 kg sulphur may be considered to be optimum for getting higher yield of sesame.

Vegetable sesame (*Sesamum radiatu*m) was fertilized with N applied as urea (46% N) at 0, 30, and 60 kg/ha and P applied as single super phosphate (SSP) (7.8% P) at 0, 15, and 30 kg/ha in a field experiment conducted by Auwalu *et al*. (2007) in the dry season of 1996 and wet season of 1997. Application of N significantly increased plant height, number of leaves per plant, leaf area index (LAI), leaf fresh and dry weight as well as total marketable yield in both seasons; shoot dry weight was not significantly increased by N application in the 1996 dry weight was not significantly increased by N application in the 1996 dry season. Zarghan local recorded the highest yield (1724 kg/ha) and harvest index with the

90 kg N/ha rate and 25.0 plants/m2 density. Application of 90 kg N/ha increased the protein accumulation by 25% compared to the control (no fertilizer). Seed oil percentage was a stable yield component and was not affected by either N rate or plant density.

A study was conducted by Abdel *et al*. (2003) in the sandy soil of Assiut, Egypt in 2001 and 2002 to investigate the effects of sowing dates, N fertilizer rate (60, 80 and 100 kg/ha) and plant population on the performance of sesame cv. Giza 32. Plants sown on 10 May showed the maximum height (178.99 cm), the height of the first branch and the number of branch per plant were the highest in plants sown on 25 May, while the height of the first capsule was the highest in plants sown on 10 June. The height of the first branch and first capsule, as well as the length of the fruiting zone were the highest at 60 kg N/ ha. The highest seed and oil yields (6.20 kg/ha and 366.39 kg/ha, respectively) were obtained at 80 kg N/ha

A study was conducted by Malik *et al*. (2003) in Faisalabad, Pakistan in 2001 to investigate the effects of different N levels (0, 40 and 80 kg/ha) on the productivity of sesame cv. TS-3 under different plant geometries (flat sowing, paired row planting, ridge sowing and bed sowing). N at 80 kg/ha produced the highest yield (0.79t/ha), 1000-seed weight (3.42 g) and seed oil content (45.88%). Among the plant geometry treatments, bed sowing (50/30 cm) produced the highest seed yield of 0.85 t/ha and seed oil contents (44.06%).

Pathak *et al*. (2002) carried out a field experiment during the kharif seasons of 1997 and 1998, in the Barak Valley Zone of Assam, India, to evaluate the effect of N levels (0, 15, 30 and 45 kg/ha) on the growth and yield of sesame (S. indicum). N at 45 kg/ha recorded the highest mean values for plant height (74.3 cm), number of branches per plant (4.50), number of capsules per plant (39.0) and 1000-grain weight (2.91 g). N at 45 kg/ha also recorded the highest seed yield (6.95 and 7.25 q/ha), net return (Rs 4450 and 4700/ha) and benefit cost ratio (1.78 and 1.84) during 1997 and 1998, respectively.

A field experiment was carried out by Singh *et al*. (2001) at Agra during rainy (kharif) seasons of 1995 and 1996 to assess the effect of nitrogen levels and different weed control techniques to *Sesamum indicu*m on weed density, seed yield, nutrients depletion by weeds and net returns. 60 kg N/ha registered the highest yield (979 kg/ha) and net returns (Rs. 10327/ha) in addition to higher N uptake by crop and N depletion by weeds. However, higher levels of N could not influence P and K removal by weeds significantly

A field experiment was conducted by Ashfaq *et al*. (2001) during the summer seasons of 1996 and 1997, in Pakistan, to study the response of 2 sesame genotypes (92001 and TS3) to different rates of N and P (0, 40, 80 and 120 kg/ha). N at 120 kg/ha and P at 40 kg/ha significantly increased the seed and stalk yield of sesame, as well as the protein content of the oil. This response was higher in TS3 than in 92001.

Six combinations of 2 N (20 and 40 kg N/ha) and 3 K rates (0, 33 and 66 kg K/ha) were applied to soybean and sesame as sole crop or intercropped in a field experiment conducted by Mondal *et al*. (2001) in West Bengal, India during the rainy and summer seasons of 1994 and 1995. Oil yield of sesame and soybean as sole crops were higher compared to the oil yield of both crops as intercrops. Highest oil yield of soybean and sesame was observed with 66 kg K/ha + 40 kg N/ha application. Nutrient uptake by soybean as a sole crop and combined uptake of nutrients by both intercrops were higher during the rainy season than their respective nutrient uptake during summer. However, nutrient uptake of sesame as sole crop was higher in summer than during the rainy season. Maximum uptake of nutrients in both sesame and soybean was observed with 66 kg K/ha + 40 kg N/ha application. Continuous N application resulted in higher N-status in soil. However, application of K with N resulted in a decreased total N status in soil after the fourth cropping.

The effects of N fertilizer application and weed control measures on sesame were investigated by Prakash *et al*. (2001) in Uttar Pradesh, India, during 1995 and 1996 treatments consisted of 4 N levels (0, 30, 60 and 90 kg/ha) and weed control. N fertilizer rate did not significantly affect the weed population. Application of 90 kg N/ha resulted in the highest number of capsules per plant, seeds per capsule, 1000-seed weight, seed yield, straw yield and harvest index in both the years.

Two field experiments were conducted by Fayed *et al*. (2000) in Egypt during 1997-98 to study the productivity and performance of sesame under drip irrigation as affected by sowing rate (3.6 kg/ha) and nitrogen fertilizer application (30, 60 and 90 kg/ha) in newly cultivated sandy soil. Increasing nitrogen rates up to 60 kg N/ha significantly increased the values of the yield and all the yield attributes of sesame. Further increase in N rates more than 60 kg/ha had no significant effects on seed yield and yield components except plant height.

A field experiment was conducted by Mitra and Pal (1999) in West Bengal, India, during the summer season (pre-kharif) of 1991 to study the effect of irrigation and nitrogen on growth, yield and water use of summer sesame (*Sesamum indicurri*). A significant increase in seed yield of sesame was recorded up to three irrigations (0.784 t/ha). The increase in dry matter, number of capsules/plant, seed/capsule and seed yield of sesame was significant up to 100 kg N/ha. Further increase in nitrogen depressed the seed yield and yield attributing characters. For seed yield, the response to applied nitrogen was quadratic in nature and maximum response (0.90 kg seed/kg N) was observed at 100 kg N/ha level.

A field experiment was conducted by Parihar *et al*. (1999) during the summer seasons of 1995 and 1996 on a clay-loam soil at Bilaspur to study the response of summer sesame to irrigation and nitrogen levels. Irrigation scheduled at 0.6 IW/CPE was found to be the optimum, with little further increase in yield from irrigation at 0.8 IW/CPE. Yield increased with increasing N rate (0-80 kg/ha).

A field experiment was conducted by Singh and Singh (1999) in Uttar Pradesh, India, for 2 years (1991 and 1992) during the monsoon season to study the N requirement of the sesame + V. mungo intercropping system. The treatments included sole cropping and intercropping of sesame and V. mungo, and application of N at 3 rates (10, 20 and 40 kg/ha). Sole crop yields were higher than intercrop yields in both crops. Growth characters of both crops in the intercropping system improved with increasing N rates. The oil content and yield of sesame sole crops, and the grain and protein yields of V. mungo sole crops increased with increasing N rates. The best N treatment in intercropping systems was the application of 40 kg N/ha to sesame and 10 kg N/ha to V. mungo.

Subrahmaniyan and Arulmozhi (1999) conducted a field study during summer 1996 and 1997 at Vridhachalam, Tamil Nadu, India, sesame cv. VS 9104 and VRJ 1 were grown at densities of 111000 or 166000 plants/ha and given 0, 35,45 or 55 kg N/ha. VS 9104 had a higher number of branches and capsules/plant and higher dry matter production/plant, 1000-seed weight and yield than VRI 1. Yield and yield component values increased with increasing N rate.

In a field experiment conducted by Singaravel and Govindasamy (1998) in 1990 at Neyveli, Tamil Nadu, India, sesame cv. TMV 4 was given 35 kg N/ha and/or Azospirillum, together with 0, 10, 20 or 30 kg humic acid/ha Seed yield and dry matter production were greatest with N fertilizer + 20 kg humic acid. In a field experiment conducted by Thakur *et al*. (1998) at Raigarh, Madhya Pradesh during the 1994 and 1995 rainy seasons, sesame cv. Gujrat 1 was given 30, 45 or 60 kg N and 20, 30 or 40 kg P2O5/ha. Seed, oil and protein yields increased significantly with up to 45 kg N and 30 kg P2O5/ha.

A field experiment carried out by Bassiem and Anton (1998) in Ismailia, Egypt, during 1996 and 1997 to investigate the effects of N (at 30, 60 and 90 kg/ha) and K (at 24 and 48 kg K2O/ha) and foliar spray with ascorbic acid (500 ppm) on yield and its components as well as seed contents of oil and protein of sesame cv.

G.32. Seed yield increased significantly by increasing N upto 90 kg/ha, whereas yield attributes increased significantly by adding N upto 60 kg N/ha.

A field experiment was conducted by Dixit *et al*. (1997) during early rabi (winter) season of 1991-92 at Powarkheda, Madhya Pradesh to assess the productivity of sesame cv. TC-25 and Rauss-17 sown at 333 000, 444,000 or 666,000 plants/ha with application of 0-90 kg N/ha. Application of N upto 60 kg/ha increased the seed yield significantly and gave the highest net profit.

In a field experiment in 1990-91 at Tikamgarh, Madhya Pradesh, 4 sesame (*Sesamum indicum*) cultivars were sown at spacing of 30 x 10 or 15 cm and given 0-90 kg N/ha by Tiwari and Namdeo (1997). The application of 90 kg N produced the highest seed yield of 0.81 t/ha. Seed oil contents decreased and protein content increased with increasing N rate.

Mondal *et al*. (1997) carried out a field trial at the University Farm, Kalyani, West Bengal, in summer 1992 in which sesame was not irrigated, irrigated at branching and seed setting growth stages or irrigated at branching, flowering and seed setting growth stages and given 0, 30, 60, 90 or 120 kg N/ha. Plant height, Dry matter accumulation, number of capsules/plant, number of seeds/capsule, 1000seed weight, seed yield and oil and protein yields were all increased as irrigation frequency and nitrogen fertilizer rate increased. Harvest index was not significantly affected by N application, but increased slightly with irrigation.

Ashok *et al*. (1996) conducted a field experiment in 1990-91 at Pusa, Bihar, where sesame was irrigated at irrigation water: cumulative pan evaporation (IW: CPE) ratios of 0.3, 0.5 or 0.7 or irrigated 30 and 60 d after sowing (DAS), and was given 0-90 kg N/ha. Irrigating at an IW: CPE ratio of 0.7 gave the highest mean seed yield of 0.81 t/ha. Irrigations at 30 and 60 DAS used the same quantity of water as irrigating at an IW: CPE ratio of 0.5, but the seed yield was significantly" higher in the former treatment in 1990. Seed yield was highest with 90 kg N in 1990 (0.91 t/ha) and increased with up to 60 kg N in 1991 (0.92 t/ha). Total N uptake increased with increasing irrigation frequency and increasing N rate. Seed oil content was highest with 30 kg N.

2.2. Effect of spacing on sesame

The effects of plant density on yield and related traits were studied in ten cultivars of spring barley, *Hordeum vulgare* L., to determine if selection in low density stands is effective in improving expression in dense stands. Five plant densities (1.6, 6.2, 25, 100, and 400 plants/m^2) were evaluated in each of 3 years. Spikes/plant, shoot weight and grain yield were the only characteristics that had significant cultivar x density interactions. All three characteristics increased asymptotically as density decreased and did not show significant changes in cultivar rank. Interplant variability, although minimum at a density of 100 plants/m^2 for spikes/plant, shoot weight and grain yield, showed a significant decrease at a density of 6.2 plants/m^2 (40 x 40 cm) for all traits. Our results show that single plant selection may be most effective at plant spacings near40 x 40 cm and that selection under low densities should be effective in improving dense seeding expression of yield and several related traits (Baker and Briggs 2007).

A field experiment was conducted to evaluate the effect of row spacing on the yield and yield contributing characters of sesame during Kharif season, using the varieties (V_1 = T_6, V_2 = Batiaghata local Til and V_3 = BINA Til) and the row spacings (S_1 = 15 cm, S_2 = 30 cm and S_3 = 45 cm). Yield were significantly influenced by the varieties and row spacings. The highest seed yield was produced by the variety BINA Til while the lowestwas by the variety Batiaghata local Til and the highest seed yield was produced by row spacing 30 cm while the lowest was by row spacing 45 cm. Seed yield was well correlated with capsules plant^{-1} and seeds capsule^{-1} (Nandita *et al.* 2009).

Yield components in oil palm were recorded in a spacing experiment comparing 56, 110, 148 and 186 palms ha^{-1}. The higher densities reduced the number of female inflorescences (due to a decrease in the proportion of female to total inflorescences and an increase in the proportion of leaves with aborted inflorescences), the weight of the frame and the number of flowers per inflorescence. The results suggest that the production of seed per bunch can be increased by at least 15% by thinning around selected palms in seed gardens. The sex ratio and the components of flower number perinflorescence were more sensitive to competition for light than the weight of the frame and floral abortion. Components determining the oil and kernel extraction showed no response to density when assisted pollination was used, but with the successful introduction of insect pollinators, oil and kernel extraction increased with planting density as a result of an increase in fruit per bunch (Breure *et al*., 2007).

Asghar *et al*. (2009) conducted a field studies in Faisalabad, Pakistan, to determine the effect of different sowing dates and row spacing on the growth and yield of sesame cv. 92006. Four sowing dates (8, 15, 22 and 29 July) and 3 row spacing (30, 45, 60 cm) were used. Effect of sowing dates was highly significant and maximum branches/plant and seed yield was produced when the crop was sown on 8 and 15 July due to higher number of capsules per plant and more seeds per capsule. Seed yield was increased with an increase in row spacing from 30 to 45 cm. However, further increase in spacing decreased the seed yield.

Cakmakc and Aydnoglu (2002) conduct a field studies during 2000-2002 in Anatolia, Turkey, to determine the influence of different row spacing (15, 30, 45 and 60 cm) and N fertilizer application rates (0, 50, 100 and 150 kg/ha) to the yield of chickling vetch (*Lathyrus sativus*). The treatment with 30 cm row spacing and 150 kg N ha-1 produced the highest forage and dry matter yield. The lowest forage yield was observed at 45 cm row spacing with no N fertilizer applied, while the lowest dry matter yield was observed at 30 cm row spacing and no N fertilizer application. The number of days for flowering was 109 days. Results indicate that if chickling vetch is sown during fall, it could provide adequate time to carry out sowing preparations for cotton, maize and sesame, which are the main crops of the region. It is concluded that chickling vetch is an alternative legume crop for rotation in terms of yield.

El-Ouesni *et al.* (2007) conducted a field trial at Nobarya, Egypt, during 2006-07, the effects were evaluated of 2 plant population densities (1 or 2 plants/hill), 2 weed control treatments (hoeing twice at 35 + 55 d after sowing and pre-em.

Prometryn at 1 kg/feddan) and 3 N fertilization levels (15, 30 and 45 kg N/feddan) for weed control in, and growth and yields of, sesame cv. Giza 32. Prometryn + 1 plant/hill + N fertilization at 45 kg resulted in the lowest weed DW and FW of 15.3 and 44.44 g/msuperscript 2, resp., and the greatest crop plant height, number of branches/plant and seed yields of 134 cm, 16.52 and 11.58 g/plant, respectively. [1 feddan=0.42 ha.].

Vieira (2004) conducted a field trial in 2003 in Cariris Velhos, Paraiba, Brazil, sesame cv. Serido 1, CNPA G2 and CNPA G3 were grown in different spacing patterns. There was no significant interaction between cultivar and spacing. CNPA G3 gave significantly higher seed yields (0.71 t/ha) than the other cultivars (0.40-0.42 t/ha). Spacing did not affect yield.

Patil (2000), in a field experiment in 1996-98 in Maharashtra, sesame cv. Padma was grown at spacings of 30 x 10 or 15 cm or 45 x 10 or 15 cm and given 0-50 kg N/ha. Mean seed yield (0.58 t/ha) and net returns were highest at the 30 x 15 cm spacing + 50 kg N.

CHAPTERS III

MATERIALS AND METHODS

The experiment was conducted during the period from February to June, 2018 to find out the effect of nitrogen and spacing on the growth and yield of sesame. This chapter presents a brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and analysis of different parameters under the following headings:

3.1 Location

The experiment was conducted in the research field of Crop Physiology and Ecology department, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental site is situated under the Dinajpur Sadar Upazila and located at 25º39″ N latitude and 88º41″ E longitude with an elevation of 37.58 meter above the sea level.

3.2 Characteristics of soil and climate

The soil was collected from 15cm depth of the research field of CPE department. The soil was non-calcareous red brown terrace with loamy texture belonging to the AEZ (Old Himalain Piedmont plain). The collected soil was well pulverized and dried in the sun and Decomposed cowdung was mixed with the soil. The soil is sandy loam under the Order Inceptisol. The experimental site is situated in the sub-tropical region characterized by heavy rainfall during the months from May to September and scantly rainfall in the rest of the year.

3.4 Planting material

Seeds of BARI Til-3 used as a test crop for the study and those were collected from Bangladesh Agricultural Research Institute, Gazipur. This variety was developed by BARI and exposed for cultivation in the year of 2001 (BARI, 2012). It is a non-hairy medium sized plant with primary and secondary branches with high potential plant.

3.5 Treatment of the experiment

The experiment considered of two factors. Details of the treatments are presented below:

Factor A: Levels of nitrogen (4 levels)

i. N_1: 25 kg N/ha (control)

ii. N_2: 45 kg N/ha

iii. N_3: 65 kg N/ha

iv. N_4: 85 kg N/ha

Factor B: Three plant spacing

i. S_1: 40 cm × 5 cm

ii. S_2: 40 cm ×10 cm

iii. S_3: 40 cm ×15 cm

3.6 Layout of the experiment

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments in each plot of each block. Each block was divided into

12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. The size of the plot was 2 m × 2.5 m. The distance between two blocks and two plots was 50 cm each.

3.7 Land preparation

The experimental field was first opened on February 05, 2018with the help of a power tiller and prepared by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a desirable fine tilth. The visible larger clods were hammered to break into small pieces. All kinds of weeds and residues of previous crop were removed from the field. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.8 Fertilizer application

Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP, half of MoP, total zinc and sulfur was applied as basal dose at the time of land preparation. The rest amount of MoP and total amount of urea (as per treatment) was applied in two installments at 15 and 30 day after seed sowing.

Table 1. Dose and method of application of fertilizers in sesame field

Fertilizers and Manures	Dose/ha	Application (%)		
		Basal	15 DAS	30 DAS
Cowdung	10 tonnes	100	--	--
Urea	As per treatment	--	50	50
TSP	150 kg	100	--	--
MoP	50 kg	50	25	25
Zinc Sulphate	5 kg	100	--	--
Sulfur	10 kg	100	--	--
Boron	1 kg	100	--	--

Source: BARI 2012

3.9 Sowing of seeds

The seeds of BARI Til-3 were sown on 27 February 2018.

3.10 After care

3.10.1 Irrigation

Light over-head irrigation was provided with a watering can to the plots. Irrigation also provided at 10 and 25 days after seed sowing.

3.10.2 Thinning

Thinning was done carefully for better growth of the germinated plants and it was done manually after 22 days of sowing, on March 1, 2018. Care was taken to maintain constant plant population per plot.

3.10.3 Gap Filling

Dead, injured and week seedlings were replaced by healthy one from the stock kept on the border line of the experimental plot. Those seedlings were re-transplanted with a big mass of soil with roots to minimize transplanting shock. Replacement was done with healthy seedling having balls of earth those were also sown at same date on border line. The transplanted seedlings were provided shading and watering for 03 days for the establishment of seedlings.

3.10.4 Weeding

Weeding was done two times at 10 and, 25 days after seed sowing followed by irrigation.

3.10.5 Plant Protection

The crop was protected from the attack of insect-pest by spraying Malathion. The insecticide application were made fortnightly as a matter of routine work from seedling emergence to the end of harvest.

3.11 Harvesting

The pod was harvested depending upon the attaining good sized and the harvesting was done manually. Enough care was taken during harvesting.

3.12 Data collection

The data were collected from the inner rows of plants of each treatment to avoid the border effect. In each unit plot, 10 plants were selected at random for data collection. Data were collected in respect of the plant growth characters and yield of sesame. Data were recorded on the following parameters-

3.12.1 Plant height

The height of plant was recorded at 30, 50, 70, 90 DAS and at harvest by using a meter scale. The height was measured from the ground level to the tip of the plant of an individual plant. Mean value of ten selected plants was calculated for each unit plot and expressed in centimeter (cm).

3.12.2 Number of leaves per plant

Number of leaves per plant was counted and the data were recorded from randomly selected 10 plants at 30, 50, 70 and 90 DAS and mean value was counted and recorded.

3.12.2 Number of branch per plant

Number of branches per plant was counted and the data were recorded from randomly selected 10 plants at harvest and mean value was counted and recorded.

3.12.3 Days required from sowing to germination, flowering, first pod formation and maturity

The number of days required from sowing to germination, flowering, first pod formation and maturity was recorded from each plot.

3.12.4 Length of capsule (cm)

The capsules from each randomly selected plant were measured using centimeter scale and the mean value was calculated and was expressed in centimeter.

3.12.5 Number of capsule per plant

From 10 randomly selected plants from each unit plot numbers of capsule were counted and their mean values were recorded.

3.12.6 Seeds per capsule

Seeds per capsule were counted from 10 randomly selected capsules as harvested from each unit plot.

3.12.7 Seed yield per hectare

Mature capsule pod were harvested from each plot and seeds were separated from capsule their weight was recorded. The seed yield per plot was finally converted to yield per hectare and expressed in ton (t).

3.12.8 Stover yield per hectare

Mature sesame plants were harvested from each plot and seeds and stover were separated and weight of stover was recorded. The stover yield per plot was finally converted to stover yield per hectare and expressed in ton (t).

3. 13. Data Analysis

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT program. The treatment means were compared using Tukey's test at $P \leq 1\%$ level.

CHAPTER IV

RESULTS AND DISCUSSION

The influence of nitrogen fertilizer and different plant spacing on the growth and yield of sesame variety (BARI Til-3) are presented in several tables and figures. Adequate discussion and possible interpretations whenever suitable have been provided in this chapter.

4.1. Phenological characters

4.1.1 Days to germination

Days required to germination was not significantly influenced by different nitrogen levels (Fig. 1). It was found that days required to germination were different for different nitrogen doses. The highest days required to germination (6.88) was observed in N_4 (85 kg N/ha) which was followed by N_1 (25 kg/ha), N_2 (45 kg/ha) and the lowest days required to germination (5.66) was observed in N_3 (65 kg/ha).

Days required to germination were not significantly influenced by different plant spacing (Fig 2). The highest days required to germination (6.75) were observed in S_1 (40 cm × 05 cm) which was followed by S_3 (40 cm ×15 cm) and the lowest days to germination (5.91) was observed in S_2 (40 cm ×10 cm).

The days required to germination was not significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 3). The highest days required to germination (7.33) were observed in S_1N_4 interaction and lowest days required to germination (5.33) were observed in S_2N_3 and S_3N_3 combination.

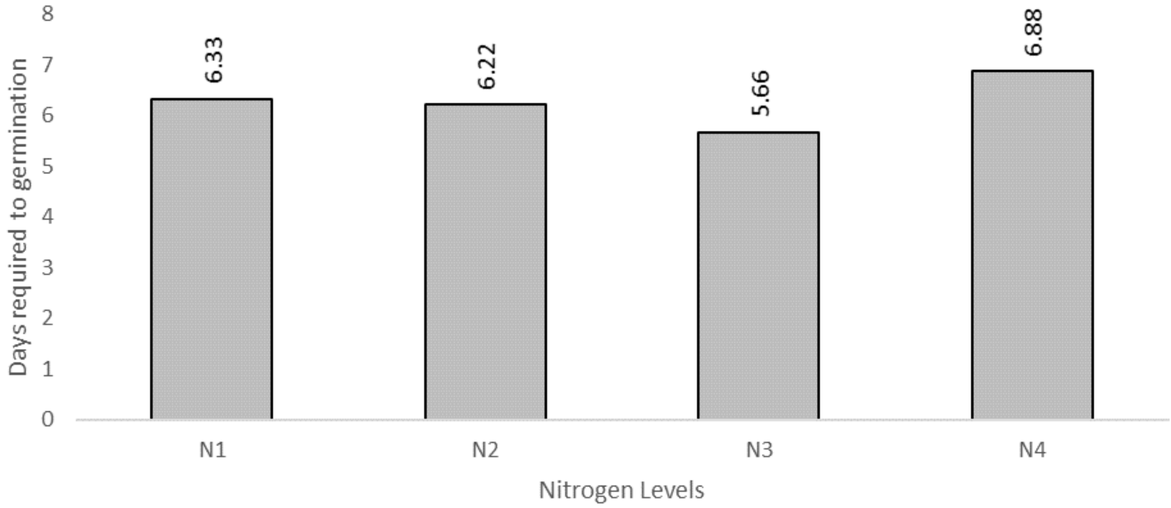

Fig 1. Effect of nitrogen on days to germination

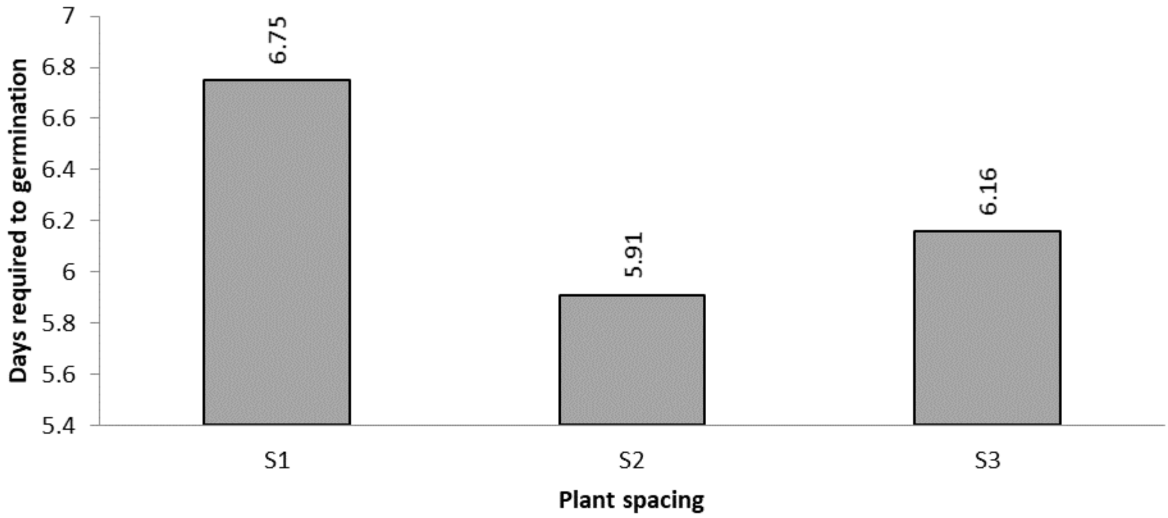

Fig 2. Effect of plant spacing on days to germination

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N_1: 25 kg N/ha (control) S_1: 40 cm × 05 cm
N_2: 45 kg N/ha S_2: 40 cm ×10 cm
N_3: 65 kg N/ha S_3: 40 cm ×15 cm
N_4: 85 kg N/ha

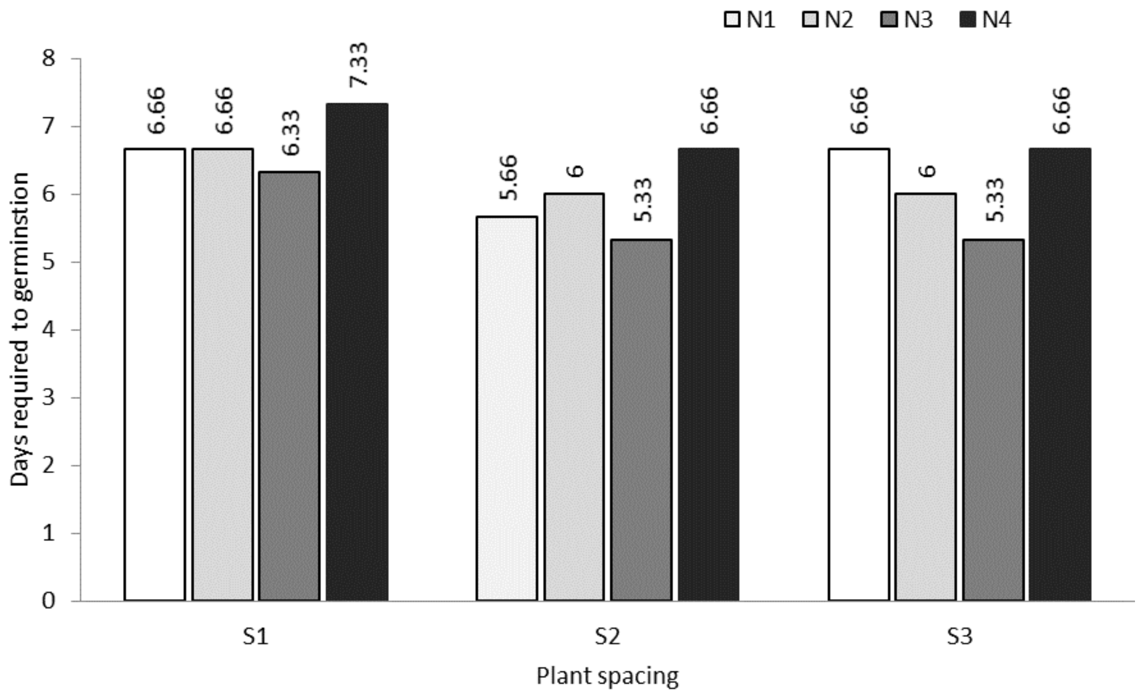

Fig 3. Effect of nitrogen and plant spacing on days to germination

N_1: 25 kg N/ha (control)
N_2: 45 kg N/ha
N_3: 65 kg N/ha
N_4: 85 kg N/ha

S_1: 40 cm × 05 cm
S_2: 40 cm ×10 cm
S_3: 40 cm ×15 cm

4.1.2 Days to flowering

Days required to flowering was significantly influenced by different nitrogen levels (Fig. 4). It was found that days required to flowering was increased with the increment of nitrogen doses. The highest days required to flowering (47) was observed in N_4 (85 kg/ha) which was followed by N_3 (65 kg/ha) which was statistically similar with N_2 (45 kg/ha) and the lowest days required to flowering (43.27) was observed in N_1 (25 kg/ha).

Days required to flowering were significantly influenced by different plant spacing (Fig 5). It was found that days required to flowering was increased with the increment of plant spacing. The highest days required to flowering (45.62) were observed in S_3 (40 cm ×15 cm) which was statistically similar with S_2 (40 cm ×10 cm) and the lowest days to flowering (43.89) was observed in S_1 (40 cm × 05 cm).

This may be due to the intense overcrowding of the crop at closer spacing which might have induced competitive demands on available nutrients and moisture could have been responsible for prolonging days to flowering. Ijoyah *et al*, (2015) reported similar findings in sesame and attributed the result to intensified competition in closely spaced plants. The days required to flowering was significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 6). The highest days required to flowering (7.33).

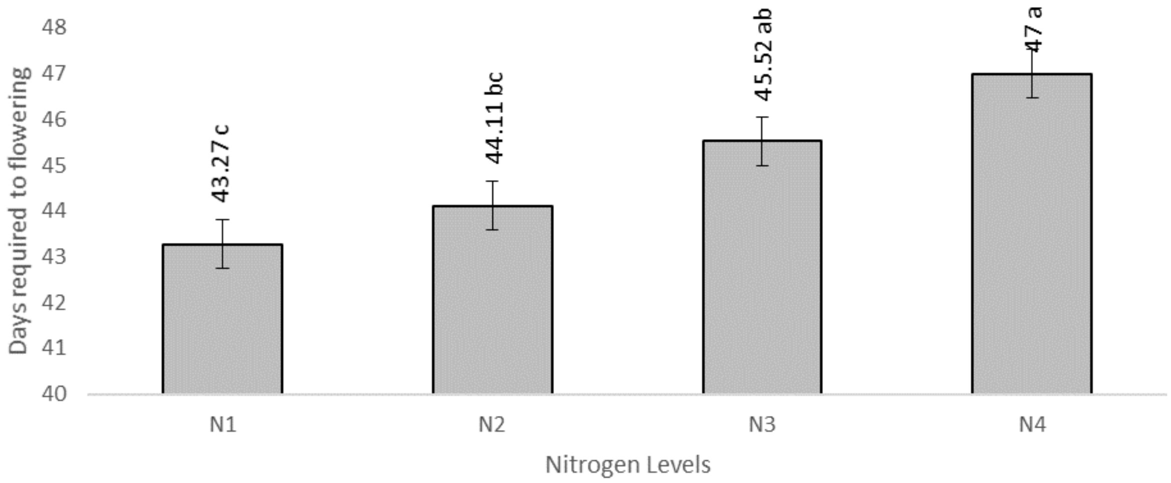

Fig 4. Effect of nitrogen on days to flowering

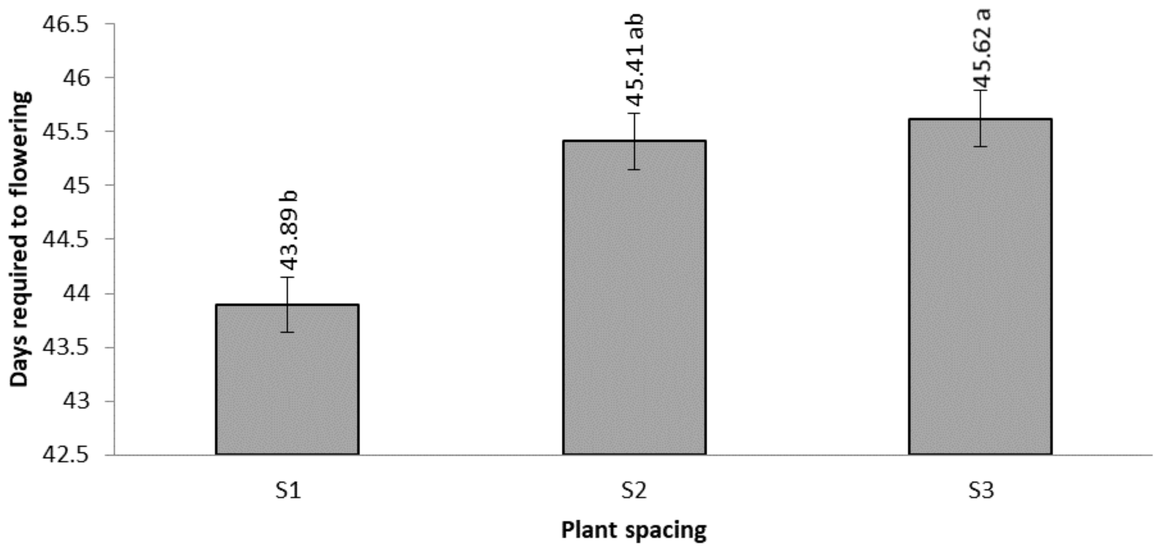

Fig 5. Effect of plant spacing on days to flowering

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control) S_1: 40 cm × 05 cm
N_2: 45 kg N/ha S_2: 40 cm ×10 cm
N_3: 65 kg N/ha S_3: 40 cm ×15 cm
N_4: 85 kg N/ha

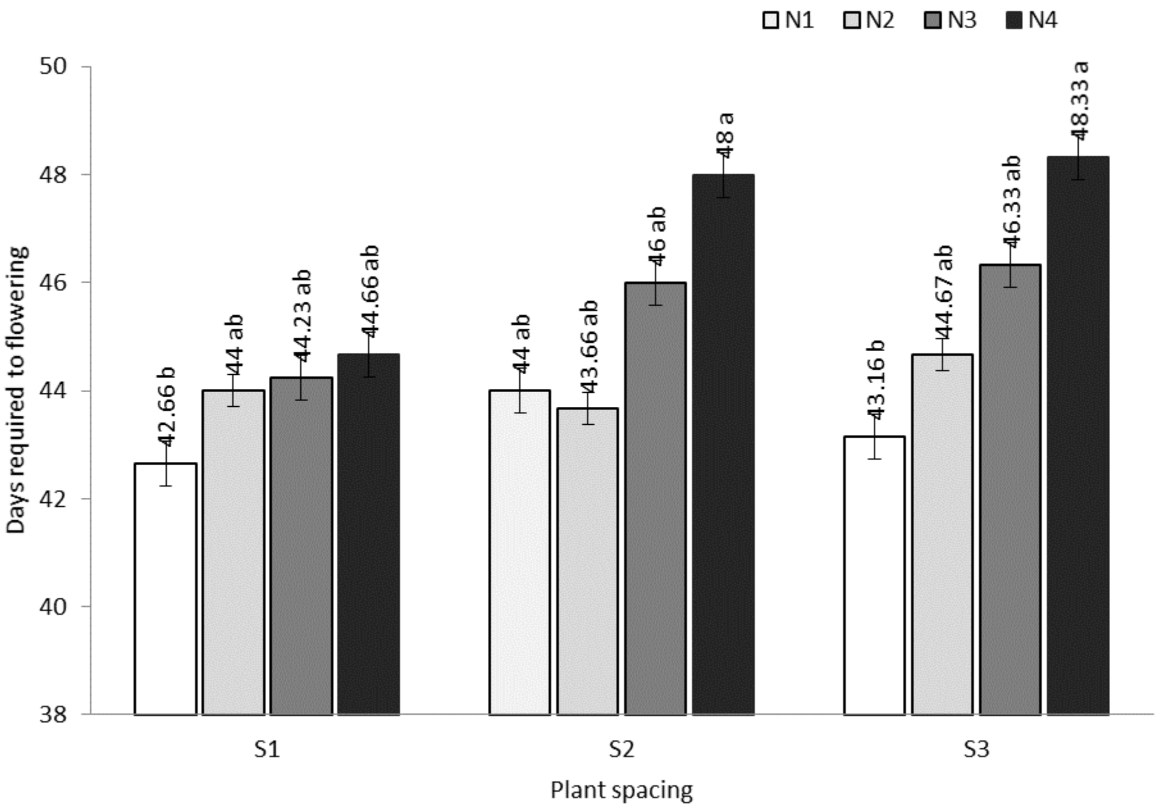

Fig 6. Effect of nitrogen and plant spacing on days to flowering

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

were observed in S_3N_4 interaction which was statistically similar with S_2N_4 interaction followed by S_3N_3, S_2N_2, S_3N_2, S_1N_3, S_1N_2, S_2N_2 and the lowest days required to flowering (42.66) were observed in S_1N_1 which was statistically similar with S_3N_1 combination.

4.1.3 Days to pod formation

Days required to pod formation was significantly influenced by different nitrogen levels (Fig. 7). It was found that the days required to pod formation were increased with the increment of nitrogen doses. The highest days required to pod formation (60.11) was observed in in N_4 (85 kg N/ha) which was statistically similar with N_3 (65 kg/ha) and the lowest days required to pod formation (56.44) was observed in N_1 (25 kg/ha) which was statistically similar with N_2 (45 kg/ha).

Days required to pod formation were significantly influenced by different plant spacing (Fig 8). It was found that the days required to pod formation were increased with the increment of plant spacing. The highest days required to pod formation (59.5) were observed in S_3 (40 cm ×15 cm) was statistically similar with S_2 (40 cm ×10 cm) and the lowest days to pod formation (56) was observed in S_1 (40 cm × 05 cm).

The days required to pod formation was not significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 9). The highest days required to pod formation (61.66) were observed in S_3N_4 interaction and lowest days required to pod formation (55) were observed in S_1N_1 combination.

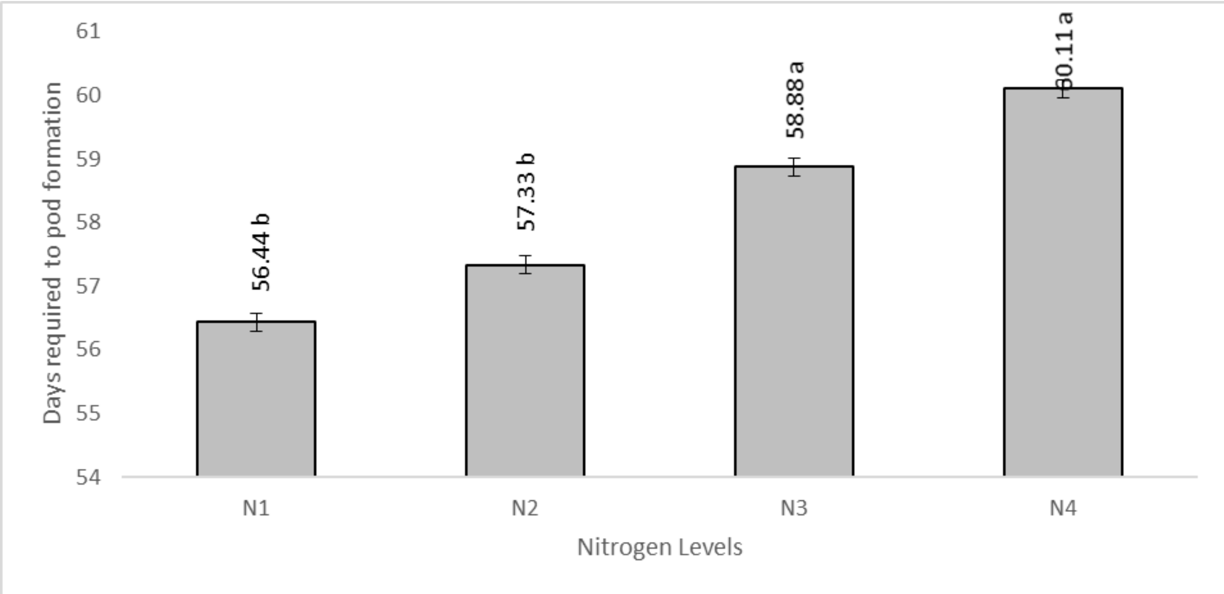

Fig 7. Effect of nitrogen on days required to pod formation

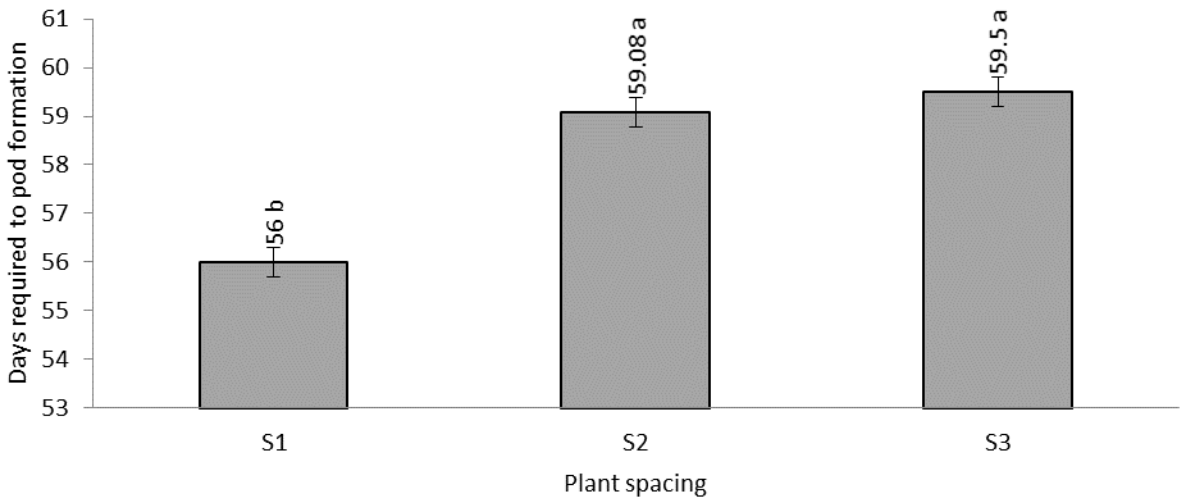

Fig 8. Effect of plant spacing on days required to pod formation

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

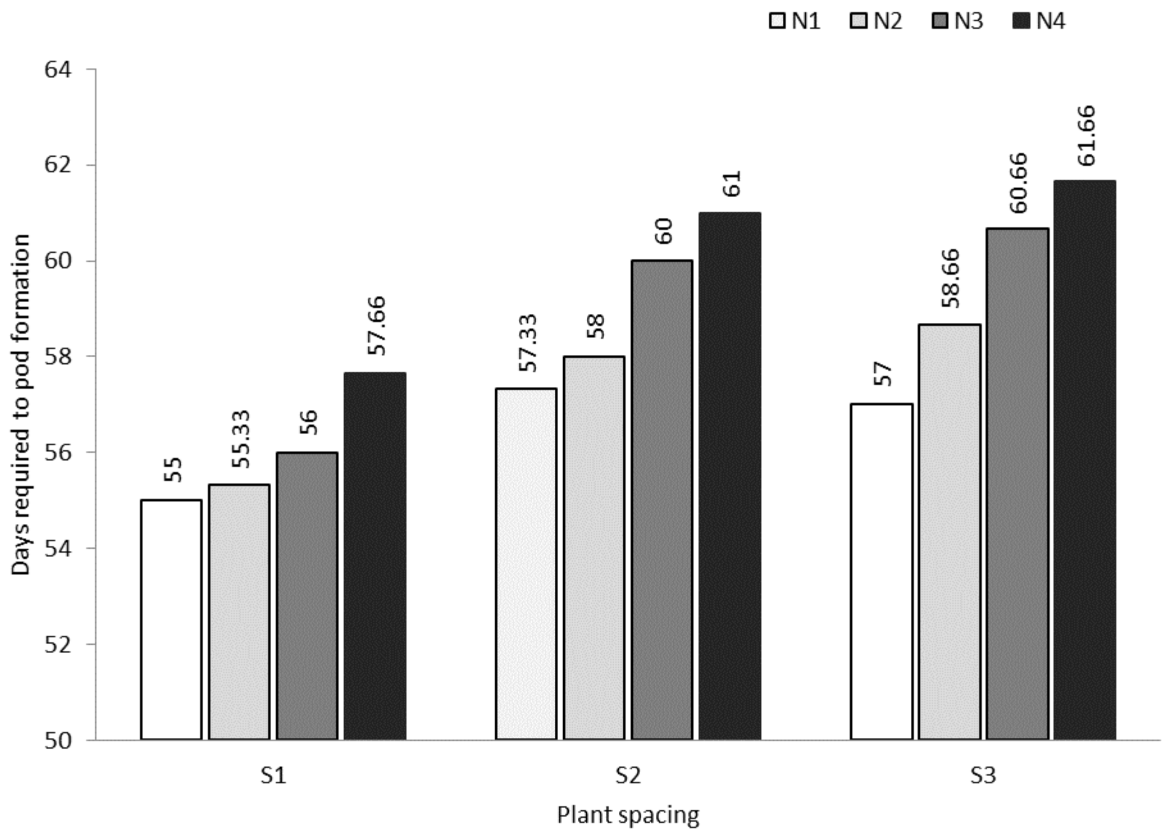

Fig 9. Effect of nitrogen and plant spacing on days required to pod formation

N_1: 25 kg N/ha (control) S_1: 40 cm × 05 cm
N_2: 45 kg N/ha S_2: 40 cm ×10 cm
N_3: 65 kg N/ha S_3: 40 cm ×15 cm
N_4: 85 kg N/ha

4.1.4 Days to maturity

Days required to maturity was significantly influenced by different nitrogen levels (Fig. 10). The highest days required to maturity (89) was observed in in N_4 (85 kg N/ha) and the lowest days required to maturity (86.44) was observed in N_1 (25 kg/ha) which was statistically similar with N_2 (45 kg/ha) and N_3 (65 kg/ha).

Days required to maturity were significantly influenced by different plant spacing (Fig 11). It was found that the days required to maturity were increased with the increment of plant spacing. The highest days required to maturity (89.16) were observed in S_3 (40 cm ×15 cm) which was followed by S_2 (40 cm ×10 cm) and the lowest days to maturity (85.66) was observed in S_1 (40 cm × 05 cm).

The days required to maturity was not significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 12). The highest days required to maturity (90.66) were observed in S_3N_4 interaction and lowest days required to to maturity (84.66) were observed in S_1N_3 combination.

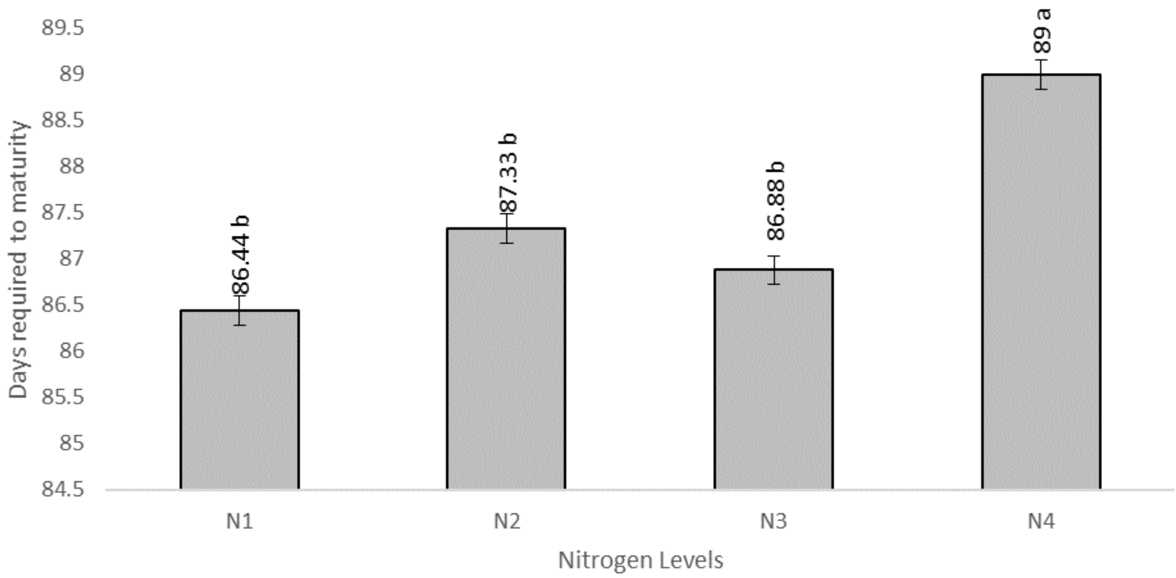

Fig 10. Effect of nitrogen on days to maturity

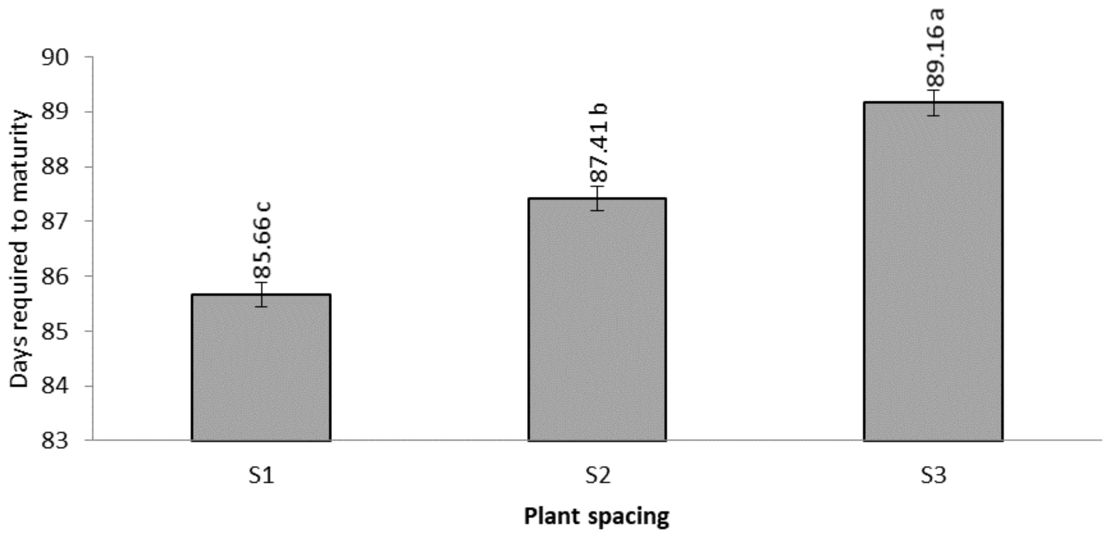

Fig 11. Effect of plant spacing on days to maturity

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

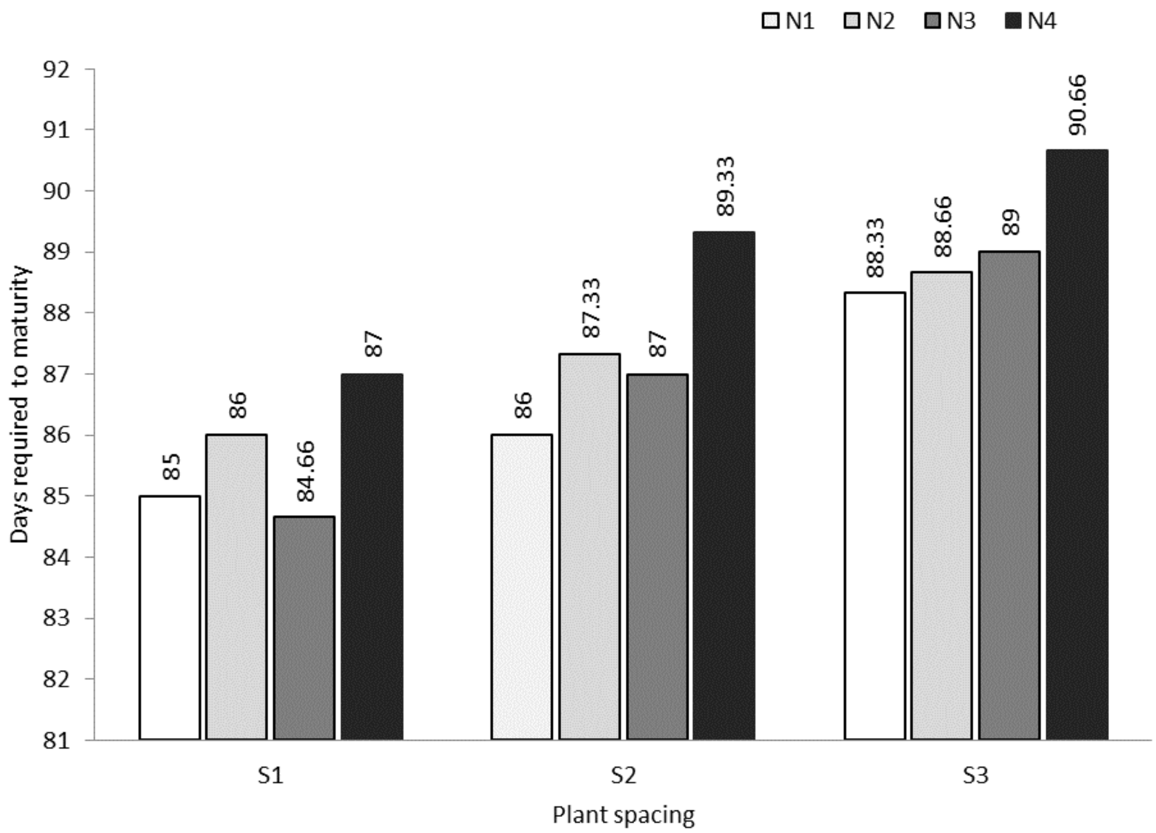

Fig 12. Effect of nitrogen and plant spacing on days required to maturity

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

4.2. Growth, yield attributes and yield characters

4.2.1 Plant height

Plant height at 30, 50, 70 and 90 days after sowing were significantly influenced by different nitrogen levels (Fig.13). In every time the tallest plant height was found in N_4 (85 kg N/ha) and the shortest plant height was found in N_1 (25 kg/ha). In all cases, plant height was increased with the advancement of time and also with the increment of nitrogen levels. These results were expected since nitrogen stimulates cell division and extension in turn increases number and length of internodes resulting in taller plants. Confirming results were detected by Bassiem and Anton (1998) up to 142 Kg N/ha, Ali (2002) up to 178.5 Kg N/ ha and Muhamman and Gungula (2008) up to 90 Kg N/ ha.

Plant height at 30, 50, 70 and 90 days after sowing were significantly influenced by different plant spacing (Fig. 14). In all cases, plant height was increased with the advancement of time and also with the reduction of spacing. In every time the tallest plant height was found in S_1 (40 cm ×5 cm) and the shortest plant height was found in S_3 (40 cm × 15 cm).

The interaction of nitrogen levels and spacing influenced the height of plant significantly at 30, 50 and 90 days after sowing (Fig.15) but not significantly influenced at 70 DAS. In general the height of plant increased with the advanced

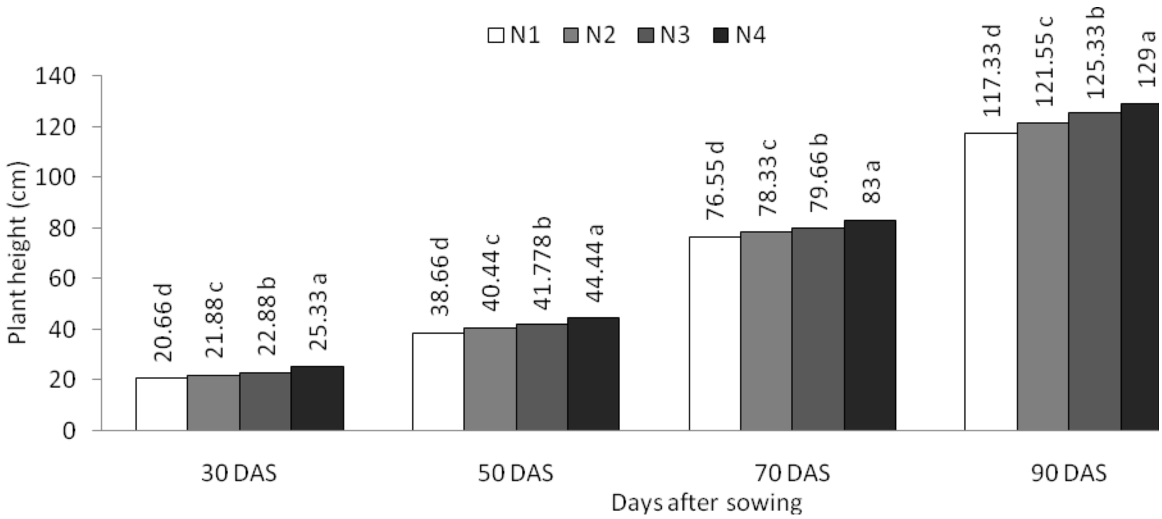

Fig 13. Effect of nitrogen on plant height at different days after sowing

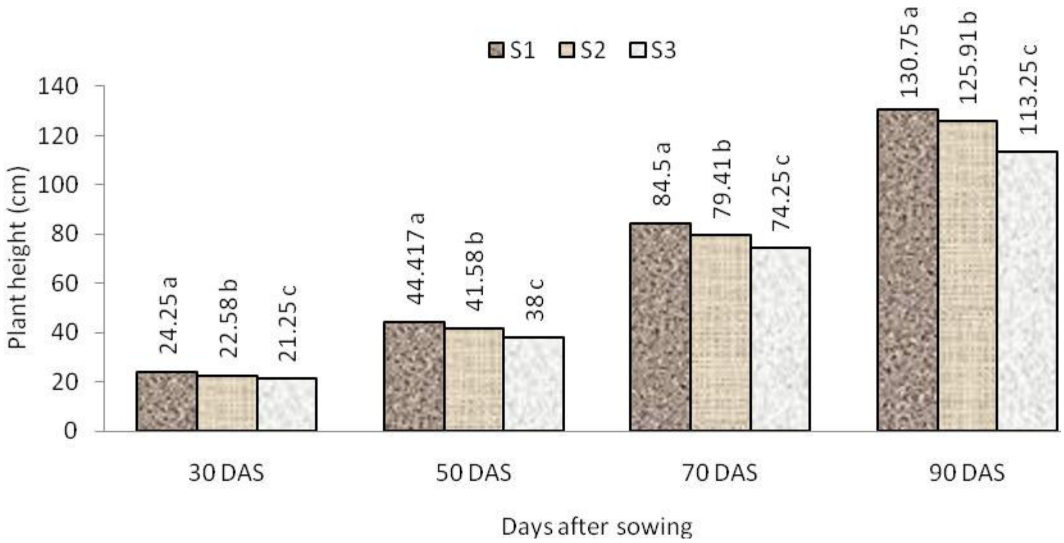

Fig 14. Effect of plant spacing on plant height at different days after sowing

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

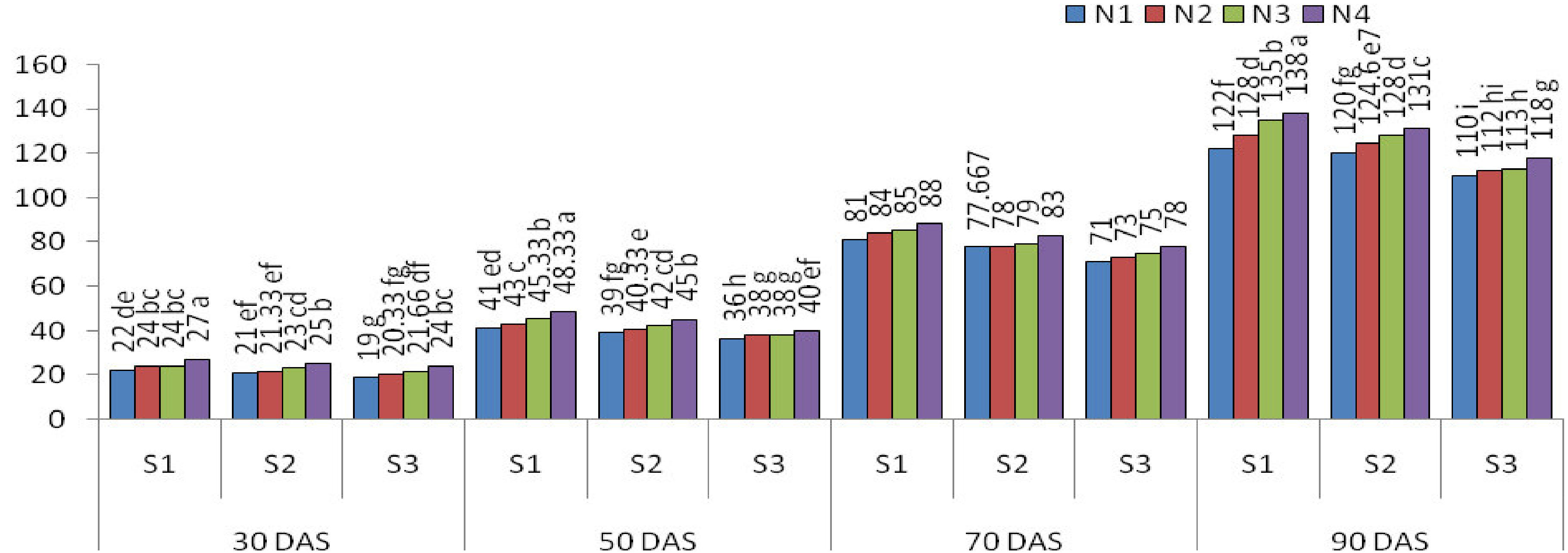

Fig 15. Effect of nitrogen and plant spacing on plant height at different days after sowing

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at P ≤ 5% level of probability.

N_1: 25 kg N/ha (control)
N_2: 45 kg N/ha
N_3: 65 kg N/ha
N_4: 85 kg N/ha

S_1: 40 cm × 05 cm
S_2: 40 cm ×10 cm
S_3: 40 cm ×15 cm

of time after sowing. At 30 days after sowing, the tallest plant (27 cm) was observed in S_1N_4 interaction followed by S_2N_4, S_2N_2, S_1N_3, S_1N_2, S_3N_4, S_2N_3, S_1N_1, S_3N_3, S_2N_2, S_2N_1, S_3N_2 and shortest plant height (19 cm) were observed in S_3N_1 interaction. At 50 days after sowing, the tallest plant (48.33 cm) was observed in S_1N_4 interaction followed by S_1N_3, S_2N_4, S_2N_3, S_2N_3, S_1N_1, S_2N_2, S_3N_4, S_2N_1, S_3N_3, S_3N_2 and shortest plant height (36 cm) were observed in S_3N_1. At 70 days after sowing, the tallest plant (88 cm) was observed in S_1N_4 interaction and shortest plant height (71 cm) was observed in S_3N_1 interaction. At 90 days after sowing, the tallest plant (138 cm) was observed in S_1N_4 interaction followed by S_1N_3, S_2N_4, S_1N_2, S_2N_2, S_1N_1, S_2N_1, S_3N_4, S_3N_3, S_2N_2, and shortest plant height (110 cm) were observed in S_3N_1 interaction.

4.2.2 Number of leaves per plant

Number of leaves per plant at 30, 50, 70 and 90 days after sowing were significantly influenced by different nitrogen levels (Fig.16). In all cases, number of leaves per plant were increased with the advancement of time and also with the increment of nitrogen levels. In every time the maximum number of leaves per plant was found in N_4 (85 kg N/ha) and the minimum number of leaves per plant was found in N_1 (25 kg/ha).

Number of leaves per plant at 30, 50, 70 and 90 days after sowing were significantly influenced by different plant spacing (Fig. 17). In all cases, numberof leaves per plant were increased with the advancement of time and also with the increment of spacing. In every time the maximum number of leaves per plant was found in S_3 (40 cm ×15 cm) and the minimum number of leaves per plant was

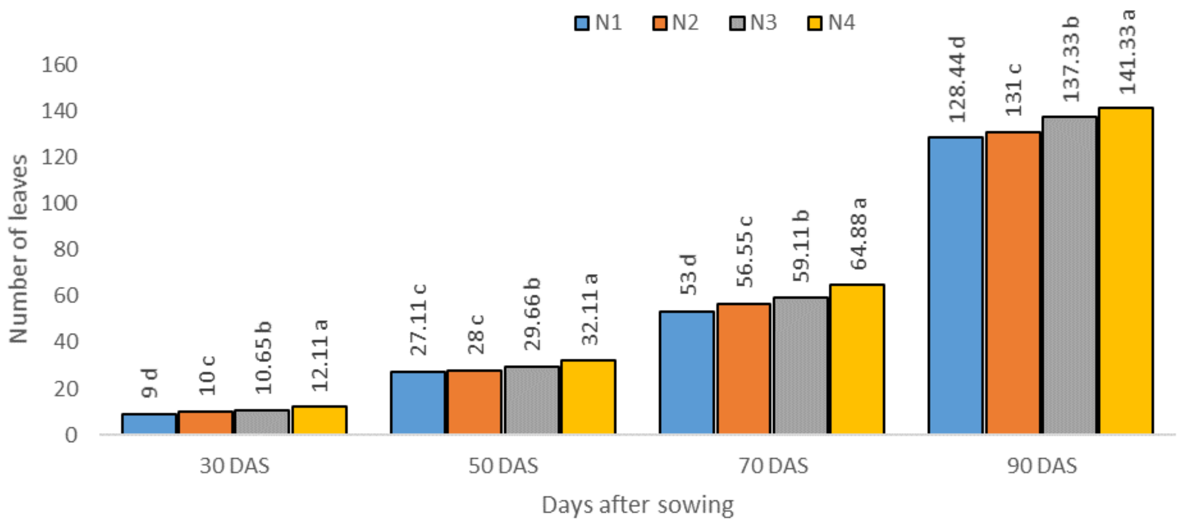

Fig 16. Effect of nitrogen on number of leaves at different days after sowing

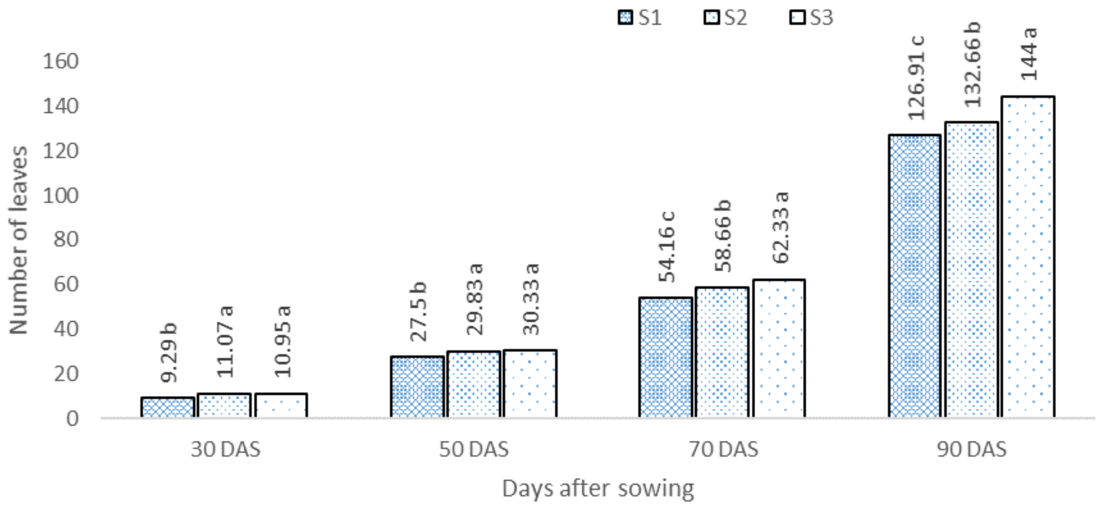

Fig 17. Effect of plant spacing on number of leaves at different days after sowing

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

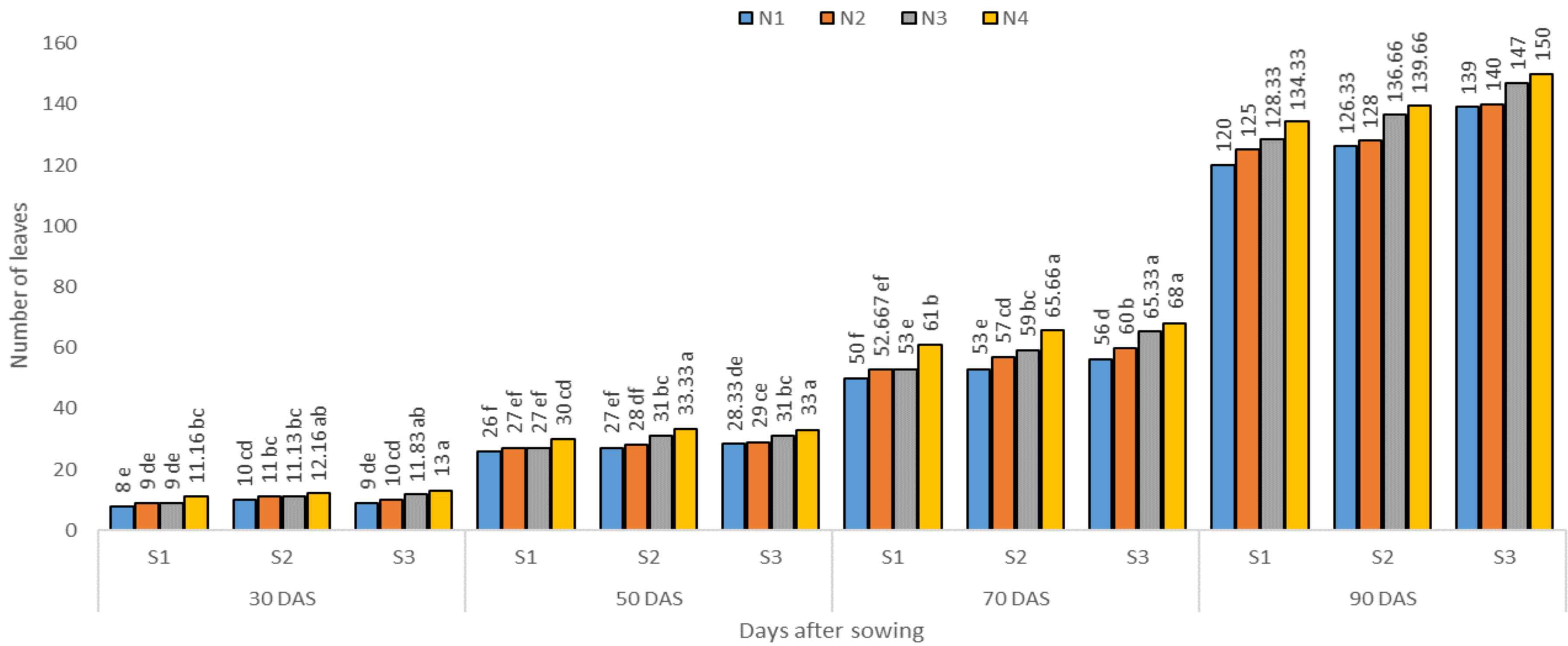

Fig 18. Effect of nitrogen and plant spacing on number of leaves at different days after sowing

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control) S_1: 40 cm × 05 cm
N_2: 45 kg N/ha S_2: 40 cm ×10 cm
N_3: 65 kg N/ha S_3: 40 cm ×15 cm
N_4: 85 kg N/ha

found in S_1 (40 cm × 05 cm). The interaction of nitrogen levels and spacing influenced the number of leaves per plant significantly at 30, 50 and 70 days after sowing (Fig. 18) but not significantly influenced at 90 DAS. In general the number of leaves per plant increased with the advanced of time after sowing. At 30 days after sowing, the maximum number of leaves per plant (13) was observed in S_3N_4 interaction followed by S_2N_4 S_3N_3, S_2N_3, S_2N_2, S_1N_3, S_1N_2 interaction and lowest number of leaves per plant (8) were observed in S_1N_1 which was statistically similar with S_3N_1 interaction. At 50 days after sowing, maximum number of leaves per plant (33.33) was observed in S_2N_4 interaction followed by S_3N_4, S_3N_3, S_2N_3, S_1N_4, S_3N_2, S_3N_1,, S_2N_2, S_1N_2 interaction and lowest number of leaves per plant (26) were observed in S_1N_1 interaction. At 70 days after sowing, maximum number of leaves per plant (68) was observed in S_3N_4 interaction followed by S_2N_3, S_3N_3, S_3N_2, S_1N_4, S_2N_3, S_3N_2, S_2N_1, S_1N_3, S_1N_2, interaction and the lowest number of leaves per plant (50) were observed in S_1N_1 interaction. At 90 days after sowing, maximum number of leaves per plant (150) was observed in S_3N_4 interaction and lowest number of leaves per plant (120) were observed in S_1N_1 interaction.

4.2.3 Number of branches per plant

Number of branches per plant was significantly influenced by different nitrogen levels (Fig. 19). The highest number of branches per plant (5.04) was observed in N_4 (85 kg N/ha) which was statistically similar with N_3 (65 kg/ha) followed by N_2 (45 kg/ha) and the lowest number of branches per plant (4.17) was observed in N_1

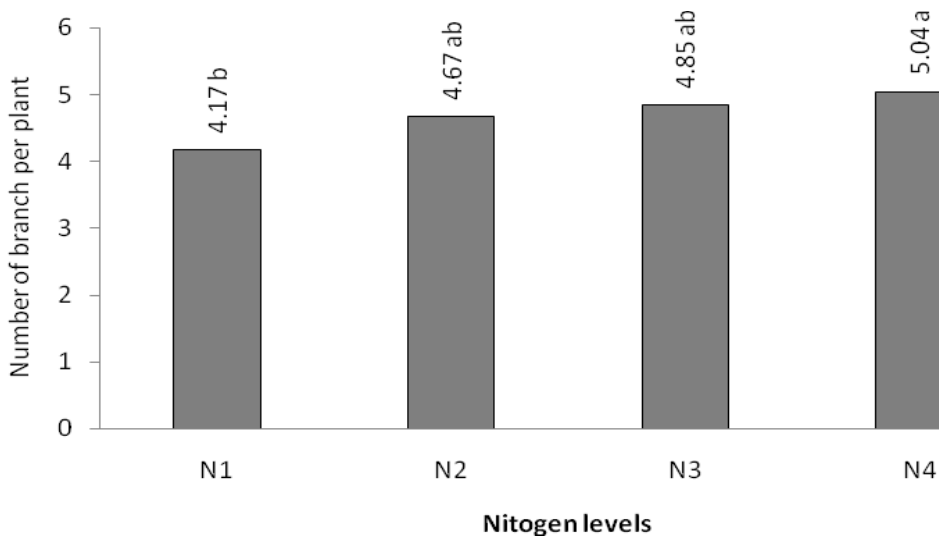

Fig 19. Effect of nitrogen on number of branches per plant

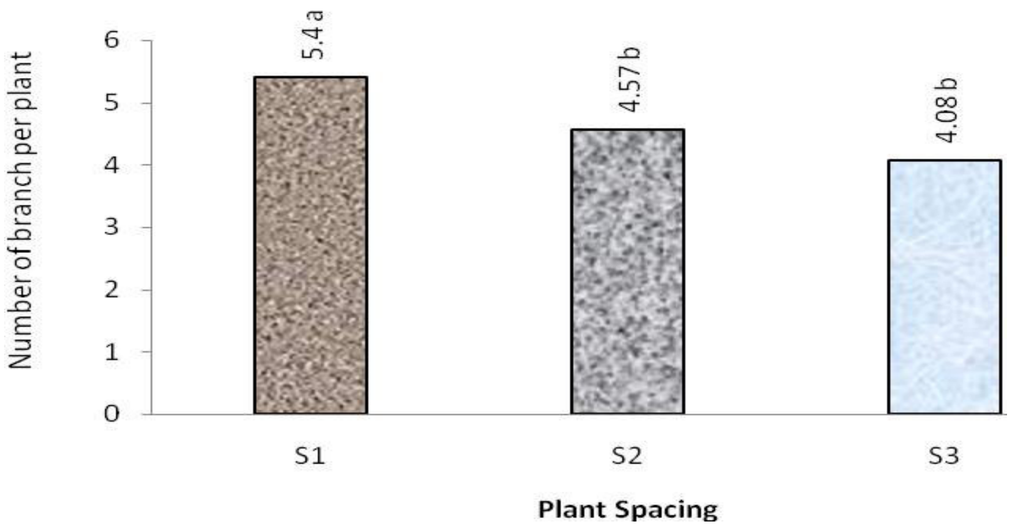

Fig 20. Effect of plant spacing on number of branch per plant

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at P ≤ 5% level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

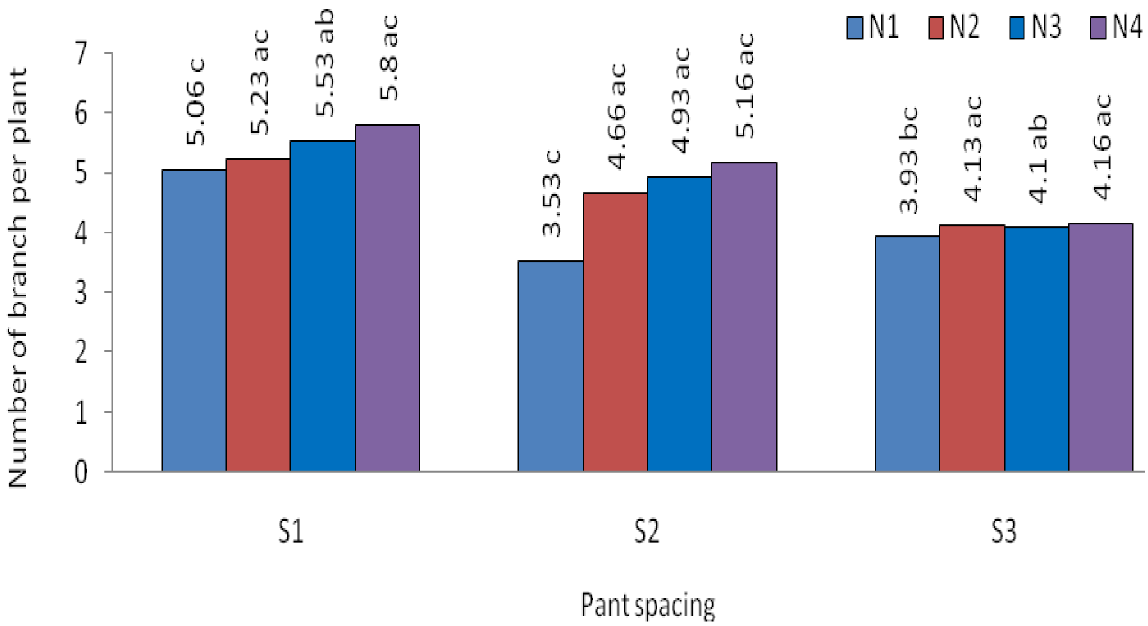

Fig 21. Effect of nitrogen and plant spacing on number of branches per plant

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

(25 kg/ha). It was found that number of branches per plant was increased with the increment of nitrogen doses. It was found that number of branches per plant wasincreased with the increment of nitrogen doses. It might be due to the fact that N encourages the meristematic activity and photosynthesis rate, which produced more number of branches/plant. In this respect, Ashfaq *et al.* (2001) noted similar finding by applying N up to 120 Kg/ha and El Mahdi (2008) up to Kg 40 N/ha.

Number of branches per plant was significantly influenced by different plant spacing (Fig 20). It was found that number of branches per plant was increased with the increment of plant spacing. The highest number of branches per plant (5.4) was observed in S_1 (40 cm × 5 cm) and the lowest number of branches per plant (4.08) was observed in S_3 (40 cm × 15 cm) which was statistically similar with S_2 (40 cm ×10 cm). The significant effect of spacing on primary and secondary branches were in line with the findings of Anonymous (2002) and that of Sardauna *et al.* (2007) who reported that plant population could reduce the number of primary and secondary branches per plant in the study of groundnut.

Number of branches per plant was significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 21). The highest number of branch per plant (5.8) were observed in S_1N_4 interaction which was statistically similar with S_1N_3 interaction followed by S_1N_2, S_2N_4, S_1N_1, S_2N_3, S_2N_2, S_3N_4, S_3N_2, S_3N_3 and lowest number of branches per plant (3.53) was observed in S_2N_1 which was statistically similar with S_3N_1 combination.

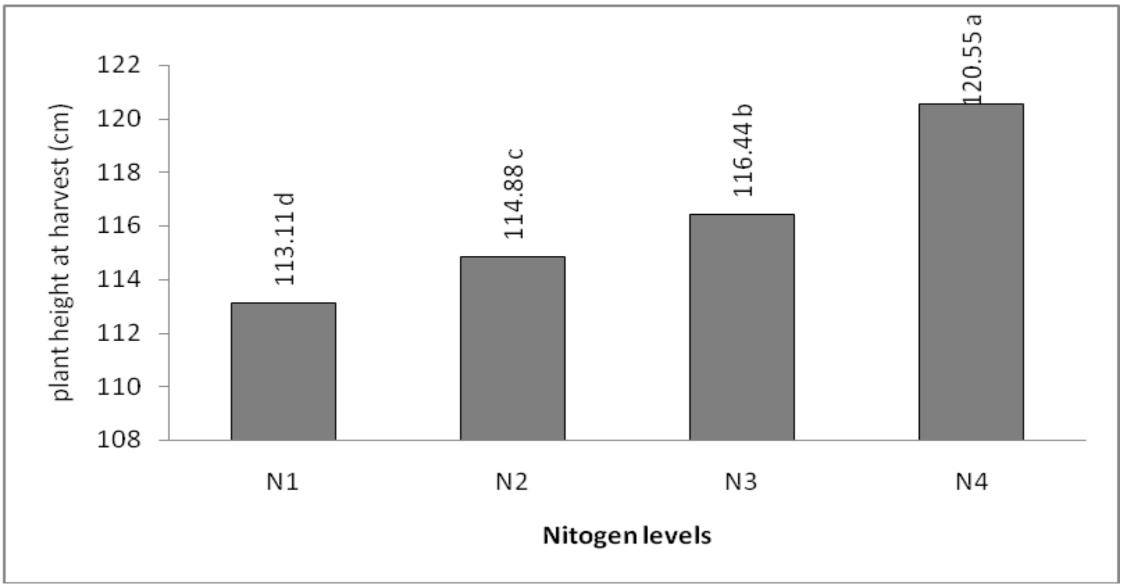

Fig 22. Effect of nitrogen on plant height at harvest

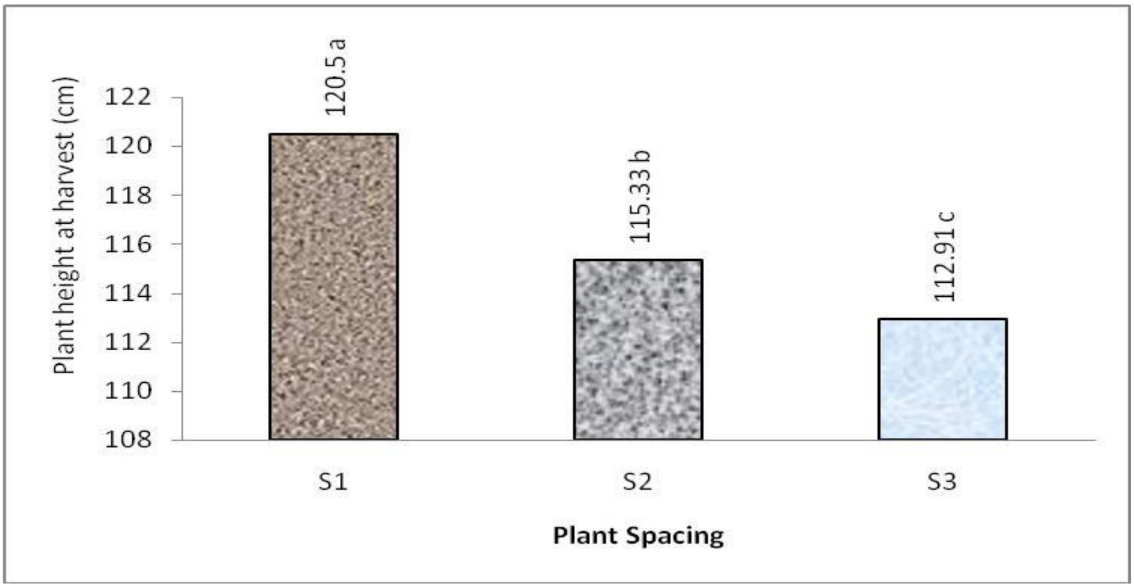

Fig 23. Effect of plant spacing on plant height at harvest

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_1: 25 kg N/ha (control)	S_1: 40 cm × 05 cm
N_2: 45 kg N/ha	S_2: 40 cm ×10 cm
N_3: 65 kg N/ha	S_3: 40 cm ×15 cm
N_4: 85 kg N/ha	

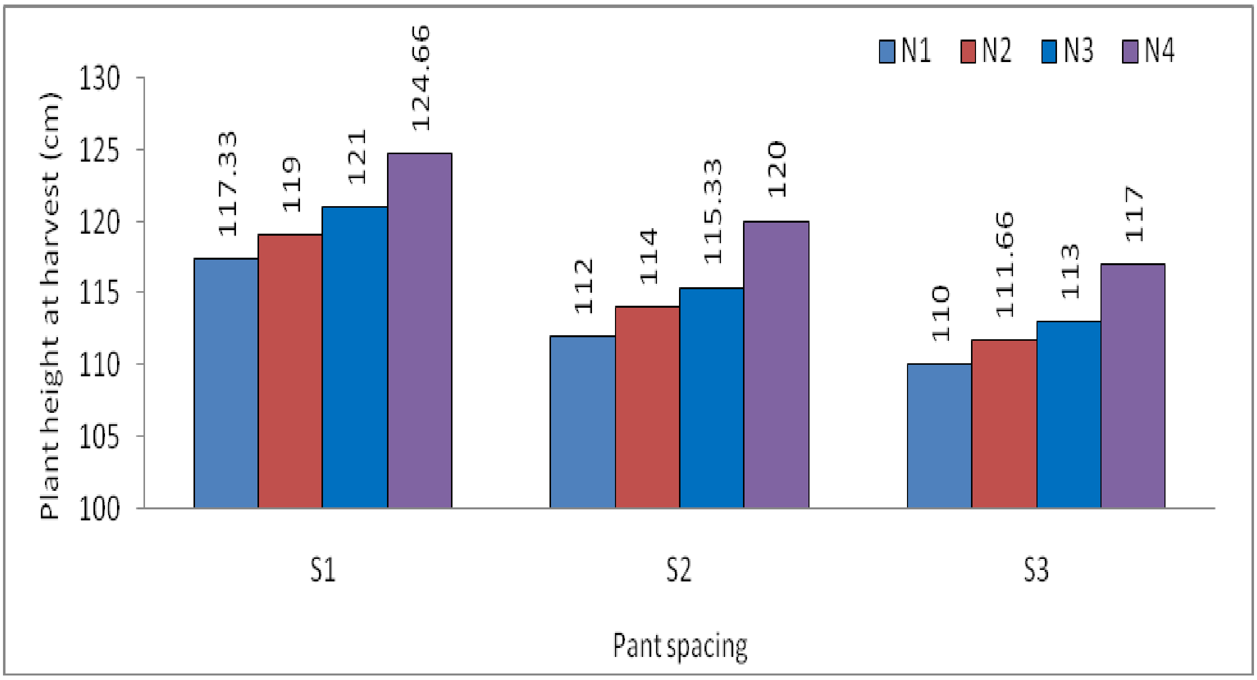

Fig 24. Effect of nitrogen and plant spacing on plant height at harvest

N_1: 25 kg N/ha (control)
N_2: 45 kg N/ha
N_3: 65 kg N/ha
N_4: 85 kg N/ha

S_1: 40 cm × 05 cm
S_2: 40 cm ×10 cm
S_3: 40 cm ×15 cm

4.2.4 Plant height at harvest

Plant height at harvest was significantly influenced by different nitrogen levels (Fig. 22). It was found that plant height at harvest was increased with the increment of nitrogen doses. The highest plant height at harvest (120.55 cm) was observed in N_4 (85 kg N/ha) which was followed by N_3 (65 kg/ha), N_2 (45 kg/ha) and the lowest plant height at harvest (113.11 cm) was observed in N_1 (25 kg/ha).

Plant height at harvest was significantly influenced by different plant spacing (Fig 23). It was found that plant height at harvest was increased with the increment of plant spacing. The highest plant height at harvest (120.5 cm) was observed in S_1 (40 cm × 5 cm) which was followed by S_2 (40 cm ×10 cm) and the lowest plant height at harvest (112.91 cm) was observed in S_3 (40 cm × 15 cm).

Plant height at harvest was not significantly affected due to the interaction of different nitrogen levels and plant spacing (Fig. 24). The highest plant height at harvest (124.66 cm) was observed in S_1N_4 interaction and lowest plant height at harvest (110 cm) was observed in S_3N_1 combination.

4.2.5 Capsule length

Capsule length was significantly influenced by different nitrogen levels (Table 2). It was found that capsule length was increased with the increment of nitrogen doses. The highest capsule length (94.04 cm) was observed in N_4 (85 kg N/ha) which was statistically similar with N_3 (65 kg/ha) followed by N_2 (45 kg/ha) and the lowest capsule length (82.67 cm) was observed in N_1 (25 kg/ha).

Capsule length was significantly influenced by different plant spacing (Table 2). It was found capsule length was increased with the increment of plant spacing. The highest capsule length (94.37 cm) was observed in S_3 (40 cm ×15 cm) which was followed by S_2 (40 cm ×10 cm) and the lowest capsule length (85.01 cm) was observed in S_1 (40 cm × 05 cm).

Capsule length was not significantly affected due to the interaction of different nitrogen levels and plant spacing (Table 2). The highest capsule length (100.00 cm) was observed in S_3N_4 interaction and lowest capsule length (76.66 cm) was observed in S_1N_1 combination.

4.2.6 Number of capsules per plant

Number of capsules per plant were significantly influenced by different nitrogen levels (Table 2). The highest number of capsules per plant (69.70) were observed in N_3 (65 kg/ha) which was statistically similar with N_4 (85 kg N/ha) followed by N_2 (45 kg/ha) and the lowest number of capsules per plant (59.65) were observed in N_1 (25 kg/ha). The increase in number of capsules/plant might be due to the favorable effect of N on the amount of metabolites synthesized and pods setting. In this respect, Fayed *et al.*, (2000) with 142 Kg N/ha Muhamman *et al.*, (2009) with 90 Kg N/ha showed similar results.

Number of capsules per plant were significantly influenced by different plant spacing (Table 2). It was found that number of capsules per plant were increased with the increment of plant spacing. The highest number of capsules per plant (72.04) were observed in S_3 (40 cm ×15 cm) followed by S_2 (40 cm ×10 cm) and the lowest number of capsules per plant (57.80) were observed in S_1 (40 cm × 05 cm). Increase in the number of capsules per plant might be attributed to wider row spacing and less inter or intra plant competition in the community as compared to narrow row spacing. Jakusko *et al*. (2013) also reported higher number of capsules per plant at wider spacing.

Number of capsules per plant were significantly affected due to the interaction of different nitrogen levels and plant spacing (Table 2). The highest number of capsules per plant (82.00) were observed in S_3N_3 which were statistically similar with S_3N_4, S_2N_3, S_3N_1, S_3N_4 followed by S_2N_2, S_1N_3, S_1N_2, S_2N_1 and lowest number of capsules per plant (55.46) was observed in S_1N_1 which was statistically similar with S_1N_4 combination.

4.2.7 Number of seeds per capsule

Number of seeds per capsule were significantly influenced by different nitrogen levels (Table 2). The highest number of seeds per capsule (60.11) were observed in N_3 (65 kg/ha) which was statistically similar with N_2 (45 kg/ha) and the lowest number of seeds per capsule (55.00) was observed in N_1 (25 kg/ha) followed by N_4 (85 kg N/ha).

Number of seeds per capsule were significantly influenced by different plant spacing (Table 2). It was found that number of seeds per capsule were increased with the increment of plant spacing. The highest number of seeds per capsule (62.58) were observed in S_3 (40 cm ×15 cm) followed by S_2 (40 cm ×10 cm) and the lowest number of seeds per capsule (52.09) was observed in S_1 (40 cm × 05 cm).

Table 2. Effect of nitrogen fertilizer and plant spacing on capsule length (cm), number of capsule per plant, seeds per capsule, yield and stover yield

Treatment		Capsule length (cm)	Number of capsules per plant	Number of seeds per capsule	Yield (t/ha)	Stover yield (t/ha)
Nitrogen levels						
N_1		82.67 c	59.65 b	55.00 b	1.07 b	2.13 d
N_2		86.78 bc	61.76 b	56.95 ab	1.17 b	2.24 c
N_3		90.17 ab	69.70 a	60.11 a	1.29 a	2.40 b
N_4		94.04 a	65.68 ab	55.00 b	1.06 b	2.52 a
Level of significance		**	**	**	**	**
Plant spacing						
S_1		85.01 b	57.80 c	52.09 b	1.33 a	2.42 a
S_2		85.85 b	62.76 b	55.62 b	1.11 b	2.25 b
S_3		94.37 a	72.04 a	62.58 a	1.00 c	2.29 b
Level of significance		**	**	**	**	**
Nitrogen levels × Plant spacing						
N_1	S_1	76.66	55.46 c	52.00 e	1.25	2.21
	S_2	81.00	58.00 bc	55.00 c	1.04	2.10
	S_3	90.33	65.50 ac	58.00 bc	0.91	2.09
N_2	S_1	85.66	58.30 bc	53.36 cd	1.36	2.30
	S_2	81.66	61.00 bc	54.83 c	1.10	2.20
	S_3	93.00	66.00 ac	62.66 b	1.05	2.21
N_3	S_1	87.66	60.43 bc	53.33 cd	1.51	2.52
	S_2	88.66	66.66 ac	59.00 bc	1.21	2.28
	S_3	94.16	82.00 a	68.00 a	1.15	2.40
N_4	S_1	90.06	57.00 c	49.66 f	1.20	2.67
	S_2	92.06	65.40 ac	53.66 cd	1.11	2.41
	S_3	100.00	74.66 ab	61.66 bc	0.88	2.46
Level of significance		NS	**	**	NS	NS
CV		6.67	7.8	11.23	13.12	10.23

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq$ 5%.

N_1: 25 kg N/ha (control) S_1: 40 cm × 05 cm
N_2: 45 kg N/ha S_2: 40 cm ×10 cm
N_3: 65 kg N/ha S_3: 40 cm ×15 cm
N_4: 85 kg N/ha

This work confirms the earlier work reported by Jakusko *et al*., (2013) who reported that the number of seeds per capsule increases significantly as spacing increases. The findings also is in line with Kathiresan (2002) who reported that decrease in row spacings increased intra-specific competition which eventually caused reduction in the number of seeds per capsules compared to wider spacing.

Number of seeds per capsule were significantly affected due to the interaction of different nitrogen levels and plant spacing (Table 2). The highest number of seeds per capsule (68.00) were observed in S_3N_3 followed by S_3N_2 S_3N_4, S_2N_3, S_3N_1, S_2N_1, S_2N_2, S_2N_4, S_1N_2, S_1N_3, S_1N_1 and the lowest number of seeds per capsule (49.66) were observed in S_1N_4.

4.2.8 Yield

Yield was significantly influenced by different nitrogen levels (Table 2). The highest yield (1.29 t/ha) was observed in N_3 (65 kg/ha) which was followed by N_2 (45 kg/ha) which was also statistically similar with N_1 (25 kg/ha) and N_4 (85 kg N/ha). The positive effect of increasing N fertilizer level on seed yield/ha of sesame might be attributed to the beneficial role of nitrogen on stimulating plant growth. Higher plant height, number of branches/plant and fruiting zone length which reflects favor on yield attributes i.e. capsules number/plant and seed weight/capsule in turn increased seed yield/ha. Many researchers reported increasing in seed yield/ha by applying N fertilizer up to 178.5, 214, 40, 142, 80 and 90 Kg N/ha (Ali 2002; Bassiem and Anton 1998; El-Mahdi 2008; Fayed *et al*. 2000 Malik *et al*. 2003 and Muhamman and Gungula 2008) respectively.

Yield was significantly influenced by different plant spacing (Table 2). The highest yield (1.33 t/ha) was observed in S_1 (40 cm ×5 cm) followed by S_2 (40 cm × 10 cm) and the lowest yield (1.0 t/ha) was observed in S_3 (40 cm ×15 cm). The high seed yield obtained at 40 cm x 5 cm spacing may be attributed to higher number of harvestable capsules per unit area observed with sesame planted at narrower row spacing or at higher population density as compared to fewer at wider row spacing or low population densities. Therefore, the higher number of capsules, length of capsule and number of seeds/capsule per plant recorded at wider row spacing of 40 cm x 15 cm was unable to compensate for higher number of threshed capsules obtained at narrow row spacing of 40 cm x 5 cm. This agreed with the finding of Chimanshette and Dhole (1992); Adebisi *et al.* (2005) and Umar (2011).

Yield was not significantly affected by the interaction of different nitrogen levels and plant spacing (Table 2). The highest yield (1.51 t/ha) was observed in S_1N_3 and lowest yield (0.88 t/ha) was observed in S_3N_4.

4.2.9 Stover yield

Stover yield was significantly influenced by different nitrogen levels (Table 2). The highest stover yield (2.52 t/ha) was observed in N_4 (85 kg N/ha) followed by N_3 (65 kg/ha), N_2 (45 kg/ha) and the lowest stover yield (2.13 t/ha) was observed in N_1 (25 kg/ha).

Stover yield was significantly influenced by different plant spacing (Table 2). The highest stover yield (2.42 t/ha) was observed in S_1 (40 cm × 05 cm) followed by

S_3 (40 cm ×15 cm) and the lowest stover yield (2.29 t/ha) was observed in S_2 (40 cm ×10 cm).

Stover yield was not significantly affected by the interaction of different nitrogen levels and plant spacing (Table 2). The highest stover yield (2.67 t/ha) was observed in S_1N_4 and lowest stover yield (2.09 t/ha) was observed in S_3N_1.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at research field and laboratory in the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of February to June 2018 to evaluate the performance of BARI Til 3 under the influence of different Nitrogen levels and plant spacing. The experiment was laid out in a randomized complete block design with three replications. Each block then divided into twelve unit plot of 2 m x 2.5 m sizes. The distance between sub plots was 1 m and plot to plot was 0.5 m. The experiment comprised of two sets of factors such as A: Four nitrogen levels, N_1: 25 kg N/ha (control), N_2: 45 kg N/ha, N_3: 65 kg N/ha and N_4: 85 kg N/ha; B: three plant spacing like, S_1: 40 cm × 05 cm, S_2: 40 cm × 10 cm and S_3: 40 cm × 15 cm. Data were collected on days to germination, days to flowering, days to pod formation, days to maturity, plant height at different days, number of leaves per plant, number of branches per plant, plant height at harvest, capsule length, number of capsules per plant, number of seeds per capsule, seed yield per hectare and stover yield per hactare. Result revealed that seeds took highest days to attain germination (6.88), plants took highest days to attain flowering (47), pod formation (60.11) and maturity (89) when treated with nitrogen N_4 (85 kg N/ha) while the N_3 (65 kg/ha) took lowest days (5.66) to germination and N_1 (25 kg/ha) days took lowest days to flowering, pod formation and maturity respectively (43.27, 56.44 and 86.44 respectively). Plant spacing S_1 (40 cm × 05 cm) took highest days to attain germination (6.75), spacing S_3 (40 cm ×15 cm) took highest days to attain flowering (45.62), pod formation (59.5) and maturity (89.16) while spacing S_2 (40 cm ×10 cm) took lowest days to attain germination (5.91), spacing S_1 (40 cm × 05 cm) took shortest days to attain flowering, pod formation and maturity (43.89, 56 and 85.66 respectively. Days to germination, pod formation and maturity were not significantly affected due to the interaction of different nitrogen and spacing but days to flowering was significantly affected due to the interaction of different nitrogen and spacing they were highest in S_3N_4 combination (7.33) and were lowest in S_1N_1 combination(42.66). Plant height at different days after sowing were significantly influenced by different nitrogen levels and plant spacing. In all cases, plant height was increased with the advancement of time and also with the increment of nitrogen levels and spacing. The tallest plant height was found in N_4 (85 kg N/ha) and the shortest plant height was found in N_1 (25 kg/ha) whereas the tallest plant height was found in spacing S_1 (40 cm ×5 cm) and the shortest plant height was found in spacing S_3 (40 cm × 15 cm). The interaction of nitrogen levels and spacing influenced the height of plant significantly at 30, 50, and 90 days after sowing but not significantly influenced at 70 DAS. At all days after sowing, the tallest plant was observed in S_1N_4 interaction and shortest plant height were observed in S_3N_1 interaction. Number of leaves per plant at different days after sowing were significantly influenced by different nitrogen levels and plant spacing. In all cases, number of leaves per plant were increased with the advancement of time and also with the increment of nitrogen levels and spacing. The maximux number of leaves per plant was found in N_4 (85 kg N/ha) and the mi nimum number of leaves per plant was found in N_1 (25 kg/ha) whereas the maximum number of leaves per plant was found in spacing S_3 (40 cm ×15 cm) and the minimum number of leaves per plant was found in spacing S_1 (40 cm × 05 cm). The interaction of nitrogen levels and spacing influenced the number of leaves per plant significantly at 30, 50 and 70 days after sowing but not significantly influenced at 90 DAS. At all days after sowing, the maximum number of leaves per plant was observed in S_3N_4 interaction and minimum number of leaves per plant was observed in S_1N_1 interaction. Maxium number of branches per plant (5.04), plant height at harvest (120.55 cm), capsule length (94.04 cm) was observed in N_4 (85 kg N/ha) and the minimum number of branches per plant (4.17), plant height at harvest (113.11 cm), capsule length (82.67 cm) were observed in N_1 (25 kg/ha) whereas maximum number of branches per plant (5.4), plant height at harvest (120.5 cm) were observed in S_1 (40 cm ×15 cm) and lowest in S_3 (40 cm × 15 cm) of all above characters resulting highest interaction in S_1N_4 and lowest in S_3N_1 combination. Highest number of capsules per plant (69.70), seeds per capsule (60.11) and yield (1.29 t/ha) were observed in N_3 (65 kg/ha) and lowest number of capsules per plant (59.65) and seeds per capsule (55.00) were observed in N_1 (25 kg/ha) and lowest yield (1.06 t/ha) was observed in N_4 (85 kg N/ha). In case of spacing, highest number of capsules per plant (72.04) and seeds per capsule (62.58) were observed in S_3 (40 cm ×15 cm) and lowest number of capsules per plant (57.80) and seeds per capsule (52.09) were observed in S_1 (40 cm × 05 cm) resulting highest interaction in S_3N_3 and lowest in S_1N_1 combination. The highest yield (1.29 t/ha) was observed in N_3 (65 kg/ha) and the lowest yield (1.06 t/ha) was observed in N_4 (85 kg N/ha). In case of spacing, the highest yield (1.33 t/ha) was observed in S_1 (40 cm ×5 cm) and the lowest yield (1.0 t/ha) was observed in S_1 (40 cm ×5 cm). Therefore, the higher number of capsules per plant, length of capsule and number of seeds per capsule recorded at wider row spacing of 40 x 15 cm was unable to compensate for higher number of threshed capsules obtained at narrower row spacing of 40 x 5cm.

it can be concluded that BARI Til 3 planted at 40 cm x 5 cm. spacing with application of 65kg N/ha gave the highest grain yield of sesame, cultivation in the Dinajpur area of Bangladesh.

REFERENCES

Abdel-Rahman K. A., A. Y. Allam, A. H Galal and B. A. Bakry. 2003. Response of sesame to sowing dates, nitrogen fertilization and plant populations in sandy soil. Assiut J. Agril. Sci. 34(3): 1-13.

Adebisi M. A., M. O. Ajala, D. K. Ojo and A. W. Salau. 2005. Influence of population density and season on seed yield and its component in Nigerian sesame genotypes. J. Trop. Agri. 43(1-2). 13-18.

Ali E. A. 2002. Response of sesame crop (*Sesamum indicum* L.) to nitrogen and PK fertilizers. Proc. 27th International Conf. for Statistics, Computer Science and its Applications. Cairo Univ. 297-309.

Anonymous. 2002. Overview of the Nigeria Sesame industry. Prepared for the United States Agency for International Development (USAID)/Nigeria. Chemonic International Inc. Washington DC, USA.34.

Asghar A., T. Asif, M. A. Nadeem and A. L. Bajwa. 2009. Effect of sowing dates and row spacings on growth and yield of sesame. J. Agric. Res. 43(1): 19-26.

Ashfaq A., H. Abid, A. Mahboob and M. M Ehsanullah. 2001. Yield and quality of two sesame varieties as affected by different rates of nitrogen and phosphorus. Pak. J. Agri. Sci. 38(1/2): 4-7.

Ashfaq A., M. Akhtar, A. Hussain, A. Ehsanullah and M. Musaddique. 2001. Genotypic response of sesame to nitrogen and phosphorus application. Pak. J. Agric. Sci. 38(1-2): 12-15.

Ashok K., T. N. Prasad and U. K. Prasad. 1996. Effect of irrigation and nitrogen on growth yield, oil content, nitrogen uptake and water-use of summer sesame (Sesamum indicum). Indian J. Agron. 41(1): 111-115.

Auwalu B. M., F. E. Babatunde, T. O. Oseni and Y. M. Muhammad. 2007. Productivity of vegetable sesame (Sesamum radiatum) as influenced by nitrogen, phosphorus and seasons. Adv. Hort. Sci. 21(1): 9-13.

Baker R. J. and K. G. Briggs. (2007). Effects of Plant Density on the Performance of 10 Barley Cultivars. Crop Development Ctr., Univ. of Saskatchewan, Saskatoon, Sask. S7N 0W0, and professor, Dep. of Plant Science, Univ. of Alberta, Edmonton, Alta. T6G 2H1, respectively.

BARI (Bangladesh Agricultural Research Institute). 2004. Annual Report for 2003. BARI. p. 28.

BARI (Bangladesh Agricultural Research Institute). 2012. BARI Til-3. Oil seeds Research Centre. p. 16.

Bassiem M. M. and N.A. Anton. 1998. Effect of nitrogen and potassium fertilizers and foliar spray with ascorbic acid on sesame plant in sandy soil. Ann. Agric. Sci., Moshtohor, 36(1): 95-103.

BBS (Bangladesh Bureau of Statistics). 2014. Yearly Statistical Book. Bangladesh Bureau of Statistics, Dhaka Bangladesh. p. 153.

Breure C. J., T. Menendez and M. S. Powell. 2007. The Effect of Planting Density on the Yield Components of Oil Palm (*Elaeis Guineensis*). Dami Oil Palm Research Station, Kimbe, West New Britain, Papua New Guinea. PNG Oil

Palm Research Association, PO Box 97, Kimbe, West New Britain, Papua New Guinea.

Cakmakc S. and B. Aydnoglu. 2002. The effects of different row spaces and fertilizer dosages on forage yield of chickling vetch (*Lathyrus sativus* L.) in the Mediterranean coastal region. Antalya, Turkey: Akdeniz Universitesi, Ziraat Fakultesi. Ziraat-Fakultesi-Dergisi,-Akdeniz-Universitesi. 5(1): 95-99.

Chaubey A. K., M. K Kaushik, and S. B. Singh. 2003. Response of sesame (Sesamum indicum) to nitrogen and sulphur in light-textured entisol. New Agriculturist. 14(1/2): 61-64.

Chimanshette T. G., H. Dhoble. 1992. Effect of Sowing Date and Plant Density of Seed Yield of Sesame (Sesamum indicum L) varieties. Indian Journal of Agronomy 37, 280-282.

Dixit J. P., V. S. N. Rao, G. R. Ambabatiya and, R. A. Khan. 1997. Productivity of sesame cultivars sown as semi-rabi under various plant densities and nitrogen levels. Crop Res. Hisar., 13(1): 27-31.

Dudley T. S, W. James and A. Mc Callum. 2000. Texas Agricultural Experimental Station, College Station and Yankum, Prepared April 12. 2000 p. 125.

El Mahdi A. A. 2008. Response of sesame to nitrogen and phosphorus fertilization in Northern Sudan. Proceedings of the 1st. International Conference on Agricultural BioSciences, 1: 62-63 (Abstract ID: IeCAB08-140).

El-Ouesni F. E. M., S. S. M. Gaweesh and A. K. Abd-El-Haleen. 2007. Effect of plant population density, weed control and nitrogen level on associated weeds, growth and yield of sesame plant(s). Bulletin of Faculty of Agriculture, University of Cairo. 45(2): 371-388.

Fayed E. H. M., A. A. Hassan and S. M. A. Hussain. 2000. Sesame performance as affected by seeding rate and nitrogen levels under drip irrigation system in newly cultivated sandy soil. Ann. Agric. Sci. 38(1): 65-73.

Gebremichael D. E. 2011. Sesame research under irrigation. Oilseeds-Engine for economic development, Terefe G, Wakjira A, Gorfu D (eds.). Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia..73-74.

Harper F. 1983. Principles of Arable Crop Production. Blackwell Science Limited, London. 336.

Ibrahim, M., M. Hussain, A. Khan, Y. Jamal, M. Ali and M. F. A. Malik. 2014. Effect of nitrogen and phosphorus on yield and yield components of Sesame. Int. J. Sci. Basic Appl. Res. 18(1): 95-101.

Ijoyah M. O, I. K. Hashin and R.T. Geza. 2015. Effects of intra-row spacing of pearl millet (*Pennisetum glaucum* (L.) R. Br) and cropping systems on the productivity of soybean-pearl millet intercropping system in a Southern Guinea Savanna location, Nigeria. World Scientific News 18: 35-48.

Islam J. K. and S. P. Noor. 1982. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. Pak. J. Sci. Res. 34(3-4): 113-119.

Jakusko B.B., B.D. Usman and A. B. Mustapha. 2013. Effect of row spacing on growth and yield of sesame (*Sesamum indicum* L.) J. Agri. Vet. Sci. 2.36-39.

Kathiresan G. 2002. Response of sesame (*Sesamum indicum* L.) genotypes of level of nutrients and spacing under different seasons. Ind. J. Agron. 47. 537-540.

Malik M. A., F. Saleem, M A. Cheema and S. Ahmed. 2003. Influence of different nitrogen levels on productivity of sesame (*Sesamum indicum* L.) under varying planting patterns. Int. J. Agri. and Bio., 1560-8530/05-4-490-492.

Mass A. L., W. W. Hanna and B. G. Mullinix 2007. Planting date and row spacing affects grain yield and height of pearl millet Tifgrain 102 in the Southeastern coastal plain of the United States. ICRISAT. 5 (1) 13-22.

Mitra S. and A. K. Pal. 1999. Water use and productivity of summer sesame as influenced by irrigation and nitrogen. J. Ind. Soc. Soil Sci. 47(3): 400-404.

Mondal D. K., G. Sounda, P. K. Panda, P. Ghosh, S. Maitra and , D. K. Roy. 1997. Effect of different irrigation levels and nitrogen doses on growth and yield of sesame (*Sesamum indicum* L.). Ind. Agricul. 41(1): 15-21.

Mondal S. S., C. K. Pramanik and J. Das. 2001. Effect of nitrogen and potassium on oil yield, nutrient uptake and soil fertility in soybean (Glycine max) - sesame (*Sesamum indicum*) intercropping system. Indian J. Agril. Sci. 71(1): 44-46.

Muhamman M. A. and D. T. Gungula. 2008. Growth parameters of sesame (Sesamum indicum L.) as affected by nitrogen and phosphorous levels in Mubi. Nigeria. J. of Sustainable Development in Agriculture & Environment, 3(2): 80-86.

Muhamman M. A., D. T. Gungula and A. A. Sajo. 2009. Phenological and yield characteristics of sesame (Sesamum indicum L.) as affected by nitrogen and phosphorous rates in Mubi, Northern Guinea Savanna Ecological Zone of Nigeria. Emir. J. Food Agric. 21(1): 01-09.

Nandita R. S., M. Abdullah, H. Mamun and S. Jahan, (2009). Yield Performance of Sesame *(Sesamum Indicum* L.) Varieties at Varying Levels of Row Spacing. Agrotechnology Discipline, Khulna University, Khulna, Bangladesh.

Ngala A. L., I. Y Dugje and H. Yakubu. 2013. Effect of inter-row spacing and plant density on performance of sesame (Sesamum indicum L.) in a Nigerian Sudan Savannah. Sci. Int 25. 513-519.

Obreza A and C. S. Vavrina. 1993. Production of chinese cabbage in relation to nitrogen source, rate and leaf nutrient concentration. Soil Sci. Plant Analysis. 24: 13-14.

Opena R. T., C.C. Kuo and J. Y. Yoon. 1988. Breeding and Seed Production of Root crops in the Tropics and Subtropics. Tech. Bul. 17. p. 97.

Parihar S. S., D. Pandey and R. K Shukla. 1999. Response of summer sesame (*Sesamum indicum*) to irrigation schedule and nitrogen level in clay-loam soil. Int. J. Trop. Agric. 17(1/4): 189-193.

Pathak K., U. Barman, M. K. Kalita and B. N. Hazarika. 2002. Effect of nitrogen levels on growth and yield of sesamum (*Sesamum indicum*) in Barak Valley Zone of Assam. Adv. Pl. Sci. 15(1): 341-343.

Patil A.B. (2000). Influence of nitrogen levels and spacings on grain yield of sesamum. J. Maharashtra Agric. Univ. 21(3): 368-369.

Prakash O., B. P. Singh and P. K. Singh. 2001. Effect of weed-control *measures and nitrogen fertilization on yield and yield attributes of sesame (Sesamum indicum*) under rainfed condition. Indian J. Agril. Sci. 71(9): 610-612.

Purseglove J.W. 1974. Tropical Crop Dicotyledons. Longman, London. 430-435.

Rahnama A. and A. Bakhshandeh. 2006. Determination of optimum row spacing and plant density for unibranched sesame in Khuzestan province. Journal of Agricultural Science and Technology 8. 25-33.

Sardauna V and S. S. Kandhola. 2007. Productivity of semi-spreading and bunch type varieties of groundnut as influenced by sowing data. An open access ICRISAT. 5(1):1-3.

Shilpi S., M. N. Islam, G. N .C. Sutradhar, A. Husna and F Akter. 2012. Effect of Nitrogen and Sulfur on the Growth and Yield of Sesame. Intl. J. of Bioresource Stress Manag. 3(2): 177-182.

Singaravel R. and R. Govindasamy. 1998. Effect of humic acid, nitrogen and biofertilizer on the growth and yield of sesame. J. Oilseeds Res. 15(2): 366-367.

Singh K., R.S. Dhaka and M. S. Fageria. 2004. Response of cauliflower (Brassica oleracea var. botrytis L.) cultivars to row spacing and nitrogen fertilization. Progress. Horticultural Science Journal 36. 171-173.

Singh P. K., O. Prakash and B. P. Singh. 2001. Studies on the effect of Nfertilization and weed control techniques on weed suppression, yield and nutrients uptake in sesame (Sesamum indicum). Indian J. Weed Sci. 33(3/4): 139-142.

Singh S. P. and Singh R. A. 1999. Effect of nitrogen on growth, yield and quality of sesame (Sesamum indicum L.) and blackgram (Vigna mungo L.) in intercropping system. J. Appl. Biol. 9(2): 163-166.

Subrahmaniyan K. and N. Arulmozhi. 1999. Response of sesame (Sesamum indicum) to plant population and nitrogen under irrigated condition. Indian J. Agron., 44(2): 413-415.

Thakur D. S., S. R. Patel and L. Nageshwar. 1998. Yield and quality of sesame (Sesamum indicum) as influenced by nitrogen and phosphorus in lighttextured inceptisols. Indian J. Agron. 43(2): 325-328.

Tiwari K. P. and K. N. Namdeo. 1997. Response of sesame (Sesamum indicum) to planting geometry and nitrogen. Indian J. Agron. 42(2): 365-369.

Umar U. A. 2011. Performance of sesame varieties (Sesamum indicum L.) as influenced by nitrogen fertilizer level and intra row spacing. M.Sc Thesis, Department of Agronomy, Ahmadu Bello University, Zaria pp. 87-92.

Vieira D. J. 2004. Growth analysis of sesame in Cariris Velhos, Paraiba: effect of cultivars and spacing. Comunicado-Tecnico-Centro-Nacional-de-Pesquisa-de-Algodao. 56: 7.

Yoshizawa, T. C. H. M. and Y. C. Roan. 1981. Management of Summer Pulse in Taiwan. AVRDC, Shanhua, Taiwan. p. 125.

APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	Description	
Location	Crop Physiology and Ecology, HSTU, Dinajpur	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	**Value**	
Bulk density (g cm-3)	0.86-1.07	
Particle size (%)		
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	**Content**	**Interpretation**
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh